- Alternative BTEX-S3: Excavation and Disposal
- Alternative BTEX-S4: Biosparging

5.1 CONCLUSIONS

Based the results of the detailed analysis of alternatives, the recommended alternatives were identified as:

- Alternative PCB-S2: Excavation, Disposal, Asphalt Cover and Institutional Controls.
- Alternative BTEX-S3: Excavation, Off-Site Treatment/Disposal and Groundwater/Surface Water Monitoring.
- Alternative G4: Groundwater and Hackensack River Surface Water Monitoring.

The recommended alternative for the PCB impacted soils, PCB-S2, is selected based on protection of human health and the environment and cost. Alternative PCB-S2 provides an equivalent level of human health and environmental protection as Alternative PCB-S3 at a significantly lower cost. Alternative PCB-S1 does not provide for adequate protection of human health and the environment.

Alternative BTEX-S3 is recommended as the remedial action alternative for BTEX impacted soils based on protection of human health and the environment and cost. This alternative provides for a level of human health and environmental protection equivalent to Alternatives BTEX-S2 and BTEX-S4. Although the cost for alternative BTEX-S4 is lower than alternative BTEX-S3, the presence of the organic silt layer could potentially reduce the effectiveness of this procedure.

Alternative G4 will provide groundwater and Hackensack River surface water data on the effectiveness of the BTEX source removal. The data will be evaluated after two-years of quarterly monitoring to determine if additional monitoring or remedial action is warranted.

It is not anticipated that additional groundwater treatment will be required. The BTEX source removal remedial action will result in elimination of BTEX impacted soil as a threat to groundwater. Although chlorinated compounds were detected in groundwater above the NYSDEC groundwater standard, no on-site source was identified. Also, there is no known potable use of groundwater within two miles downgradient of the Site. Hackensack River surface water analytical data indicate that the surface water quality has not been impacted. However, if it is determined that additional treatment of groundwater is warranted, the selected treatment alternative is Alternative G2.

APPENDIX A

BACKUP FOR COST ESTIMATES

CALCULATION SHEET

PAGE 1 OF ___
PROJECT NO. 38301.300

CLIENT ORU
PROJECT
SUBJECT Cost Estimate Alternative PCB-S2 Excavate, disposal, Asphalt cover
Prepared By SW Date 7/23
Reviewed By ___ Date ___
Approved By ___ Date ___

ALTERNATIVE PCB-S2

Excavation, disposal & transport, and asphalt cover.

ASSUMPTIONS

1. Costs based on approximately 419 cy of contaminated soil.
2. PCB levels to be excavated to 10 ppm.
3. Institutional controls to be implemented
4. Assume maximum no. of analytical samples as outlined by: EPA Verification of PCB Spill Cleanup by Sampling and Analysis.
5. Full time Field oversight
6. Asphalt cover: 1½" wearing surface
   3" binder course
   12" Structural subbase
7. Entire ORU site to be paved.
8. Disposal at CWM Chemical Services inc in Model City, NY.

RUST Rust Environment & Infrastructure

CALCULATION SHEET

PROJECT NO. ___

CLIENT: ORU

PROJECT: ___

SUBJECT: Cost Estimate Alternative PCB-S2 Asphalt Cover

Prepared By: SW Date: 7/23/96

Reviewed By: ___ Date: ___

Approved By: ___ Date: ___

PCB-S2 Asphalt Cover

Wearing Course	1½"
Binder Course	3"
Structural Subbase	12"

Area = 116,370 ft 2
= 12,930 sy
= 2.7 acres

Volume (1 foot deep)
116,370 ft² × 1 ft = 116,370 cu ft
= 4310 cy

Means Cost Data: < Paving and Surfacing 025100 >

025104	Asphalt Wearing Surface	3^{61}/sy × 12930 sy = $47,0[illegible]
025104	Binder Course	4^{75}/sy × 12930 sy = $62,0[illegible]
022200	Select granular fill	5^{1}/cy × 4310 cy = $25,00[illegible]
025250	Asphaltic Curbing 8" high × 6" high (40 LF/ton)	1^{38}/LF × 790 LF = $1090
022200	Compaction	1^{77}/cy × 4310 cy = $7700

Oil/Water Separator (Size tank for 50 yr event)

$Q = CIA$

$C = 0.95$

$A = 116,370\ ft^2$

$I = 4.8\ in/hr$ (30 min duration)

24 hr rainfall Rockland Cty 7.0 inches

$Q = (0.95)(4.8\ in/hr)(2.7\ acre)$

$(.95)\cdot 4.8\frac{in}{hr}\cdot\frac{ft}{12in}\cdot\frac{hr}{3600sec}$ [illegible]

$Q = 12.4\ ft^3/sec$

Rev 11/94

scale: 4 sq./inch

F051/General

RUST Rust Environment & Infrastructure

CALCULATION SHEET

PROJECT NO. ___

CLIENT ___ SUBJECT Alternative PCB-S2 Continued

PROJECT ___

Prepared By ___ Date ___

Reviewed By ___ Date ___

Approved By ___ Date ___

027400 HDPE 40,000 gall tank ≈ $1000.00

Add

Excavation and piping/CB's ≈ 5000.00

See following page for remaining estimates.

Maintenance (Every 10 years)

Crack Sealing (every 3yrs)

1^{50}/sy × 12930 sy × 10yrs/3yrs = $65,000

Seal Coating (every 3yrs)

$0.^{30}$/sy × 12930 sy × 10/3 = $13,000

Wearing Surface (every 7 years)

3^{41}/sy × 12930 sy × 10/7 = $67,000

Admin/Eng Cost (every 10yrs)

0.03 × 145,000 = $4,350

$149,350 10yrs

Rev. 11/94 scale: 4 sq./inch F051/General

ANNUAL MAINT COST $14,935 ≈ 15,000

RUST Rust Environment & Infrastructure

CALCULATION SHEET

PROJECT NO.: ______

CLIENT ______ SUBJECT ______ Prepared By ______ Date ______

PROJECT ______ PCB - S2 ______ Reviewed By ______ Date ______

______ continued ______ Approved By ______ Date ______

Excavate 419 cy

Cost includes Mob/demob, excavation, stockpile, loading

$14 /cy × 419 cy = $ 5,866

Transport & disposal

→ To TSCA facility → Model City 20 ton/min

$300/ton

419 cy × 1.35 ton/cy = 568 ton

568 ton / 20 ton/trk ≅ 28.4 trucks → 29 trucks

29 trucks × 20 ton/trk = 580 ton

580 ton × $ 300/ton = $ 174,000

419 cy / 419 cy/day ≐ 1 day to excavate

Mob/demob / sampling / backfill & compaction ≃ 5 day

Total duration 6 days

Institutional Controls — $ 5,000

RUST Rust Environment & Infrastructure

CALCULATION SHEET

PAGE 5 OF ___

PROJECT NO. ___

CLIENT ORM

SUBJECT Pcid S-2 [illegible]

PROJECT West Nyack

Prepared By ___ Date ___

Reviewed By ___ Date ___

Approved By ___ Date ___

Backfill

419 cy × $20/cy = $8,380

Compaction

419 cy × $2/cy = $839

Post Excavation Analytical - 8 = Max # of Samples/area (Assumed)
8 × 2 areas = 16 × $130 = $2080

Field Oversight

6 days × 10 hr/day × $60/hr = $3,600

Excavate & Disposal ≅ $200,000

Asphalt Cap ≅ $149,000

349,000

Engineering 10% $34,900

Contingency 20% $69,800

Capital Cost + Expenses $453,700

OM&M Annual Cost $15,000

RUST Rust Environment & Infrastructure

CALCULATION SHEET

PAGE 6 OF ___

PROJECT NO. 38301.300

CLIENT ___ SUBJECT COST ESTIMATE Prepared By SW Date ___

PROJECT ___ Alternative PCB-S3 Reviewed By ___ Date ___

Excavation & Disposal Approved By ___ Date ___

ALTERNATIVE PCB-S3

Excavation, transport, and disposal

ASSUMPTIONS

1. Costs based on approximately 3,050 cy of contaminated Soil
2. PCB levels to be excavated: 0-2' → 1 ppm
   > 2' → 10 ppm

   All levels above 10 ppm exist in the upper 2' ∴ excavation depth is 2 ft.
3. Assume maximum no. of analytical samples as outlined by: EPA Verification of PCB Spill Clear Up by Sampling and Analysis.
4. Full time field oversight.
5. Disposal at CWM Chemical Services Inc. in Model City, NY.

CALCULATION SHEET

PAGE 1 OF ___

PROJECT NO. ___

CLIENT ORV

PROJECT ___

SUBJECT Alternative PCB-S3 Excavation & Disposal

Prepared By SW Date 7/23

Reviewed By ___ Date ___

Approved By ___ Date ___

PCB - S3 Excavation and Disposal

(J. Besca)

Excavation :

Volume = 3,050cy

Cost includes Mob/demob, excavation, stockpile, loading

\$ 14/cy × 3,050cy = \$ 43,000

Transportation & Disposal:

→ To TSCA facility → Model City 20 ton/minimum

\$300 / ton

3,050 cy × 1.3 ton/cy = 3,965 ton

3,965 ton / 20 ton/trk = 198.3 trucks ≐ 200 trks

200 trucks × 20 ton/truck = 4,000 ton

4,000 ton × \$300/ton = \$1.2 ×10^6

3,050cy / 300cy/day ≅ 11 days

Mob-demob / sampling / backfill & compaction ≃ 10 days

Total 21 days

RUST **Rust Environment & Infrastructure**

CALCULATION SHEET

PROJECT NO. ___

CLIENT ___ SUBJECT Alternative PCB-S3 continued

PROJECT ___

Prepared By ___ Date ___
Reviewed By ___ Date ___
Approved By ___ Date ___

Backfill

3050 cy x 20/cy = $ 61,000

Compaction

3050 cy x 2^{00}/cy = 6,100

Post Excavation Analytical

EPA Verification of PCB Spill Cleanup by Samp. & Analysis p.16 Max Number of analysis → 8

2 areas x 8 = 16 analysis

130^{00} x 8 = $ 2,080

Field oversight

21 days x 10 hrs/day x 60/hr = $ 12,600

Health and Safety facility $ 1,500

$ 1,326,280

RUST Rust Environment & Infrastructure

CALCULATION SHEET

PROJECT NO: ___

CLIENT ___ SUBJECT ___ Prepared By ___ Date ___

PROJECT ___ Alt PCB-53 Reviewed By ___ Date ___

Continued Approved By ___ Date ___

$ 1,326,280		
25,256	Engineering Cost	20% (less disposal Cost)
132,628	Contingency	10%

$ 1,484,164 CAPITAL COSTS

NO associated OM & M costs

ALTERNATIVE BTEX-S2

Dual phase groundwater vapor extraction system

ASSUMPTIONS

1. Cost for extracting & treating groundwater (to depress groundwater table to make SVE more amenable) are not included in this estimate. The associated cost of extraction well and treatment system are included in Alternative GW3.

