EA Engineering, Science, and Technology

3468 Mt. Diablo Boulevard
Suite B-100
Lafayette, CA 94549
Telephone: 510-283-7077
Fax: 510-283-3894

ENVIRONMENTAL PROTECTION
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26 September 1996

Ms. Jennifer Eberle
Alameda County Health Agency
Department of Environmental Protection
1131 Harbor Bay Parkway, 2nd Floor
Alameda, California 94502

RE: Selection of a product recovery system for the Nestle USA Former Carnation Dairy Site, Oakland, California

Dear Jennifer:

Nestle has been investigating different methods of recovering non-aqueous phase liquid (NAPL) at their site in Oakland. The methods that have been investigated are:

- Passive skimming
- Vacuum-enhanced passive skimming
- Dual-phase pumping
- Multi-phase extraction

Binayak and I have met with Rob Hinchee and Dave McWhorter. Rob Hinchee is an industry expert who has guided the U.S. Air Force's bioslurping pilot program (also known as multi-phase extraction). Dave McWhorter is a geology professor at Colorado State University. Dave has also worked on the Air Force bioslurping project, providing theoretical interpretation of the data collected. Both Dave and Rob have reviewed the geology and pilot testing information for the Oakland site, and recommend the use of multi-phase extraction for this site.

Enclosed is a copy of a cost/benefit analysis comparing each of the four NAPL recovery technologies. We would like to go over this information with you and get your perspective on this project some time next week. Binayak or I will contact you to arrange a time for a conference call.

If you have any questions regarding the enclosed material or wish to discuss any other matters, please contact Binayak or me.

Sincerely,

Doug Oram
Project Manager

DEO/dah 60966.01.926LTR.1
Enclosure
cc: Binayak Acharya, Nestle USA

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Suite B-100
Lafayette, CA 94549
Telephone: 510-283-7077
Fax: 510-283-3894

Binayak Acharya
Senior Environmental Engineer
Nestle USA, Inc.
800 North Brand Blvd.
Glendale, CA 91203

17 September 1996

RE: Cost comparison of NAPL recovery technologies for Nestle's Oakland site

Dear Binayak:

Please find enclosed a comparison of NAPL recovery technologies. The four technologies that have been evaluated are:

- Passive skimming
- Vacuum-enhanced passive skimming
- Dual-phase pumping
- Multi-phase extraction

For each of these recovery methods a brief description is given and the relative advantages and disadvantages are listed along with the costs and an implementation schedule. A summary of the equipment costs, total costs including one year of O&M, and implementation time is listed below.

Recovery Method	Equipment Cost	Total Cost	Implementation Time
Passive Skimming (manual)	$8,200	$20,800	2-3 wks
Passive Skimming (pneumatic)	$13,500	$24,500	4-5 wks
Vacuum-Enhanced Skimming	$38,000	$62,500	11-17 wks
Dual-Phase Extraction	$35,500	$70,500	11-17 wks
Multi-Phase Extraction	$49,000	$85,000	11-17 wks

The costs are based on quotes received within the last week. These costs are rough, meaning that they are not entirely complete, but are good enough to compare relative costs. The costs have been broken down into categories of design/permitting, equipment, installation/procurement, and O&M for one year. A spreadsheet containing equipment costs has also been enclosed. The cost

of the pneumatic skimmers has been estimated based on past projects. An estimate for this equipment is forthcoming.

This should be enough to start making a decision on which recovery method to use at the Oakland site. I will contact you on Wednesday to discuss the information further.

Sincerely.

Doug Oram
Project Manager

Attachments

Comparison of NAPL Recovery Technologies

The four most common technologies used to recover NAPL are:

- Passive skimming
- Vacuum-enhanced passive skimming
- Dual-phase pumping
- Multi-phase extraction

The advantages, disadvantages, estimated costs, and implementation schedule for each of the four NAPL recovery methods are described below.

Passive Skimming

Passive skimming can be accomplished by one of two ways: using manually emptied skimmers as is currently being used at the site, or using a pneumatic system that pumps the recovered product to drums at the surface. Figure 1 is a diagram showing the configuration of a pneumatic recovery system.