2. Discharge of treated water to Hackensack River. ($$ included)

3. 20' x 30' x 12' Treatment building to house SVE system.

4. Pilot study (necessary to further investigate feasible of this alternative) costs included.

RUST **Rust Environment & Infrastructure**

CALCULATION SHEET

PROJECT NO. ___

CLIENT ___ SUBJECT COST ESTIMATE Prepared By GW Date ___

PROJECT ___ Alternative BTEXS-2 Reviewed By ___ Date ___

Dual GW/Vapor extraction Approved By ___ Date ___

BTEX S-2 Dual Groundwater / Vapor Extraction

Groundwater recovery system

~~(1) Extraction Well 5gm (drilling)~~	~~1,200~~	→ See Alt. GW3
~~(1) Well connection and containment Sump~~	~~3,500~~	
~~Control Box / transducer~~	~~3,000~~	
~~80 LF electrical trenching, cable, installation~~	~~1,200~~	
	~~$ 8,900~~ ~~$10,000~~	
Mob / demob	1,000	
~~Discharge piping & metering pit~~	~~10,000~~	→ See Alt GW3
~~outfall Structure~~	~~8,000~~	→ See Alt GW3
(10) Vapor Extraction Wells	10,000	
~~80 LF double wall HDPE~~	~~3,200~~	→ See Alt GW3

RUST **Rust Environment & Infrastructure**

CALCULATION SHEET

PROJECT NO. ___

CLIENT ___ SUBJECT ___ Prepared By ___ Date ___

PROJECT ___ Reviewed By ___ Date ___

Approved By ___ Date ___

Treatment Building : (Now Corp/Philmar)

20 x 30 x 12 Wood Frame / concrete Floor Slab

Floor area 20 x 30 = 600 SF

$55 / SF x 600 SF = $33,000

~~Airstripping System : (Now Corp)~~ → See Alt GW3

Shallow tray type
(2000# Vapor phase GAC)
Pump
Flowmeters
Alarm system
piping & Appertenances
installation

~~$50,000~~

SVE System : (Now Corp)

SVE Skid (package)	12,000
200# GAC Canisters) 4 ea	3,200
Appertenances	1,500
Installation 120 hrs @ $40	4,800
	$22,000

RUST Rust Environment & Infrastructure

CALCULATION SHEET

PROJECT NO. ___

CLIENT ___ SUBJECT ___ Prepared By ___ Date ___

PROJECT ___ Reviewed By ___ Date ___

Approved By ___ Date ___

Pilot Study / Start up	$ 60,000
Permitting	$ 10,000
Health & Safety Facility	$ 1,500
	$ 104,500

- Operations and Maintenance

4hrs/WK (onsite) × 60/hr	240/WK
240/WK × 52WK	= $12,480
1 hrs/WK (admin) × 90/hr	$ 4,680

- Equipment Maintenance

Equipment Maintenance	$ 6,500/yr

- Analytical $ 5,000/yr
- Carbon Change out:

See following page

RUST **Rust Environment & Infrastructure**

CALCULATION SHEET

PAGE 14 OF ___

PROJECT NO. ___

CLIENT ___ SUBJECT ___ Prepared By ___ Date ___

PROJECT ___ Reviewed By ___ Date ___

Approved By ___ Date ___

SVE System → 2 times per year @ 800#

800# × 2 × 2.50/# = $ 4,000

Labor 5 days @ 60/hr = $ 2,400

ANNUAL OM&M COST $ 35,060

		104,500
Engineering	20%	20,900
Contingency	20%	20,900
CAPITAL COST		$ 146,300

CALCULATION SHEET

CLIENT ___	SUBJECT Cost Estimate	PROJECT NO. ___
PROJECT ___	BTEX S3	Prepared By SW/Date ___
	Excavation & Disposal	Reviewed By ___ Date ___
		Approved By ___ Date ___

BTEX-S3 Excavation & off site disposal

Excavation volume - 6,000 cyds

cost includes Mob/demob, ecavation, stockpile, & loading

\$ 15 /CY × 6,000 cy = (\$ 90,000)

Transportation & Disposal

From ORU to WMX G.R.O.W.S. LF Morrisville, PA

6,000 cy × 1.3 ton/cy = 7,800 ton

7,800 ton / 20 ton/trk = 390 truck

≃ 7,800 ton × \$60/TON = (\$ 468,000)

6,000 cy / 300 cy/day = 20 days

Mob/demob, sampling / backfill & compaction

≃ 10 days

Total = 30 days

Backfill & Compaction -

\$22/CY × 6,000 = (\$ 132,000)

RUST Rust Environment & Infrastructure

CALCULATION SHEET

PROJECT NO. ___

CLIENT ___ SUBJECT ___ Prepared By ___ Date ___

PROJECT ___ Reviewed By ___ Date ___

Approved By ___ Date ___

WATER Management $20,000

Post Excavation sampling:

1 Sample per 25 of perimeter of excavation

175 x 2 + 95 x 2 = 570/25 = 22 samples + 2 QA/QC = 24 AWT

(EPA 8020) 24 samples: VOA x $50 = $1,200

Field oversight:

30 days @10hrs/day x 60/hr = $18,000 AWT

Mob/demob $2,500

Health and Safety facility $1,500

$ 733,200

Engineering 5% 36,700

Contingency 15% 110,000

COSTS $ 879,900

NO ASSOCIATED OM&M COST

CALCULATION SHEET

PAGE 18 OF ___
PROJECT NO. 38301.300

CLIENT ORU
PROJECT ______
SUBJECT COST ESTIMATE Alternative BTEX-S4 Bio/Air Sparging
Prepared By SW Date 7/31
Reviewed By ______ Date ______
Approved By ______ Date ______

ALTERNATIVE BTEX-S4

Bio/Air Sparging w/ SVE

ASSUMPTIONS

20' x 30' x 12' treatment building to house SVE system.

BTEX-S4 Bio/Airsparging (2 years)

(2) Air injection wells, 1", 20 ft deep
(LS) Vapor extraction piping and bedding
(1) Air compressor (injection)
~~Blower (extraction)~~ → included in SVE skid
(1) SVE skid (blower, moisture separator, filter, exhaust)
Carbon for air treatment

Mob / demob / health & safety facility $2,500

(2) Air injection wells

(2) wells at $5,000 = $10,000

Vapor Extraction piping and bedding

900 LF 1" perforated PVC
$1.53/LF = $1,400

Appurtenances (LS) ≈ $1,000

bedding (crushed stone)

900 ft x 6" = 450 CY

450 CY x $10/CY = $4,500

CALCULATION SHEET

PROJECT NO. ______

CLIENT ______ SUBJECT ______ Prepared By ______ Date ______

PROJECT ______ Reviewed By ______ Date ______

Approved By ______ Date ______

Air Compressor — $ 10,000

SVE Skid — Filter, MS, blower, silencer, exhaust, 2 carbon drums

$17,000

↓

Treatment building:

20 x 30 x 12 Floor Area = 20 x 30 = 600 SF

600 SF x $55/SF = $ 33,000

Labor (excluding treatmt bldg)

Electrical 30 man hours @ $45/hr ≈ 1,350

General 290 man hours @ $45/hr ≈ 13,050

$ 14,400

RUST **Rust Environment & Infrastructure**

CALCULATION SHEET

PROJECT NO. ___

CLIENT ___ SUBJECT ___ Prepared By ___ Date ___

PROJECT ___ Reviewed By ___ Date ___

Approved By ___ Date ___

Pavement	$ 149,000
	$ 242,800
Engineering 15%	36,420
Contingency 20%	48,560
CAPITAL COST	$ 327,780
Annual OM&M	$ 75,000

OM&M $149,350 / 10 years pavement

OM&M Sparging $ 14,935

8 hrs/wk × $60/hr = 480/wk
= $25,000/yr

5 hrs/wk × $90/hr = $24,000/yr

Maintenance of equip $6,000/yr

Carbon Changeout Material 4,000
Labor 1,500

5,500/yr

$ 75,435

RUST ENVIRONMENT & INFRASTRUCTURE

CALCULATION SHEET

PAGE 22 OF ___
PROJECT NO. 3[illegible]

CLIENT ORU
PROJECT ___

SUBJECT Cost Estimate
Alternative GW-2
Air Sparging

Prepared By HHm Date 11/4/96
Reviewed By ___ Date ___
Approved By ___ Date ___

ALTERNATIVE GW2

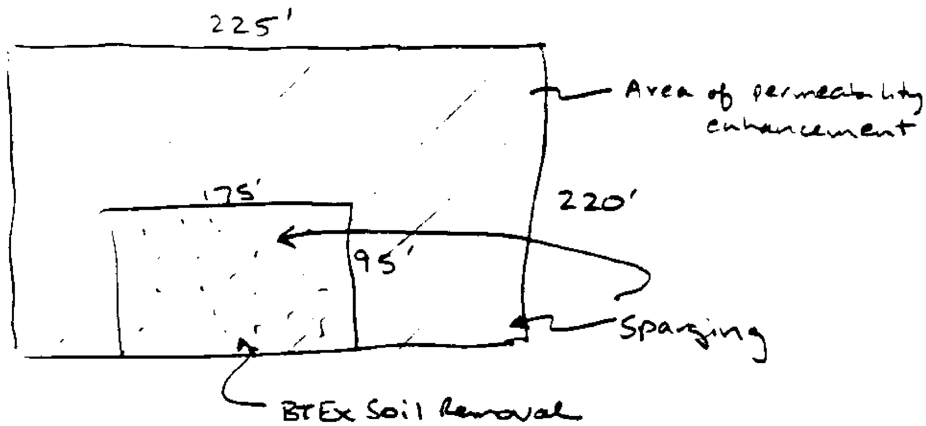
In Situ Air Sparging / Vapor Extraction System

ASSUMPTIONS

1. Semi-annual groundwater and surface [illegible] monitoring
2. 20'x30'x[illegible] treatment building to house SVE system
3. Air Sparging points have 20-25' radius of influence
4. Vapor extraction pipes have 25' radius of influence
5. Organic silt removed in BTEX area
6. Permeability enhancement required in sparge areas where silt not removed.

CALCULATION SHEET

PAGE 23 OF ___
PROJECT NO. 38301.30
CLIENT ORU
SUBJECT ALT GIV-2
Prepared By RWT Date 2/28/95
PROJECT ___
Reviewed By ___ Date ___
Approved By ___ Date ___



BTEx Area 17,000 SF
Sparge Area 50,000 SF
Perm Enhancement = (50000 - 17000) = 33,000

Perimeter vapor control trench/wells installed around sparge area = 890'

COST ESTIMATE
ORU-AIR SPARGING DETAIL

		Quant	Unit	Rate	Total		
1	*SVE Laterals*					$18,590	Therefore, Unit Price = $7.2 to $11.7/LF
	Perf. pipe	1980	LF	$2.50	$4,950		2" pvc perf pipe @ 25' spcaing
	Blank header pipe	495	LF	$2.00	$990		4" pvc 25% of perf pipe quantity
	Materials, other	1	LS	$2,000.00	$2,000		estimate-typical
	Valves	15	LS	$150.00	$2,250		control valves - 4" butterfly
	Labor	240	HR	$35.00	$8,400		Incl. hand-spread stone, stone in Item asphalt estimate, 2 laborers for three weeks
2	*Perimiter vapor control*					$19,613	Therefore, Unit Price = $17 to $28/LF
	Blank header pipe	890	LF	$2.00	$1,780		4" pvc - 220+225+220+225
	Vapor control points	30	EA	$500.00	$14,833		2" well , 15' deep, drive-over @ 30" O.C. on perimeter
	Pipe fitting/connections	1	LS	$2,000.00	$2,000		estimate-typical
	Materials, other	1	LS	$1,000.00	$1,000		estimate-typical
3	*Sparge points*					$121,200	Therefore, Unit Price = $1515/EA for 80 to 125 points
	Air supply piping (header)	16000	LF	$2.00	$32,000		1" to 80 points @ ave dist of 200'
	Sparge points	80	EA	$1,000.00	$80,000		2" well , 30' deep, drive-over
	Materials, other	1	LS	$5,000.00	$5,000		estimate-typical
	Labor	120	HR	$35.00	$4,200		Incl. hand-spread stone, stone in Item xx
4	*Perm enghancement holes*					$28,000	Therefore, Unit Price = $350/EA for 80 to 125
	Drill/fill complete	80	EA	$350.00	$28,000		
5	*Cover system*			INCLUDED UNDER PCB ALTERNATIVE			
6	*Equipment Bldg.*					$20,800	Therefore, Unit Price = $52/SF
	Enclosure 20' x 20'	1	LS	$15,000.00	$15,000		estimate-typical
	Lights, HVAC, etc.	1	LS	$3,000.00	$3,000		estimate-typical
	Electric service	1	LS	$1,800.00	$1,800		estimate-typical
	Miscellaneous finishing	1	LS	$1,000.00	$1,000		estimate-typical

COST ESTIMATE
ORU-AIR SPARGING DETAIL

8	*Equipment*					$77,223	Price = $62,000 to $100,000
	Extraction skid	1	EA	$15,750.00	$15,750		JE Gasho Assoc - verbal estimate
	Shallow tray stripper	1	EA	$12,000.00	$12,000		NEEP - verbal estimate
	Compressor	1	EA	$8,000.00	$8,000		Rolffe Industries - verbal estimate
	Piping connections	1	LS	$5,000.00	$5,000		estimate-typical
	Electrical labor	240	HR	$40.00	$9,600		estimate-typical
	General constr labor	480	HR	$35.00	$16,800		estimate-typical
	Building incidentals/finishing	15%	-	$10,072.50	$10,073		15% of system
						$285,426	

ALTERNATIVE GW3

Groundwater Extraction and Treatment

ASSUMPTIONS

1. Shallow tray air stripper for treatment, 30gpm
2. Treated water discharged to Hackensack River
3. semi annual groundwater and Surface water monitoring

RUST Rust Environment & Infrastructure

CALCULATION SHEET

PROJECT NO. ___

CLIENT ___ SUBJECT Alternative GW3

PROJECT ___

Prepared By ___ Date ___

Reviewed By ___ Date ___

Approved By ___ Date ___

Ground water recovery system

2 extraction wells

drilling	1,200
connections & sump	3,500
transducer/control box	3,000
electrical	1,200
	$ 8,900 ≈ 10,000

2 wells x 10,000 = $20,000 ✓

2 submersible pumps and controls $ 2000 ea

2 x $4,000 = $8,000 ✓

Discharge piping and metering Pit $ 10,000 ✓

outfall structure $ 8,000

80LF double wall HDPE $ 3,200 ✓

Discharge piping

200LF x $15/LF $ 3,000

RUST Rust Environment & Infrastructure

CALCULATION SHEET

PAGE 29 OF ___
PROJECT NO. 38301.300
CLIENT ORU
SUBJECT Alternative GW3
PROJECT ___
Prepared By SW Date 7/31
Reviewed By ___ Date ___
Approved By ___ Date ___

Treatment bldg : 20' x 30' x 12'

wood frame concrete floor slab

floor area = 20' x 30' = 600 sf

$55/sf x 600 = $ 33,000

Air Stripper System

Shallow tray type
2000 # GAC
pump (transfer)
Flow meters
Alarm system
piping & Appertenances
installation

$ 50,000

Step Rate testing for new extraction wells

$4000 ea x 2 wells = $ 8,000

Deed Restriction $ 5,000

Permitting (discharge) $ 10,000

Start up $ 30,000

Rev. 11-94 scale: 4 sq./inch F051 General

Rust Environment & Infrastructure

CALCULATION SHEET

PAGE 28 OF ___

PROJECT NO. ___

CLIENT ORU

PROJECT ___

SUBJECT Alternative GW3

Prepared By SW Date 7/31

Reviewed By ___ Date ___

Approved By ___ Date ___

Total direct Capital Cost $ 188,200

Engineering 25% 47,100

Contingency 20% 37,600

$272,900

Annual OM&M COSTS

Well maintenance includes evaluation & rehabilitation:

$7000/well /10years → $ 700 /well x 14 wells =

$9,800

Groundwater and Surface water sampling & analysis (VOA) volatile organic analysis (including water level data)

Semi annual LS → $10,000

Treatment System OM&M

12hrs/wk onsite x $60/hr = 720/wk ≈ $38,000

5hrs/wk admin x $90/hr = 450/wk = $24,000/yr

$ 62,000

Rev. 11 94 scale: 4 sq./inch F051 General

CALCULATION SHEET

PAGE 1 OF 2

PROJECT NO. ______

CLIENT ORU
SUBJECT Groundwater GW4
PROJECT West Nyack FS

Prepared By ___ Date 2/1/97
Reviewed By ______ Date ______
Approved By ______ Date ______

I Sample Collection: 15 monitoring wells, 4 surface waters

A. Labor Per Event
1. $50/hour x 32 hrs = $ 1,600

B. Expenses Per Event
(lodging, transportation, Equipment) $ 700

C. Total $ 2,300

II Sample Analysis Per Event

A. Volatile Organics SW846 method 8021 - $115 sample

B 19 samples, one field duplicate, one trip blank = 21 samples x $115 = Total $ 2,415

III Reporting Per Event

A. Labor & Expenses $ 1,200

Total Per Event $ 5,915

Total For Quarterly Monitoring For Two Years
8 events x $ 5,915 /event = $47,320

RUST Rust Environment & Infrastructure

CALCULATION SHEET

PROJECT NO. ______

CLIENT ORU
PROJECT West Nyack FS

SUBJECT Groundwater
GW4

Prepared By GLF Date 3/12/97
Reviewed By ______ Date ______
Approved By ______ Date ______

III Monitoring Well Installation

A. Drilling & Well Construction

1. Cost per foot $25 x 15 feet = $375
2. Materials, Mob/Demob = $750
3. Labor Oversight 12hrs x $65/hr = $780
4. Expenses $250
5. Total $2,155

B. Well Development

1. Labor 8hrs x $50/hr = $400
2. Expenses = $250

$650

C. Total Well Installation ≅ $2805

APPENDIX B

TWODAN MODEL DESCRIPTION

1.0 INTRODUCTION

1.1 General

Groundwater extraction and treatment, as described under Remedial Alternative G3 was evaluated using a groundwater flow model, the results of which are presented as follows. The evaluation was based on information reported in the Site remedial investigation (RI) and mathematical modeling of groundwater flow in the vicinity of the Site. The purpose of the evaluation was to estimate the flow rates and optimum location for an extraction well system to be used for the feasibility cost estimate. The analyses presented herein do not constitute a design study for the remedial alternatives considered. Additional data collection and evaluation may be required in conjunction with the design and implementation of the selected remedial alternative.

1.2 Site Hydrogeology

According to the results of the RI, impacted groundwater occurs in two water bearing units, overburden and fractured bedrock, underlying the Site. The groundwater in the overburden flows in a northeastern direction across the Site, through undifferentiated sand and gravel with a hydraulic conductivity of approximately 7×10^{-4} cm/sec (2 ft/day), discharging to the Hackensack River. Groundwater in the overburden is separated from groundwater in the underlying fractured bedrock by a potentially discontinuous lower permeability layer composed of glacial till or dense sand and gravel in the lower portions of the undifferentiated sand and gravel unit. No Site groundwater monitoring wells are screened solely in this dense material, but a variation in head between groundwater in wells screened in the overburden and the fractured bedrock indicate that a lower permeability layer is present and acts as a semi-confining layer. This material is assumed to have a hydraulic conductivity of 1×10^{-5} cm/sec (0.03 ft/day) which is approximately two orders of magnitude less than the overlying less dense sand and gravel material. The hydraulic conductivity measured at wells in the fractured (weathered) bedrock was approximately 2×10^{-3} cm/sec (5 ft/day). Near the river a slight upward gradient was measured between the fractured bedrock and the overburden indicating that there is a component of flow up through the "semi-confining layer", probably toward the river. It is assumed that the remaining groundwater in the fractured bedrock flows under the river.