Advantages

- Low cost
- Easily installed
- No permitting needed
- Off-the-shelf systems are available for both manual and pneumatic systems

Disadvantages

- Only recovers NAPL that will enter a well on its own
- Slowest method of NAPL recovery
- Manual skimmers require frequent maintenance
- Technology most dependent on environmental conditions, such as water level
- Most systems require a minimum of 6 ft of water in wells for equipment installation (this is a problem for some of the wells at the Oakland site)
- Limited equipment is available for installation in 2-inch wells

Cost

The cost for both manual and pneumatic recovery systems is shown in the table below. The cost for the manual system is based on:

- Installation of skimmers in 10 wells
- Weekly O&M visits

The cost for the pneumatic system is based on:

- Installation of skimmers in 5 wells
- All piping is installed above ground
- O&M visits every other week

Phase	Cost (manual)	Cost (pneumatic)
Design/Permitting	$0	$1,500
Equipment	$8,200	$13,500
Installation/Procurement	$600	$4,500
O&M per year	$12,000	$5,000
Total	$20,800	$24,500

Implementation Schedule

Phase	Duration (wk, manual)	Duration (wk, pneumatic)
Design	0	1
Permitting	0	0
Installation/Procurement	2-3	3-4
Start-up	1 day	2 days
Total	2-3	4-5

Vacuum-Enhanced Passive Skimming

This method of recovery uses continuous or intermittent vacuum applied to a well containing a pneumatic passive skimmer to encourage NAPL to enter the well. Figure 2 shows the configuration of a system to apply constant vacuum to the recovery wells. Based on the low vapor concentrations measured during the pilot test, vapor-phase carbon has been costed as the

method of vapor abatement.

According to Dave McWhorter, the increase in the oil recovery rate attributable to vacuum is likely marginal. Vacuum enhancement extends the thickness of the oil-flow zone beyond that achieved by conventional skimming. The extended area not affected by conventional skimming is that area of the vadose zone above the oil table. The largest fraction of oil occurs below the oil table. Gradients driving oil below the oil table are identical in vacuum enhanced and conventional skimming.

Advantages

- Low cost
- Easily installed - all vacuum piping can be installed above ground

Disadvantages

- Only enhances recovery of NAPL that is exposed to a vacuum in the vadose zone
- Mounding of water created by applying a vacuum to the recovery well may hamper transport of NAPL
- A minimum depth of water in the well is still required for installation of the skimmers
- An air discharge permit for the vacuum extraction system is required

Cost

The cost for a vacuum-enhanced passive skimming system is shown in the table below. This cost is based on:

- Operating 5 wells at a time using pneumatic pumps
- All piping is installed above ground
- O&M visits every other week
- Vapor monitoring with an OVA only - no subcontracted analytical costs (this is standard operating procedure for the local Air Quality Board for vapor-phase carbon)

Phase	Cost
Design/Permitting	$8,000
Equipment	$38,000
Installation/Procurement	$10,500
O&M per year	$6,000
Total	$62,500

Implementation Schedule

Phase	Duration (wk)
Design	2
Permitting	4-8
Installation/Procurement	4-6
Start-up	1
Total	11-17

Dual-Phase Pumping

Dual-phase pumping removes both groundwater and NAPL from a recovery well. Pumping water from the recovery well creates an artificial gradient toward the well. This gradient increases the flow of NAPL to the well above the water level within the cone of influence. Figure 3 shows a typical configuration of a dual-phase recovery system.

Advantages

- Greater recovery can likely be achieved relative to passive skimming alone
- Off-the-shelf systems are available

Disadvantages

- Additional larger-diameter wells would be required to use dual-phase pumps
- Greater cost associated with having to treat extracted water
- A permit will be required for the discharge of groundwater
- No flow of NAPL to the recovery well is induced above the oil table
- Lowering the groundwater level can expose as yet unimpacted soils to free-phase hydrocarbons

Cost

The cost for a dual-phase recovery system is shown in the table below. This cost is based on:

- Operating 5 wells at a time using electric or pneumatic pumps
- All piping is installed above ground
- Water treatment is done using activated carbon (no air stripping)

- O&M visits every other week
- All water analyses associated with monitoring the groundwater treatment system are performed by Nestle's analytical laboratory

Phase	Cost
Design/Permitting	$12,000
Equipment	$35,500
Installation/Procurement	$17,000
O&M per year	$6,000
Total	$70,500

Implementation Schedule

Phase	Duration (wk)
Design	2
Permitting	4-8
Installation/Procurement	4-6
Start-up	1
Total	11-17

Multi-Phase Extraction

Multi-phase extraction is done by removing the three fluid phases (air, oil, and water) present in the vadose zone. This is done using a liquid-ring pump which can pump all fluid phases connected to wells containing dip-tubes. The dip-tubes in the wells are adjustable during operation to maximize NAPL recovery and minimize water recovery. Figure 4 shows a typical configuration of a multi-phase recovery system. Based on the low vapor concentrations measured during the pilot test, vapor-phase carbon has been costed as the method of abatement.