2.0 ANALYSIS

Groundwater flow was simulated using the two-dimensional analytical groundwater model TWODAN (Fitts, 1994). This model simulates the behavior of an aquifer by superimposing analytical solutions for the various elements that comprise the site-specific model.

2.1 Conceptual Groundwater Flow Model

Overburden: The overburden at the ORU Site was modeled as a homogeneous, unconfined "aquifer" of infinite horizontal extent with a maximum potential saturated thickness of 30 feet. Recharge to the overburden "aquifer" is assumed to be provided by infiltration of rainwater uniformly distributed over the entire extent of the "aquifer". Discharge from the model is provided by linesinks placed at the location of the Hackensack River bordering the north and east of the Site. The linesinks remain at a constant head along their length so that the groundwater elevation at the center of the linesink is equal to the ground surface elevation at the center of the linesink.

Shallow Bedrock: The shallow bedrock was modeled as a confined "aquifer" of infinite horizontal extent with a saturated thickness of 15 feet. Recharge to the bedrock "aquifer" is assumed to be provided from upgradient (southwest) producing a uniform gradient across the Site. Discharge from the model is assumed to be downgradient (northeast). It is assumed that there is no hydraulic connection between the Hackensack River and the bedrock "aquifer".

2.2 Groundwater Flow Model Calibration

Prior to simulating remedial alternatives, the groundwater models were calibrated against available site data. The goal of the model calibration was to obtain simulated heads similar to those reported in the RI for recent water level measurements.

Overburden: Figure B-1 shows the simulated heads for a recharge infiltration rate (I) of 12 inches per year (in/yr) and an "aquifer" hydraulic conductivity (K) of 2 feet per day (ft/day). Comparing these results to Figure 6 of the RI (these contours are shown on Figure B-1), it can be seen that the elevation contours are in approximately the correct locations.

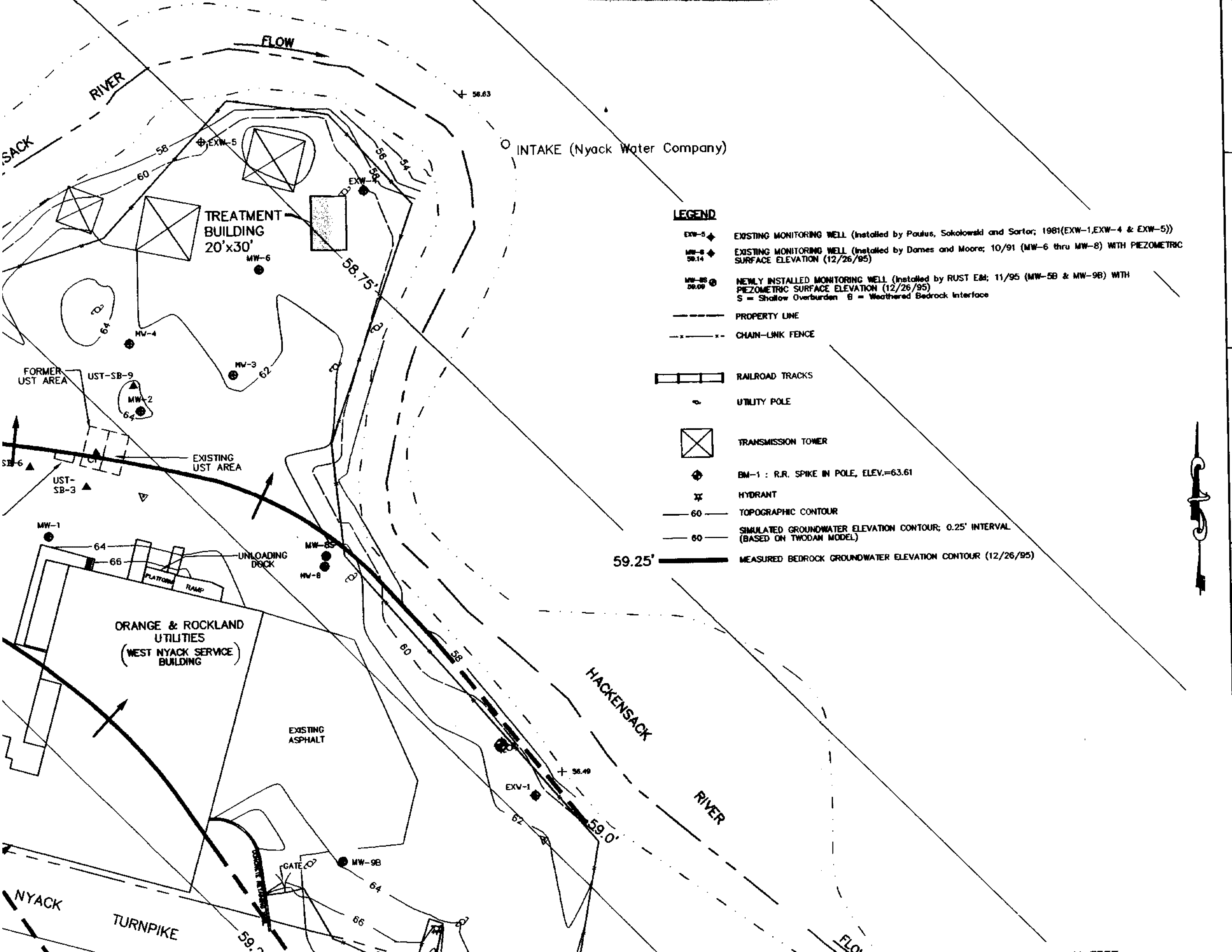
Shallow Bedrock: Figure B-2 shows the simulated heads for uniform flow with a gradient of 0.002, and an "aquifer" hydraulic conductivity (K) of 5 feet per day (ft/day). Comparing these results to Figure 7 of the RI (these contours are shown on Figure B-2), it can be seen that the elevation contours are in approximately the correct locations.

3.0 CAPTURE ZONE ESTIMATIONS

The remedial alternatives were simulated using the model described above. The results of the simulations are characterized by the capture zones of the pumping wells. The capture zones were defined by tracking particle pathlines in the upgradient direction from the pumping wells.

3.1 Overburden

A simulation of 2 wells located at points shown on Figure 2, each pumped at 3 gpm would provide adequate capture of the overburden groundwater VOC plume. Figure 2 shows the simulated groundwater elevation contours and capture zone for pumping at this rate. Likewise, one well pumped at 5 gpm, located at the point shown on Figure B-3 would also provide adequate capture of the overburden VOC plume. The appropriate extraction well system configuration would be further evaluated during design. These results indicate that a groundwater treatment system with a 5 to 10 gpm capacity would be required.


LEGEND
EXW-5 EXISTING MONITORING WELL (Installed by Paulus, Sokolowski and Sartor; 1981(EXW-1,EXW-4 & EXW-5))
MW-8 59.14 EXISTING MONITORING WELL (Installed by Dames and Moore; 10/91 (MW-6 thru MW-8) WITH PIEZOMETRIC SURFACE ELEVATION (12/26/95)
MW-8S 59.09 NEWLY INSTALLED MONITORING WELL (Installed by RUST E&I; 11/95 (MW-5B & MW-9B) WITH PIEZOMETRIC SURFACE ELEVATION (12/26/95)
S = Shallow Overburden B = Weathered Bedrock Interface
PROPERTY LINE
CHAIN-LINK FENCE
RAILROAD TRACKS
UTILITY POLE
TRANSMISSION TOWER
BM-1 : R.R. SPIKE IN POLE, ELEV.=63.61
HYDRANT
60 TOPOGRAPHIC CONTOUR
60 SIMULATED GROUNDWATER ELEVATION CONTOUR; 0.25' INTERVAL (BASED ON TWODAN MODEL)
59.25' MEASURED BEDROCK GROUNDWATER ELEVATION CONTOUR (12/26/95)
INTAKE (Nyack Water Company)
FLOW
HACKENSACK RIVER
TREATMENT BUILDING 20'x30'
58.75'
59.0'
EXW-5
EXW-4
MW-6
MW-4
MW-3
MW-2
MW-1
MW-8S
MW-8
MW-9B
EXV-1
FORMER UST AREA
UST-SB-9
UST-SB-3
EXISTING UST AREA
UNLOADING DOCK
PLATFORM
RAMP
ORANGE & ROCKLAND UTILITIES (WEST NYACK SERVICE BUILDING)
EXISTING ASPHALT
GATE
NYACK TURNPIKE
58.63
56.49

3.2 Bedrock

Due to the low hydraulic gradient in the shallow bedrock "aquifer", very low pumping rates would reverse the gradients and provide capture for the shallow bedrock VOC plume. Figure 3 shows the simulated groundwater elevation contours and capture zone for one well pumped at 1 gpm. It is likely that the upward gradient induced by pumping in the overburden would likely cause a similar capture zone in the shallow bedrock "aquifer", thereby eliminating the need for installing a well directly in the shallow bedrock. Additional evaluation including performance of a pump test would be helpful for evaluating the degree of hydraulic connection which exists between the overburden and shallow bedrock water bearing units.

4.0 CONCLUSIONS AND LIMITATIONS

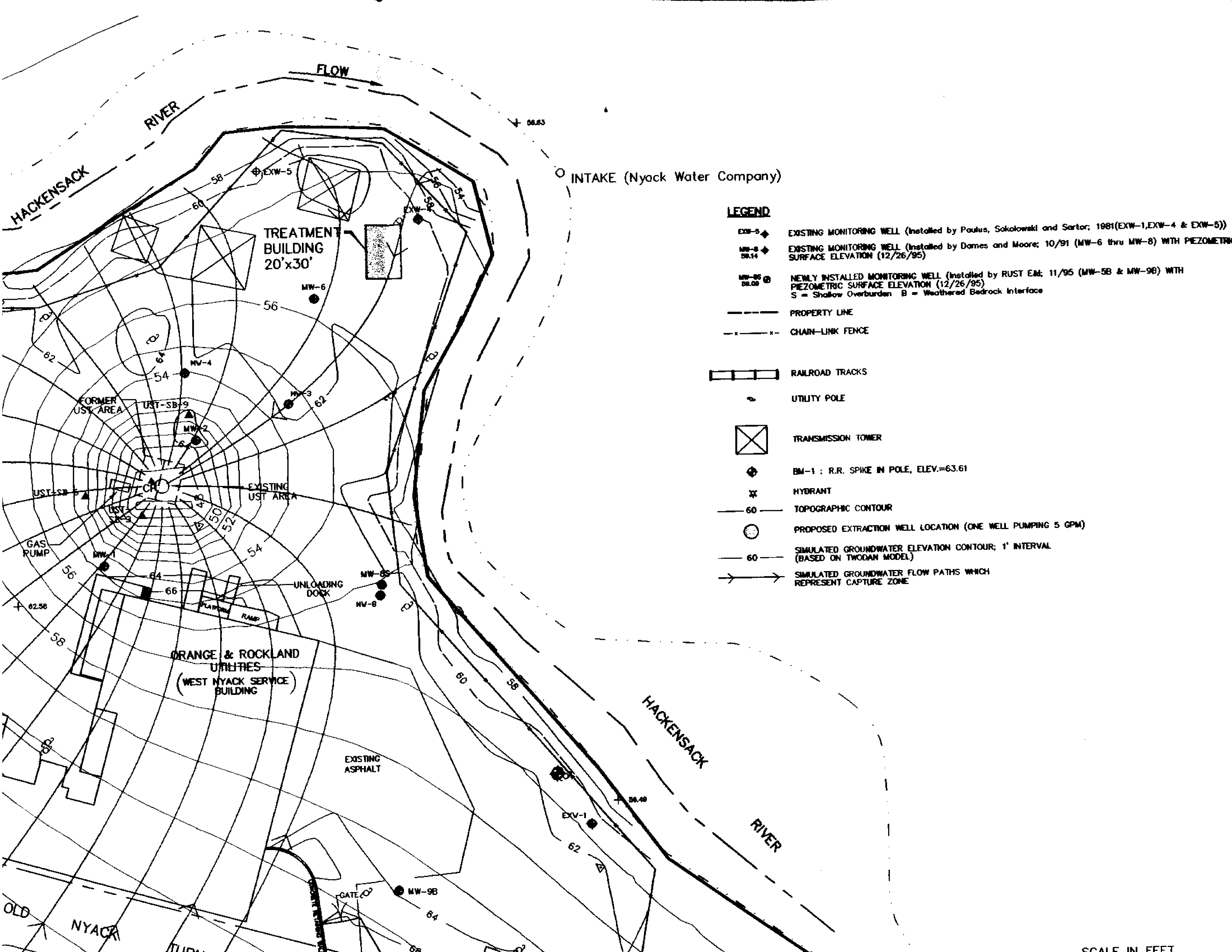
Capture zones have been calculated for overburden and bedrock "aquifers" at the ORU Site. The calculations were based on the following simplifying assumptions:

1. The overburden "aquifer" at the Site is unconfined, homogeneous and isotropic with a hydraulic conductivity of 2 ft/day and areal recharge due to infiltration of 12 in/year.

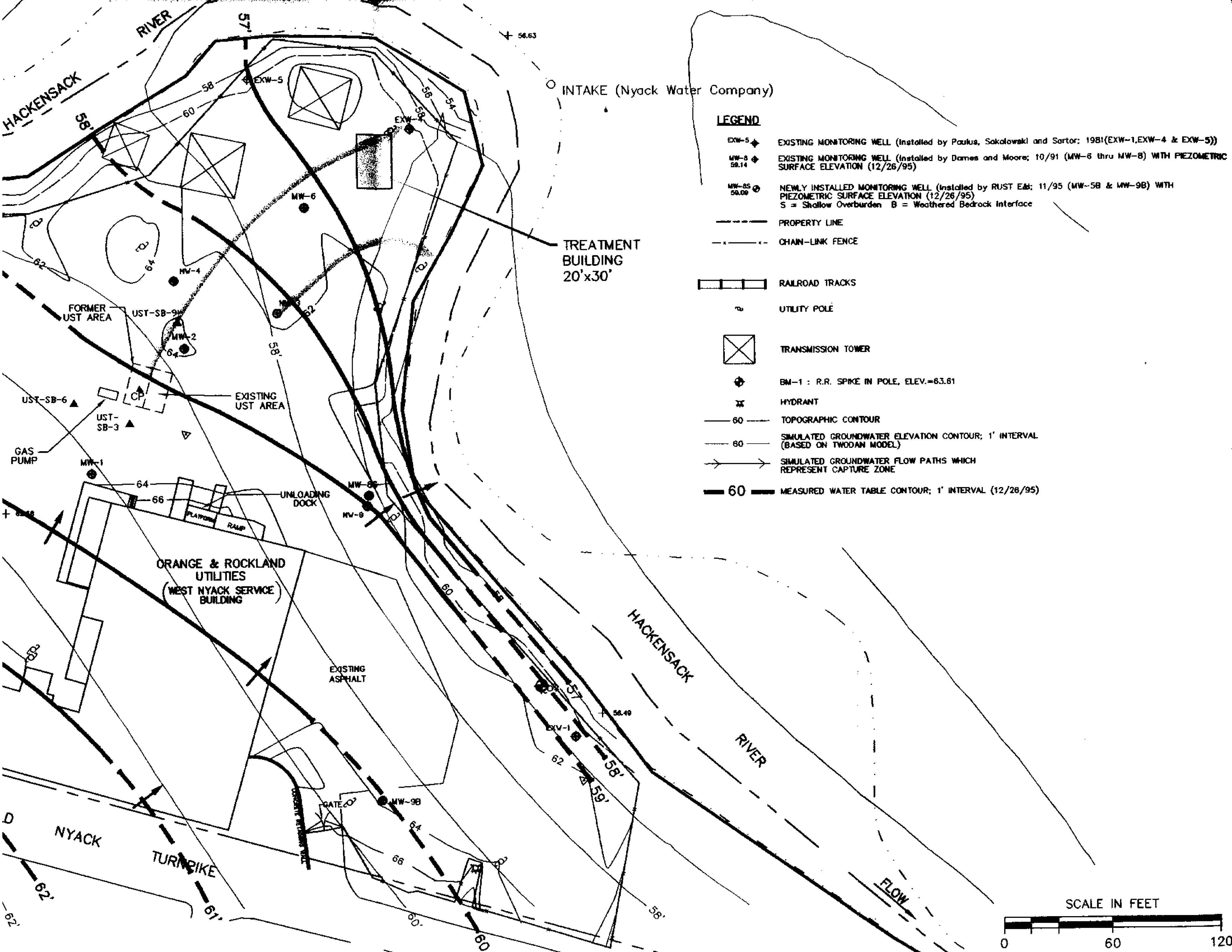
2. The bedrock "aquifer" at the Site is confined, homogeneous and isotropic with a hydraulic conductivity of 5 ft/day.

3. Flow within the "aquifer" is horizontal. The assumption of horizontal flow is implicit for the use of a two-dimensional, areal groundwater model. The result is that no flow in the vertical dimension is modeled. Under aggressive pumping, some vertical component of flow would be induced in the vicinity of the well. Aside from the potential for "aquifer" inhomogeneity, the assumption of horizontal flow is not anticipated to have a significant influence on the predicted well capture zones.

Additional data collection and evaluation may be required in conjunction with the design and implementation of the selected remedial alternative.



FLOW
HACKENSACK RIVER
INTAKE (Nyack Water Company)
TREATMENT BUILDING 20'x30'
EXW-5
EXW-
MW-6
MW-4
MW-3
MW-2
MW-1
MW-8S
MW-8
MW-9B
EXV-1
FORMER UST AREA
UST-SB-9
UST-SB-5
UST SB-3
EXISTING UST AREA
GAS PUMP
UNLOADING DOCK
PLATFORM
RAMP
ORANGE & ROCKLAND UTILITIES (WEST NYACK SERVICE BUILDING)
EXISTING ASPHALT
GATE
OLD NYACK
58.63
62.56
58.49
LEGEND
EXW-5 EXISTING MONITORING WELL (Installed by Paulus, Sokolowski and Sartor; 1981(EXW-1,EXW-4 & EXW-5))
MW-8 58.14 EXISTING MONITORING WELL (Installed by Dames and Moore; 10/91 (MW-6 thru MW-8) WITH PIEZOMETRIC SURFACE ELEVATION (12/26/95)
NEWLY INSTALLED MONITORING WELL (Installed by RUST E&I; 11/95 (MW-5B & MW-9B) WITH PIEZOMETRIC SURFACE ELEVATION (12/26/95)
S = Shallow Overburden B = Weathered Bedrock Interface
PROPERTY LINE
CHAIN-LINK FENCE
RAILROAD TRACKS
UTILITY POLE
TRANSMISSION TOWER
BM-1 : R.R. SPIKE IN POLE, ELEV.=63.61
HYDRANT
60 TOPOGRAPHIC CONTOUR
PROPOSED EXTRACTION WELL LOCATION (ONE WELL PUMPING 5 GPM)
60 SIMULATED GROUNDWATER ELEVATION CONTOUR; 1' INTERVAL (BASED ON TWODAN MODEL)
SIMULATED GROUNDWATER FLOW PATHS WHICH REPRESENT CAPTURE ZONE
SCALE IN FEET


INTAKE (Nyack Water Company)
LEGEND
EXW-5 EXISTING MONITORING WELL (Installed by Paulus, Sokolowski and Sartor; 1981(EXW-1,EXW-4 & EXW-5))
MW-8 59.14 EXISTING MONITORING WELL (Installed by Dames and Moore; 10/91 (MW-6 thru MW-8) WITH PIEZOMETRIC SURFACE ELEVATION (12/26/95)
MW-8S 59.09 NEWLY INSTALLED MONITORING WELL (Installed by RUST E&I; 11/95 (MW-5B & MW-9B) WITH PIEZOMETRIC SURFACE ELEVATION (12/26/95)
S = Shallow Overburden B = Weathered Bedrock Interface
PROPERTY LINE
CHAIN-LINK FENCE
RAILROAD TRACKS
UTILITY POLE
TRANSMISSION TOWER
BM-1 : R.R. SPIKE IN POLE, ELEV.=63.61
HYDRANT
60 TOPOGRAPHIC CONTOUR
60 SIMULATED GROUNDWATER ELEVATION CONTOUR; 1' INTERVAL (BASED ON TWODAN MODEL)
SIMULATED GROUNDWATER FLOW PATHS WHICH REPRESENT CAPTURE ZONE
60 MEASURED WATER TABLE CONTOUR; 1' INTERVAL (12/26/95)
TREATMENT BUILDING 20'x30'
HACKENSACK RIVER
FORMER UST AREA
EXISTING UST AREA
GAS PUMP
UNLOADING DOCK
PLATFORM
RAMP
ORANGE & ROCKLAND UTILITIES (WEST NYACK SERVICE BUILDING)
EXISTING ASPHALT
GATE
NYACK TURNPIKE
FLOW
SCALE IN FEET
0
60
120

APPENDIX C

CUTOFF WALL EVALUATION

Estimate of Seepage into Area Confined by Cutoff Wall

Project: Orange and Rockland Utilities FS
Date: 7/22/96
By: Helen H. Mongillo

Problem: Calculate flow into area confined by cutoff wall resulting from maintenance of an inward gradient.