According to Dave McWhorter, the major attribute of multi-phase extraction is the creation of a much larger gradient in the zone below the oil table. This can be expected to result in significantly greater oil recovery rates as compared to vacuum enhanced skimming.

larger than what?

Advantages

- Best method to recover L-NAPL
- All components are available off the shelf
- Design and installation is comparable to VES and dual-phase systems
- All existing 2-inch wells can be used - no new wells would be required
- Will complete NAPL recovery the fastest of all technologies
- Less groundwater is extracted and treated than with a dual-phase system
- Can recover NAPL from more wells with little added expense

Disadvantages

- Most costly system due to having to treat air and water waste streams (carbon can likely be used to abate the air because of the lack of volatile hydrocarbons in the vadose zone)
- Emulsions can cause oil/water separation problems

Cost

The cost for a multi-phase recovery system is shown in the table below. This cost is based on:

- Operating 30 wells more wells
- All piping is installed above ground
- O&M visits every other week
- Vapor monitoring with an OVA only - no subcontracted analytical costs (this is standard operating procedure for the local Air Quality Board for vapor-phase carbon)
- All water analyses associated with monitoring the groundwater treatment system are performed by Nestle's analytical laboratory

Phase	Cost
Design/Permitting	$12,000
Equipment	$49,000
Installation/Procurement	$17,000
O&M per year	$7,000
Total	$85,000

Implementation Schedule

Phase	Duration (wk)
Design	2
Permitting	4-8
Installation/Procurement	4-6
Start-up	1
Total	11-17

→ to start up

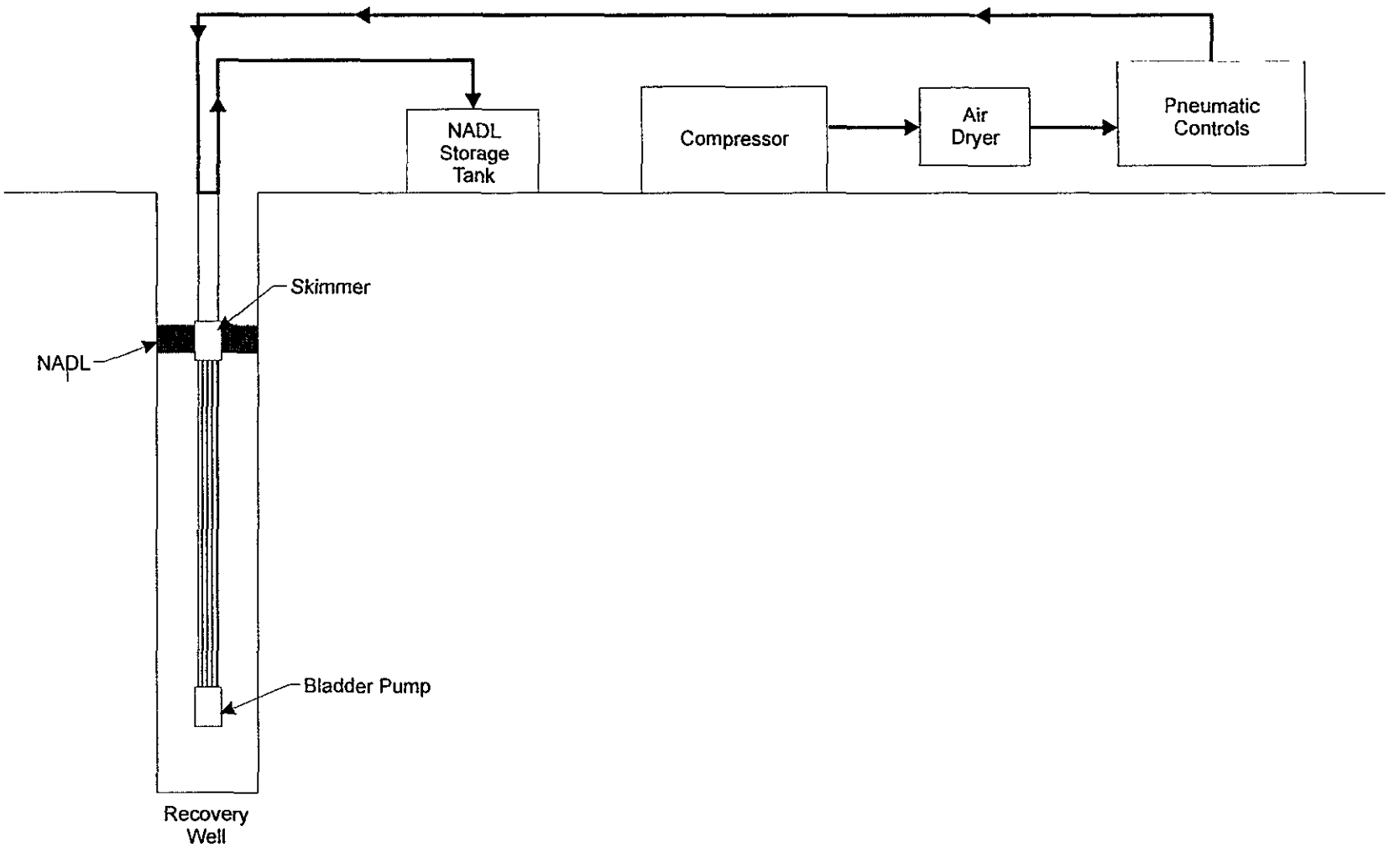

Figure 1. Process flow diagram, pneumatic passive skimming.

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Reviewed		Date	
Rev		Date	
Final		Date	

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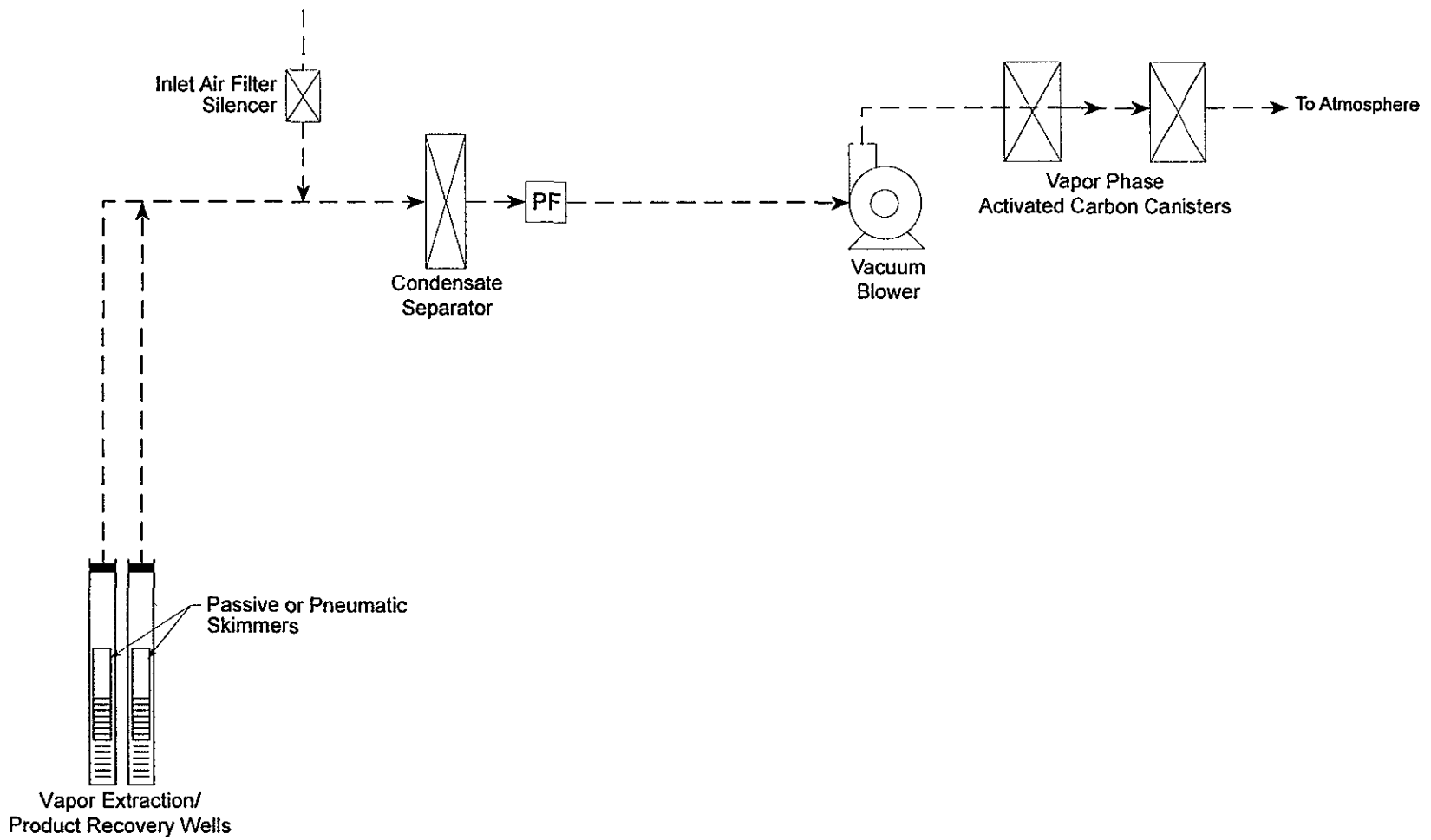