	Parameter	Symbol	Value	Unit	Converted Value	Unit
Results:	Total flow into contained area (pumping rate required to maintain inward gradient)	Q(total)	157	cfd	1	gal/min
	1. Flow through cap	Q(c)	33	cfd	0.171	gal/min
	3. Flow through cutoff wall	Q(cw)	61.43	cfd	0.319	gal/min
	5. Flow from bedrock through till	Q(bedrock)	63	cfd	0.327	gal/min
Input Parameters:	Area inside cutoff wall	A	55,000	sq ft		
	Precipitation		0.003	ft/day	15	in/year
	Percent Precip. passing cap		0.2			
	Head difference inside cutoff wall	h	2	ft		
	Length of cutoff wall	L(cw)	860	ft		
	Height of cutoff wall above till	H(cw)	25	ft		
	Width of cutoff wall	w(cw)	2	ft		
	Hydraulic conduct. (cutoff wall)	k(cw)	2.86E-03	ft/day	1.00E-06	cm/sec
	Thickness of till	T	5	ft		
	Embedment depth (cw)	s	5	ft		
	Hydraulic conduct. (till)	k(till)	2.86E-03	ft/day	1.00E-06	cm/sec

1. Flow through cap = Q(c)

	Value	Unit	Converted Value	Unit
Q(c) = Percent Precip. * Precip. * Area of Cap =	33	cfd	0.171	gal/min

Modeling the cap leakage using the HELP model or equivalent was not considered warrented for this FS evaluation.

2. Flow through cutoff wall = Q(cw)

	Value	Unit	Converted Value	Unit
Q(cw) = [k(cw)*h*H(cw)]/w(cw) * L(cw)] =	61.43	cfd	0.319	gal/min

3. Flow through low permeability layer (till) from bedrock = Q(bedrock)

	Value	Unit	Converted Value	Unit
Q(bedrock) = [k(till)*h*A]/T =	62.86	cfd	0.327	gal/min

Estimate of Seepage into Area Confined by Cutoff Wall

Project: Orange and Rockland Utilities FS
Date: 7/22/96
By: Helen H. Mongillo

Problem: Calculate flow into area confined by cutoff wall resulting from maintenance of an inward gradient.

SENSiTIVITY ANAYSIS: Boxed Value is Varied

	Parameter	Symbol	Value	Unit	Converted Value	Unit
Results:	Total flow into contained area (pumping rate required to maintain inward gradient)	Q(total)	157	cfd	1	gal/min
	1. Flow through cap	Q(c)	33	cfd	0.171	gal/min
	3. Flow through cutoff wall	Q(cw)	61.43	cfd	0.319	gal/min
	5. Flow from bedrock through till	Q(bedrock)	63	cfd	0.327	gal/min
Input Parameters:	Area inside cutoff wall	A	55,000	sq ft		
	Precipitation		0.003	ft/day	12	in/year
	Percent Precip. passing cap		0.2			
	Head difference inside cutoff wall	h	2	ft		
	Length of cutoff wall	L(cw)	860	ft		
	Height of cutoff wall above till	H(cw)	25	ft		
	Width of cutoff wall	w(cw)	2	ft		
	Hydraulic conduct. (cutoff wall)	k(cw)	2.86E-03	ft/day	1.00E-06	cm/sec
	Thickness of till	T	5	ft		
	Embedment depth (cw)	s	5	ft		
	Hydraulic conduct. (till)	k(till)	2.86E-03	ft/day	1.00E-06	cm/sec

1. Flow through cap = Q(c)

Q(c) = Percent Precip. * Precip. * Area of Cap =	33	cfd	0.171	gal/min

Modeling the cap leakage using the HELP model or equivalent was not considered warrented for this FS evaluation.

2. Flow through cutoff wall = Q(cw)

Q(cw) = [k(cw)*h*H(cw)]/w(cw) * L(cw)] =	61.43	cfd	0.319	gal/min

3. Flow through low permeability layer (till) from bedrock = Q(bedrock)

Q(bedrock) = [k(till)*h*A]/T =	62.86	cfd	0.327	gal/min

Estimate of Seepage into Area Confined by Cutoff Wall

Project: Orange and Rockland Utilities FS
Date: 7/22/96
By: Helen H. Mongillo

Problem: Calculate flow into area confined by cutoff wall resulting from maintenance of an inward gradient.

SENSiTIVITY ANAYSIS: Boxed Value is Varied

	Parameter	Symbol	Value	Unit	Converted Value	Unit
Results:	Total flow into contained area (pumping rate required to maintain inward gradient)	Q(total)	201	cfd	1	gal/min
	1. Flow through cap	Q(c)	77	cfd	0.4	gal/min
	3. Flow through cutoff wall	Q(cw)	61.43	cfd	0.319	gal/min
	5. Flow from bedrock through till	Q(bedrock)	63	cfd	0.327	gal/min
Input Parameters:	Area inside cutoff wall	A	55,000	sq ft		
	Precipitation		0.007	ft/day	30	in/year
	Percent Precip. passing cap		0.2			
	Head difference inside cutoff wall	h	2	ft		
	Length of cutoff wall	L(cw)	860	ft		
	Height of cutoff wall above till	H(cw)	25	ft		
	Width of cutoff wall	w(cw)	2	ft		
	Hydraulic conduct. (cutoff wall)	k(cw)	2.86E-03	ft/day	1.00E-06	cm/sec
	Thickness of till	T	5	ft		
	Embedment depth (cw)	s	5	ft		
	Hydraulic conduct. (till)	k(till)	2.86E-03	ft/day	1.00E-06	cm/sec

1. Flow through cap = Q(c)

Q(c) = Percent Precip. * Precip. * Area of Cap =	77	cfd	0.4	gal/min

Modeling the cap leakage using the HELP model or equivalent was not considered warrented for this FS evaluation.

2. Flow through cutoff wall = Q(cw)

Q(cw) = [k(cw)*h*H(cw)]/w(cw) * L(cw)] =	61.43	cfd	0.319	gal/min

3. Flow through low permeability layer (till) from bedrock = Q(bedrock)

Q(bedrock) = [k(till)*h*A]/T =	62.86	cfd	0.327	gal/min

Estimate of Seepage into Area Confined by Cutoff Wall

Project: Orange and Rockland Utilities FS
Date: 7/22/96
By: Helen H. Mongillo

Problem: Calculate flow into area confined by cutoff wall resulting from maintenance of an inward gradient.

SENSITIVITY ANAYSIS: Boxed Value is Varied

	Parameter	Symbol	Value	Unit	Converted Value	Unit
Results:	Total flow into contained area (pumping rate required to maintain inward gradient)	Q(total)	141	cfd	1	gal/min
	1. Flow through cap	Q(c)	16.5	cfd	0.086	gal/min
	3. Flow through cutoff wall	Q(cw)	61.43	cfd	0.319	gal/min
	5. Flow from bedrock through till	Q(bedrock)	63	cfd	0.327	gal/min
Input Parameters:	Area inside cutoff wall	A	55,000	sq ft		
	Precipitation		0.003	ft/day	15	in/year
	Percent Precip. passing cap		0.1			
	Head difference inside cutoff wall	h	2	ft		
	Length of cutoff wall	L(cw)	860	ft		
	Height of cutoff wall above till	H(cw)	25	ft		
	Width of cutoff wall	w(cw)	2	ft		
	Hydraulic conduct. (cutoff wall)	k(cw)	2.86E-03	ft/day	1.00E-06	cm/sec
	Thickness of till	T	5	ft		
	Embedment depth (cw)	s	5	ft		
	Hydraulic conduct. (till)	k(till)	2.86E-03	ft/day	1.00E-06	cm/sec

1. Flow through cap = Q(c)

Q(c) = Percent Precip. * Precip. * Area of Cap =	16.5	cfd	0.086	gal/min

Modeling the cap leakage using the HELP model or equivalent was not considered warrented for this FS evaluation.

2. Flow through cutoff wall = Q(cw)

Q(cw) = [k(cw)*h*H(cw)]/w(cw) * L(cw)] =	61.43	cfd	0.319	gal/min

3. Flow through low permeability layer (till) from bedrock = Q(bedrock)

Q(bedrock) = [k(till)*h*A]/T =	62.86	cfd	0.327	gal/min

Estimate of Seepage into Area Confined by Cutoff Wall

Project: Orange and Rockland Utilities FS
Date: 7/22/96
By: Helen H. Mongillo

Problem: Calculate flow into area confined by cutoff wall resulting from maintenance of an inward gradient.