Figure 2. Process flow diagram, Vacuum-Enhanced Passive Skimming.

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Reviewed		Date	
Rev		Date	
Final		Date	

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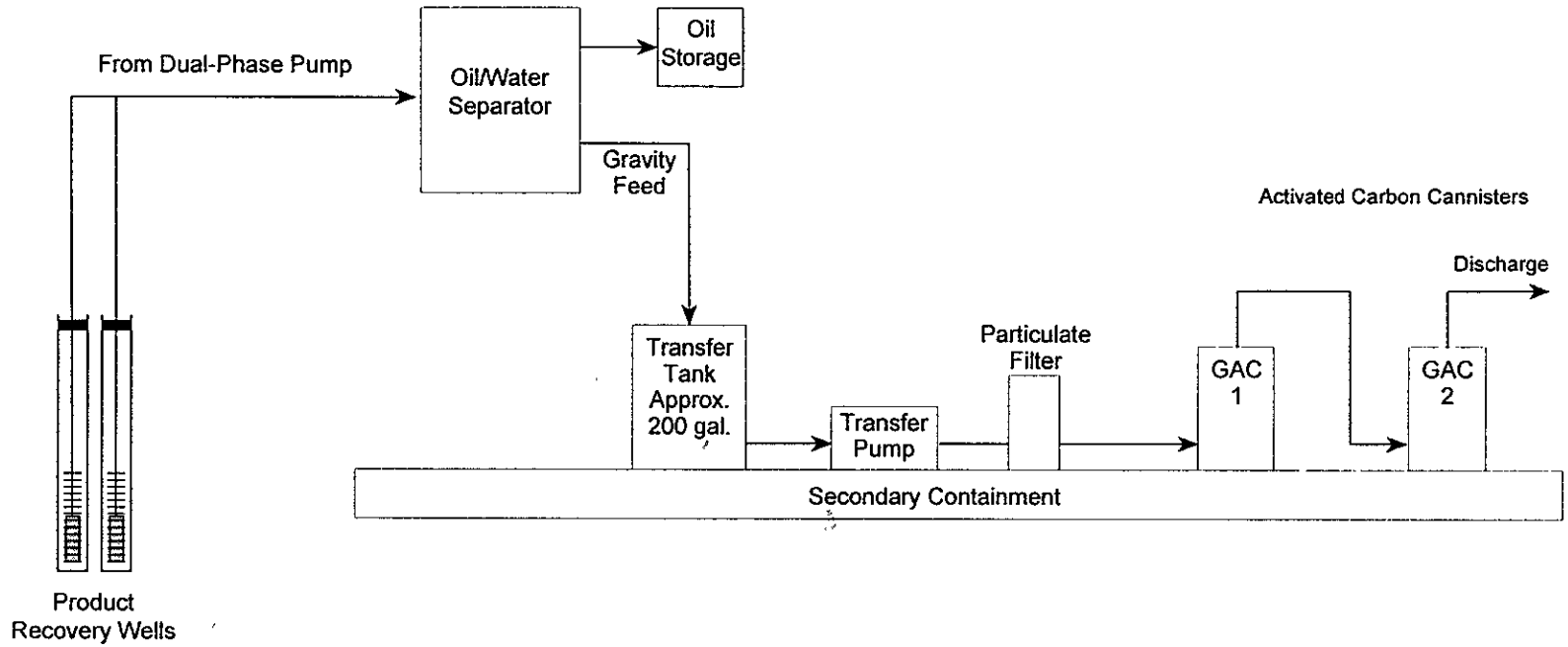

Figure 3. Dual-phase pumping process flow diagram.