SENSiTIVITY ANAYSIS: Boxed Value is Varied

	Parameter	Symbol	Value	Unit	Converted Value	Unit
Results:	Total flow into contained area (pumping rate required to maintain inward gradient)	Q(total)	207	cfd	1	gal/min
	1. Flow through cap	Q(c)	82.5	cfd	0.429	gal/min
	3. Flow through cutoff wall	Q(cw)	61.43	cfd	0.319	gal/min
	5. Flow from bedrock through till	Q(bedrock)	63	cfd	0.327	gal/min
Input Parameters:	Area inside cutoff wall	A	55,000	sq ft		
	Precipitation		0.003	ft/day	15	in/year
	Percent Precip. passing cap		0.5			
	Head difference inside cutoff wall	h	2	ft		
	Length of cutoff wall	L(cw)	860	ft		
	Height of cutoff wall above till	H(cw)	25	ft		
	Width of cutoff wall	w(cw)	2	ft		
	Hydraulic conduct. (cutoff wall)	k(cw)	2.86E-03	ft/day	1.00E-06	cm/sec
	Thickness of till	T	5	ft		
	Embedment depth (cw)	s	5	ft		
	Hydraulic conduct. (till)	k(till)	2.86E-03	ft/day	1.00E-06	cm/sec

1. Flow through cap = Q(c)

Q(c) = Percent Precip. * Precip. * Area of Cap =	82.5	cfd	0.429	gal/min

Modeling the cap leakage using the HELP model or equivalent was not considered warrented for this FS evaluation.

2. Flow through cutoff wall = Q(cw)

Q(cw) = [k(cw)*h*H(cw)]/w(cw) * L(cw)] =	61.43	cfd	0.319	gal/min

3. Flow through low permeability layer (till) from bedrock = Q(bedrock)

Q(bedrock) = [k(till)*h*A]/T =	62.86	cfd	0.327	gal/min

Estimate of Seepage into Area Confined by Cutoff Wall

Project: Orange and Rockland Utilities FS
Date: 7/22/96
By: Helen H. Mongillo

Problem: Calculate flow into area confined by cutoff wall resulting from maintenance of an inward gradient.

SENSiTIVITY ANAYSIS: Boxed Value is Varied

	Parameter	Symbol	Value	Unit	Converted Value	Unit
Results:	Total flow into contained area (pumping rate required to maintain inward gradient)	Q(total)	282	cfd	1	gal/min
	1. Flow through cap	Q(c)	33	cfd	0.171	gal/min
	3. Flow through cutoff wall	Q(cw)	122.86	cfd	0.638	gal/min
	5. Flow from bedrock through till	Q(bedrock)	126	cfd	0.653	gal/min
Input Parameters:	Area inside cutoff wall	A	55,000	sq ft		
	Precipitation		0.003	ft/day	15	in/year
	Percent Precip. passing cap		0.2			
	Head difference inside cutoff wall	h	4	ft		
	Length of cutoff wall	L(cw)	860	ft		
	Height of cutoff wall above till	H(cw)	25	ft		
	Width of cutoff wall	w(cw)	2	ft		
	Hydraulic conduct. (cutoff wall)	k(cw)	2.86E-03	ft/day	1.00E-06	cm/sec
	Thickness of till	T	5	ft		
	Embedment depth (cw)	s	5	ft		
	Hydraulic conduct. (till)	k(till)	2.86E-03	ft/day	1.00E-06	cm/sec

1. Flow through cap = Q(c)

	Value	Unit	Converted Value	Unit
Q(c) = Percent Precip. * Precip. * Area of Cap =	33	cfd	0.171	gal/min

Modeling the cap leakage using the HELP model or equivalent was not considered warrented for this FS evaluation.

2. Flow through cutoff wall = Q(cw)

	Value	Unit	Converted Value	Unit
Q(cw) = [k(cw)*h*H(cw)]/w(cw) * L(cw)] =	122.86	cfd	0.638	gal/min

3. Flow through low permeability layer (till) from bedrock = Q(bedrock)

	Value	Unit	Converted Value	Unit
Q(bedrock) = [k(till)*h*A]/T =	125.71	cfd	0.653	gal/min

Estimate of Seepage into Area Confined by Cutoff Wall

Project: Orange and Rockland Utilities FS
Date: 7/22/96
By: Helen H. Mongillo

Problem: Calculate flow into area confined by cutoff wall resulting from maintenance of an inward gradient.

SENSITIVITY ANAYSIS: Boxed Value is Varied

	Parameter	Symbol	Value	Unit	Converted Value	Unit
Results:	Total flow into contained area (pumping rate required to maintain inward gradient)	Q(total)	219	cfd	1	gal/min
	1. Flow through cap	Q(c)	33	cfd	0.171	gal/min
	3. Flow through cutoff wall	Q(cw)	122.86	cfd	0.638	gal/min
	5. Flow from bedrock through till	Q(bedrock)	63	cfd	0.327	gal/min
Input Parameters:	Area inside cutoff wall	A	55,000	sq ft		
	Precipitation		0.003	ft/day	15	in/year
	Percent Precip. passing cap		0.2			
	Head difference inside cutoff wall	h	2	ft		
	Length of cutoff wall	L(cw)	860	ft		
	Height of cutoff wall above till	H(cw)	25	ft		
	Width of cutoff wall	w(cw)	1	ft		
	Hydraulic conduct. (cutoff wall)	k(cw)	2.86E-03	ft/day	1.00E-06	cm/sec
	Thickness of till	T	5	ft		
	Embedment depth (cw)	s	5	ft		
	Hydraulic conduct. (till)	k(till)	2.86E-03	ft/day	1.00E-06	cm/sec

1. Flow through cap = Q(c)

Q(c) = Percent Precip. * Precip. * Area of Cap =	33	cfd	0.171	gal/min

Modeling the cap leakage using the HELP model or equivalent was not considered warrented for this FS evaluation.

2. Flow through cutoff wall = Q(cw)

Q(cw) = [k(cw)*h*H(cw)]/w(cw) * L(cw)] =	122.86	cfd	0.638	gal/min

3. Flow through low permeability layer (till) from bedrock = Q(bedrock)

Q(bedrock) = [k(till)*h*A]/T =	62.86	cfd	0.327	gal/min

Estimate of Seepage into Area Confined by Cutoff Wall

Project:	Orange and Rockland Utilities FS
Date:	7/22/96
By:	Helen H. Mongillo

Problem: Calculate flow into area confined by cutoff wall resulting from maintenance of an inward gradient.

SENSiTIVITY ANAYSIS: Boxed Value is Varied

	Parameter	Symbol	Value	Unit	Converted Value	Unit
Results:	Total flow into contained area (pumping rate required to maintain inward gradient)	Q(total)	710	cfd	4	gal/min
	1. Flow through cap	Q(c)	33	cfd	0.171	gal/min
	3. Flow through cutoff wall	Q(cw)	614.29	cfd	3.191	gal/min
	5. Flow from bedrock through till	Q(bedrock)	63	cfd	0.327	gal/min
Input Parameters:	Area inside cutoff wall	A	55,000	sq ft		
	Precipitation		0.003	ft/day	15	in/year
	Percent Precip. passing cap		0.2			
	Head difference inside cutoff wall	h	2	ft		
	Length of cutoff wall	L(cw)	860	ft		
	Height of cutoff wall above till	H(cw)	25	ft		
	Width of cutoff wall	w(cw)	2	ft		
	Hydraulic conduct. (cutoff wall)	k(cw)	2.86E-02	ft/day	1.00E-05	cm/sec
	Thickness of till	T	5	ft		
	Embedment depth (cw)	s	5	ft		
	Hydraulic conduct. (till)	k(till)	2.86E-03	ft/day	1.00E-06	cm/sec

1. Flow through cap = Q(c)

Q(c) = Percent Precip. * Precip. * Area of Cap =	33	cfd	0.171	gal/min

Modeling the cap leakage using the HELP model or equivalent was not considered warrented for this FS evaluation.

2. Flow through cutoff wall = Q(cw)

Q(cw) = [k(cw)*h*H(cw)]/w(cw) * L(cw)] =	614.29	cfd	3.191	gal/min

3. Flow through low permeability layer (till) from bedrock = Q(bedrock)

Q(bedrock) = [k(till)*h*A]/T =	62.86	cfd	0.327	gal/min

Estimate of Seepage into Area Confined by Cutoff Wall

Project: Orange and Rockland Utilities FS
Date: 7/22/96
By: Helen H. Mongillo

Problem: Calculate flow into area confined by cutoff wall resulting from maintenance of an inward gradient.

SENSiTIVITY ANAYSIS: Boxed Value is Varied

	Parameter	Symbol	Value	Unit	Converted Value	Unit
Results:	Total flow into contained area (pumping rate required to maintain inward gradient)	Q(total)	102	cfd	1	gal/min
	1. Flow through cap	Q(c)	33	cfd	0.171	gal/min
	3. Flow through cutoff wall	Q(cw)	6.14	cfd	0.032	gal/min
	5. Flow from bedrock through till	Q(bedrock)	63	cfd	0.327	gal/min
Input Parameters:	Area inside cutoff wall	A	55,000	sq ft		
	Precipitation		0.003	ft/day	15	in/year
	Percent Precip. passing cap		0.2			
	Head difference inside cutoff wall	h	2	ft		
	Length of cutoff wall	L(cw)	860	ft		
	Height of cutoff wall above till	H(cw)	25	ft		
	Width of cutoff wall	w(cw)	2	ft		
	Hydraulic conduct. (cutoff wall)	k(cw)	2.86E-04	ft/day	1.00E-07	cm/sec
	Thickness of till	T	5	ft		
	Embedment depth (cw)	s	5	ft		
	Hydraulic conduct. (till)	k(till)	2.86E-03	ft/day	1.00E-06	cm/sec

1. Flow through cap = Q(c)

Q(c) = Percent Precip. * Precip. * Area of Cap =	33	cfd	0.171	gal/min

Modeling the cap leakage using the HELP model or equivalent was not considered warrented for this FS evaluation.

2. Flow through cutoff wall = Q(cw)

Q(cw) = [k(cw)*h*H(cw)]/w(cw) * L(cw)] =	6.14	cfd	0.032	gal/min

3. Flow through low permeability layer (till) from bedrock = Q(bedrock)

Q(bedrock) = [k(till)*h*A]/T =	62.86	cfd	0.327	gal/min

Estimate of Seepage into Area Confined by Cutoff Wall

Project: Orange and Rockland Utilities FS
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Problem: Calculate flow into area confined by cutoff wall resulting from maintenance of an inward gradient.