Drawn	ELA	Date	9/16/96
Reviewed		Date	
Rev		Date	
Final		Date	

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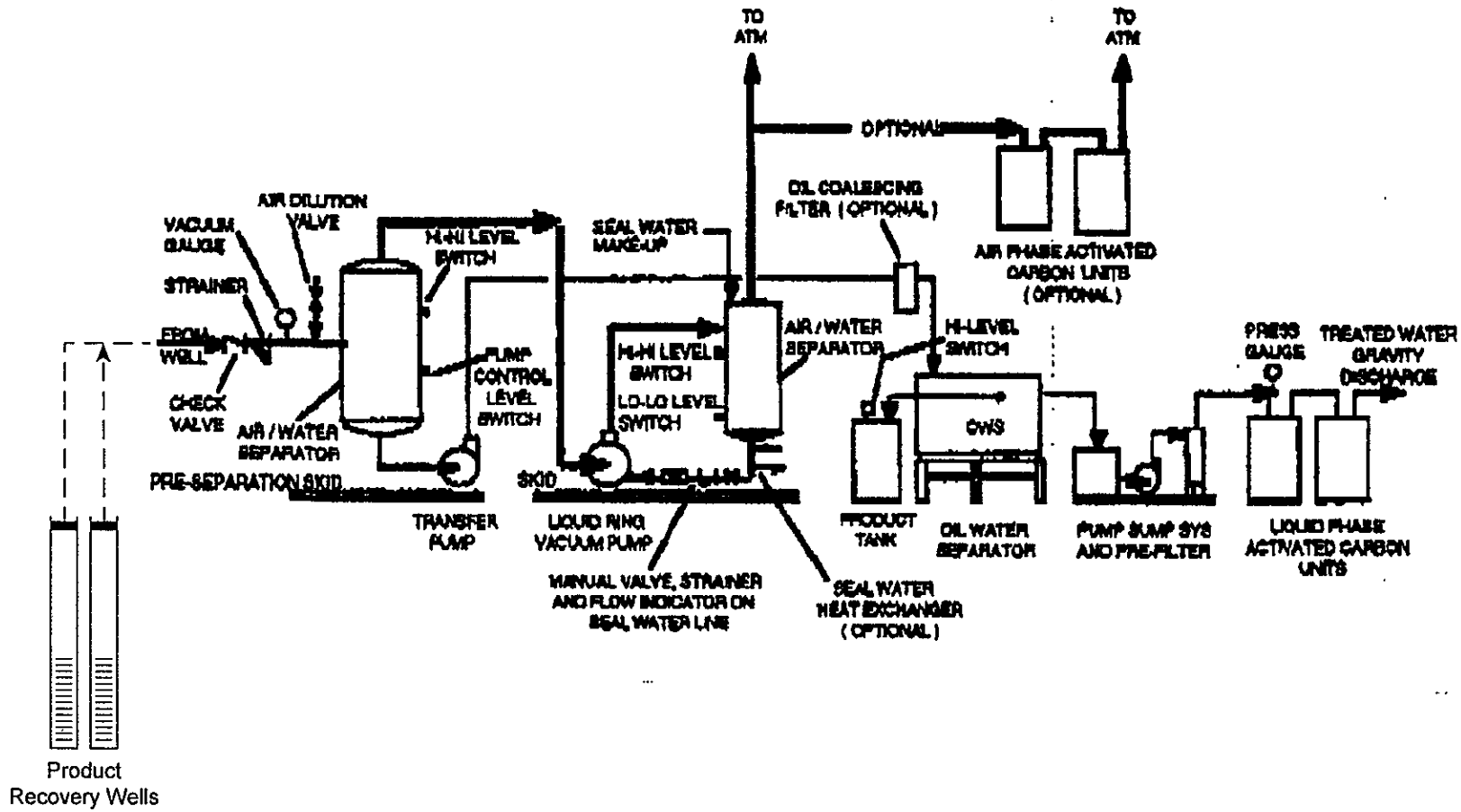

Figure 4. Multi-phase extraction process flow diagram.

Drawn	ELA	Date	9/16/96
Reviewed		Date	
Rev		Date	
Final		Date	

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EQUIPMENT COSTS

Nestles
NAPL Treatment System

Equipment	Description	Quantity	Cost	Total Cost	Manufacturer	Vendor	Contact
Remediation Option #1A - Passive Skimmers (manual)							
Passive skimmers	2" 3 Liter Passive Bailer	10	$800.00	$8,000.00	Keck Instruments	Envirosupply	Scott Beckley, 800-201-8150 ext 108
Product Storage Tank	with secondary containment	1	$200.00	$200.00			
Total				$8,200.00			
Remediation Option #1B - Passive Skimmers (pneumatic)							
Pneumatic Skimmers*		5	$1,600.00	$8,000.00			
Air compressor		1	$1,500.00	$1,500.00			
Air dryer		1	$300.00	$300.00			
Process Equipment				$0.00			
PVC Piping		1	$700.00	$700.00			
Hose		1	$1,500.00	$1,500.00			
Miscellaneous		1	$1,500.00	$1,500.00			
Total				$13,500.00			
Remediation Option #2 - Passive Skimmers with Soil Vapor Extraction							
Skimmers*	2" 3 Liter Passive Bailer	10	$800.00	$8,000.00	Keck Instruments	Envirosupply	Scott Beckley, 800-201-8150 ext 108
Vapor Extraction skid	Including: 100 cfm, 16"Hg Blower, knockout pot, & Controls, skid mounted	1	$17,135.00	$17,135.00	Cetco Industrial	Same	Donald Doucet, 318-527-0084
Vapor Phase Carbon	1000 lbs, pressure vessels	2	$4,175.00	$8,350.00	Cetco Aquatec	Same	Fran Avery 800-527-9948
Process Equipment							
PVC Piping		1	$1,000.00	$1,000.00			
Hose		1	$100.00	$100.00			
Valving		1	$600.00	$600.00			
Product Storage Tank	with secondary containment	1	$200.00	$200.00			
Miscellaneous		1	$2,000.00	$2,000.00			
Total				$37,385.00			
Remediation Option #3 - Dual phase Groundwater Extraction							
Dual phase pumps	Total fluids, pneumatic pumps	5	$1,575.00	$7,875.00	Boart Longyear	Same	Bill Henry, 510-606-9299

EQUIPMENT COSTS

	2" top and bottom loading						
Treatment Skid	Including :Oil/Water Separator, Transfer tank *Transfer pump, filtration* Control Panel	1	$18,550.00	$18,550.00	Cetco Industrial	Same	Donald Doucet, 318-527-0084
Liquid Phase carbon	200 lbs, 55-gal canisters	2	$490.00	$980.00	Cetco Aquatec	Same	Fran Avery 800-527-9948
Air compressor		1	$1,500.00	$1,500.00			
Process Equipment				$0.00			
PVC Piping		1	$700.00	$700.00			
Hose		1	$1,500.00	$1,500.00			
Valving		1	$200.00	$200.00			
Secondary Containment	Complete system coverage	1	$2,000.00	$2,000.00			
Miscellaneous		1	$2,000.00	$2,000.00			
Total				$35,305.00			

Remediation Option #4 - Multipy phase extraction with liquid ring pump

Treatment Skid	Including: Liquid Ring Pump *2 - air/water separators* Oil/Water separator Transfer Tank, Transfer pump, filtration, controls	1	$31,779.00	$31,779.00	NEPCCO	Same	C.J. Sanders 800-277-3279
Liquid Phase Carbon	200 lbs, 55-gal canisters	2	$490.00	$980.00	Cetco Aquatec	Same	Fran Avery 800-527-9948
Vapor Phase Carbon	1000 lbs pressure vessels	2	$4,175.00	$8,350.00	Cetco Aquatec	Same	Fran Avery 800-527-9948
Process Equipment				$0.00			
PVC Piping		1	$1,000.00	$1,000.00			
Hose		1	$1,500.00	$1,500.00			
Valving		1	$600.00	$600.00			
Secondary Containment	Complete system coverage	1	$2,000.00	$2,000.00			
Miscellaneous		1	$2,500.00	$2,500.00			
Total				$48,709.00			

Note * = Guess based on past projects. Quote is forthcoming.