SENSiTIVITY ANAYSIS: Boxed Value is Varied

	Parameter	Symbol	Value	Unit	Converted Value	Unit
Results:	Total flow into contained area (pumping rate required to maintain inward gradient)	Q(total)	115	cfd	1	gal/min
	1. Flow through cap	Q(c)	33	cfd	0.171	gal/min
	3. Flow through cutoff wall	Q(cw)	61.43	cfd	0.319	gal/min
	5. Flow from bedrock through till	Q(bedrock)	21	cfd	0.109	gal/min
Input Parameters:	Area inside cutoff wall	A	55,000	sq ft		
	Precipitation		0.003	ft/day	15	in/year
	Percent Precip. passing cap		0.2			
	Head difference inside cutoff wall	h	2	ft		
	Length of cutoff wall	L(cw)	860	ft		
	Height of cutoff wall above till	H(cw)	25	ft		
	Width of cutoff wall	w(cw)	2	ft		
	Hydraulic conduct. (cutoff wall)	k(cw)	2.86E-03	ft/day	1.00E-06	cm/sec
	Thickness of till	T	15	ft		
	Embedment depth (cw)	s	5	ft		
	Hydraulic conduct. (till)	k(till)	2.86E-03	ft/day	1.00E-06	cm/sec

1. Flow through cap = Q(c)

Q(c) = Percent Precip. * Precip. * Area of Cap =	33	cfd	0.171	gal/min

Modeling the cap leakage using the HELP model or equivalent was not considered warrented for this FS evaluation.

2. Flow through cutoff wall = Q(cw)

Q(cw) = [k(cw)*h*H(cw)]/w(cw) * L(cw)] =	61.43	cfd	0.319	gal/min

3. Flow through low permeability layer (till) from bedrock = Q(bedrock)

Q(bedrock) = [k(till)*h*A]/T =	20.95	cfd	0.109	gal/min

Estimate of Seepage into Area Confined by Cutoff Wall

Project: Orange and Rockland Utilities FS
Date: 7/22/96
By: Helen H. Mongillo

Problem: Calculate flow into area confined by cutoff wall resulting from maintenance of an inward gradient.

SENSiTIVITY ANAYSIS: Boxed Value is Varied

	Parameter	Symbol	Value	Unit	Converted Value	Unit
Results:	Total flow into contained area (pumping rate required to maintain inward gradient)	Q(total)	723	cfd	4	gal/min
	1. Flow through cap	Q(c)	33	cfd	0.171	gal/min
	3. Flow through cutoff wall	Q(cw)	61.43	cfd	0.319	gal/min
	5. Flow from bedrock through till	Q(bedrock)	629	cfd	3.265	gal/min
Input Parameters:	Area inside cutoff wall	A	55,000	sq ft		
	Precipitation		0.003	ft/day	15	in/year
	Percent Precip. passing cap		0.2			
	Head difference inside cutoff wall	h	2	ft		
	Length of cutoff wall	L(cw)	860	ft		
	Height of cutoff wall above till	H(cw)	25	ft		
	Width of cutoff wall	w(cw)	2	ft		
	Hydraulic conduct. (cutoff wall)	k(cw)	2.86E-03	ft/day	1.00E-06	cm/sec
	Thickness of till	T	5	ft		
	Embedment depth (cw)	s	5	ft		
	Hydraulic conduct. (till)	k(till)	2.86E-02	ft/day	1.00E-05	cm/sec

1. Flow through cap = Q(c)

Q(c) = Percent Precip. * Precip. * Area of Cap =	33	cfd	0.171	gal/min

Modeling the cap leakage using the HELP model or equivalent was not considered warrented for this FS evaluation.

2. Flow through cutoff wall = Q(cw)

Q(cw) = [k(cw)*h*H(cw)]/w(cw) * L(cw)] =	61.43	cfd	0.319	gal/min

3. Flow through low permeability layer (till) from bedrock = Q(bedrock)

Q(bedrock) = [k(till)*h*A]/T =	628.57	cfd	3.265	gal/min

Estimate of Seepage into Area Confined by Cutoff Wall

Project: Orange and Rockland Utilities FS
Date: 7/22/96
By: Helen H. Mongillo

Problem: Calculate flow into area confined by cutoff wall resulting from maintenance of an inward gradient.

SENSiTIVITY ANAYSIS: Boxed Value is Varied

	Parameter	Symbol	Value	Unit	Converted Value	Unit
Results:	Total flow into contained area (pumping rate required to maintain inward gradient)	Q(total)	101	cfd	1	gal/min
	1. Flow through cap	Q(c)	33	cfd	0.171	gal/min
	3. Flow through cutoff wall	Q(cw)	61.43	cfd	0.319	gal/min
	5. Flow from bedrock through till	Q(bedrock)	6	cfd	0.033	gal/min
Input Parameters:	Area inside cutoff wall	A	55,000	sq ft		
	Precipitation		0.003	ft/day	15	in/year
	Percent Precip. passing cap		0.2			
	Head difference inside cutoff wall	h	2	ft		
	Length of cutoff wall	L(cw)	860	ft		
	Height of cutoff wall above till	H(cw)	25	ft		
	Width of cutoff wall	w(cw)	2	ft		
	Hydraulic conduct. (cutoff wall)	k(cw)	2.86E-03	ft/day	1.00E-06	cm/sec
	Thickness of till	T	5	ft		
	Embedment depth (cw)	s	5	ft		
	Hydraulic conduct. (till)	k(till)	2.86E-04	ft/day	1.00E-07	cm/sec

1. Flow through cap = Q(c)

Q(c) = Percent Precip. * Precip. * Area of Cap =	33	cfd	0.171	gal/min

Modeling the cap leakage using the HELP model or equivalent was not considered warrented for this FS evaluation.

2. Flow through cutoff wall = Q(cw)

Q(cw) = [k(cw)*h*H(cw)]/w(cw) * L(cw)] =	61.43	cfd	0.319	gal/min

3. Flow through low permeability layer (till) from bedrock = Q(bedrock)

Q(bedrock) = [k(till)*h*A]/T =	6.29	cfd	0.033	gal/min

APPENDIX D

December 1996

Hackensack River Surface Water Sediment Analytical Data

RUST Rust Environment & Infrastructure Inc.

Rust Environment & Infrastructure, P.E., ARCH & L.S., P.C.
12 Metro Park Road
Albany, NY 12205

Phone 518.458.1313
Fax 518.458.2472

January 27, 1997

Ms. Maribeth McCormick
Sr. Environmental Scientist
Orange & Rockland Utilities, Inc.
One Blue Hill Plaza
Pearl River, New York 10965

RE: Hackensack River, Water/Sediment Volatile Organic Data

Dear Ms. McCormick:

This letter presents the volatile organic analytical results for the surface water and sediment samples collected by Rust Environment & Infrastructure from the Hackensack River on December 19, 1996. Four surface water and four sediment samples were collected from the Hackensack River, one upstream of the Orange & Rockland Utilities (ORU) West Nyack facility and three adjacent to/downstream of the facility. Samples were submitted to Nytest Environmental for volatile organic analysis by USEPA SW-846 Method 8021 with NYSDEC Category B deliverables.

Sample SW-1/SED-1 was collected upstream of the site on the downstream side of the railroad bridge, sample SW-2/SED-2 was collected on the southwest side of the river across from the Nyack Water Company intake, SW-3/SED3 was collected on the south side of the river, halfway between monitoring wells MW-3 and MW-8, and sample SW-4/SED-4 was collected downstream of the site just above the dam. Approximate sampling locations are depicted on the enclosed site map.

The surface water analytical results revealed that no volatile organic compounds were detected in any of the surface water samples. Data indicate that at the time of sample collection, the site had not impacted Hackensack River surface water quality.

Sediment analytical data indicated that with the exception of sample SED-4, no site related compounds were detected in any of the sediment samples collected adjacent to or downstream of the site. The methylene chloride reported in the sediment samples and the acetone reported in sample SED-2 are considered laboratory derived and not site related. Methylene chloride and acetone are common laboratory contaminants; methylene chloride and acetone were detected in laboratory blanks associated with this data package. Sample results were less than ten times the blank values and consistent with USEPA data validation guidelines, the reported sample concentrations are considered laboratory derived.

Three site related compounds, cis-1,2-dichloroethene, 1,1,1-trichloroethane and trichloroethene, were detected in the SED-4 sediment sample. The SED-4 trichloroethene concentration (140 ug/kg) was elevated with respect to the NYSDEC human health bioaccumulation sediment criteria (60 ug/kg assuming 3% organic matter). However, trichloroethene was not detected in the SED-2 and SED-3 samples and therefore the data indicate that trichloroethene is not a significant concern in the Hackensack River sediments in the vicinity of the site. The 1,1,1-trichloroethane and cis-1,1-dichloroethene SED-4 sediment concentrations were low and are not indicative of significant sediment volatile organic contamination. This is supported by the SED-2 and SED-3 samples in which no site related volatile organic compounds were detected. \

Tetrachloroethene was detected in both the upstream SED-1 sample and SED-4 at relatively equal concentrations. Tetrachloroethene has not been identified as a site related compound and the detection of this sample in the upstream sample indicates the reported SED-4 tetrachloroethene concentration is not site related.

In summary, the Hackensack River surface water and sediment data indicate that the site has not had a significant impact on surface water or sediment quality with respect to volatile organics. If you have any questions or comments please contact me at (518) 437-8310.

Sincerely,

Edward Fahrenkopf
Senior Environmental Scientist

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TABLE 1
Summary of Hackensack River
Surface Water/Sediment Volatile Organic Data
12/1/96

PARAMETER	SW-1 ug/L	SW-2 ug/L	SW-3 ug/L	SW-4 ug/L	SED-1 ug/Kg	SED-2 ug/Kg	SED-3 ug/Kg	SED-4 ug/Kg
Methylene Chloride	ND	ND	ND	ND	19	14	8	7
Toluene	ND	ND	ND	ND	2	ND	ND	ND
cis-1,2-Dichloroethene	ND	ND	ND	ND	ND	ND	ND	21
Acetone	ND	ND	ND	ND	ND	31	ND	ND
Trichloroethene	ND	ND	ND	ND	ND	ND	ND	140
Tetrachlorethene	ND	ND	ND	ND	2	ND	ND	7
Xylene	ND	ND	ND	ND	2	ND	ND	ND
1,2,4 - Trimethylbenzene	ND	ND	ND	ND	2	ND	ND	ND
1,1,1-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	2
1,2,4-Trichlorobenzene	ND	ND	ND	ND	9	ND	ND	ND

ND indicates not detected at or above the laboratory reporting limit