Water Pollution Control Laboratory
Conceptual Report

PREPARED FOR

Portland, Oregon
Bureau of Environmental Services

PREPARED BY

CH2M HILL

SERA Architects, P.C.

September 1992

Engineers
Planners
Economists
Scientists

Portland Office

September 28, 1992

PDX27865.80

Mr. Thomas E. Bottenberg, P.E.
Principal Engineer
City of Portland
Bureau of Environmental Services
1120 S.W. 5th Avenue, 5th Floor
Portland, OR, 97204-1972

Dear Mr. Bottenberg:

Subject: Water Pollution Control Laboratory Conceptual Report

We are pleased to submit the final report on the concepts for a new laboratory that would assist the Bureau of Environmental Services (BES) in responding to emerging environmental regulations requiring significant increases in testing. The report summarizes our findings and presents our recommendations.

On behalf of the Project Manager, Mike Soderquist, Project Architect, Don Eggleston and myself, we wish to express our sincere appreciation to the BES staff, especially yourself and Jim Cooke, for their valuable assistance in preparing and reviewing this report. We look forward to continuing our professional relationship with BES. If our project team can be of further assistance or answer any questions, please feel free to contact Mike Soderquist.

Sincerely,

CH2M HILL

Earl A. Hadfield II
Senior Laboratory Consultant

eah/pdxbes2.ltr
Attachment

Serving Oregon and Southwest Washington from two locations:

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- 2.84 acre site, if one story in height
- Construction cost: $7,912,245
- Probable project without land cost: $13,680,618
- Probable project plus land cost: $14,639,453
- Annual outside laboratory cost savings: $1,857,625

These land acquisition and building office space figures represent a proposed growth factor over the next 5 years, as described in this report.

A preliminary cost estimate for co-location of the proposed WPC laboratory with the BES offices is shown in Table 11, page 6-2. However, based on this report, there are some significant factors that could not be fully detailed relative to the co-location of the WPC Laboratory with the overall office needs of the Bureau. In addition to this limited conceptual study effort, an actual, full-scale, programming effort would need to be done in order to determine in greater depth the factors that would favor or not favor co-location and its attendant needs for a larger site and/or existing building. Further programming would need to determine applicable requirements for co-location in a renovated building as defined by the City of Portland, Bureau of Buildings.

Section 1

Summary

Purpose and Scope

CH2M HILL was contracted by the Portland Bureau of Environmental Services (BES) to conduct a conceptual study for a new Water Pollution Control (WPC) Laboratory. The new laboratory would help BES respond to emerging environmental regulations requiring significantly increased testing. The study was to determine the following:

- Cost justification of potential tests by comparison of in-house costs with contract costs for outside laboratories in 1992 dollars
- Space, equipment, and staff necessary to perform the tests
- Laboratory support functions (offices, rest rooms, mechanical room, etc.)
- Laboratory facility size after combining non-analytical departments: Hydra Computer, Industrial Pretreatment, Spill Response and Emergency Management, and Environmental Investigation and Sampling
- Laboratory site size and site criteria for a new building and/or a renovated building
- Cost estimate in 1992 dollars

The first two items above were completed in draft form in late 1991 and are included in Appendix B. Subsequently, SERA Architects, P.C. was retained by CH2M HILL through its contract with BES to provide a conceptual report to help address the remaining items. At that time, BES staff informed the consultants that the Bureau would have to move out of its present location to a new site. Thus, the concept of co-locating the WPC Laboratory and the BES offices became incorporated into the study. BES staff agreed that co-location issues would only be addressed in a broad sense because detailing needs of the BES offices was beyond the scope-of-work for this study.

Conclusions and Recommendations

Based upon this report, the WPC Laboratory would include departments for Administration, Hydra Computer, Industrial Pretreatment, Spill Response and Emergency Management, Environmental Investigation and Sampling. The fully developed WPC Laboratory would initially have these "1992 order-of-magnitude" estimated features:

- 53,707 square feet

Section 2

Program Detail

The following tables detail individual department needs as communicated to us by BES staff. The tables delineate staff and support functions and our assignment of appropriate square footage.

Table 2 DEPARTMENT: Hydra Computer					
Staff	**Type**	**1992**	**1997**	**Unit SF**	**Total SF**
Supervisor	Workstation	1	1	100	100
Staff	Workstation	4	7	80	560
Total Staff		5	8		660
Support Function					
Computer Room			1	160	160
Electronics Work Area			1	288	288
Storage			1	360	360
Total Support Function					808
Total Staff and Support Function					
Subtotal Space Requirements					1,468
Intra-Departmental Circulation at 35%					514
Total Space Requirements					1,982

Comments:
1. Access to loading area.
2. 6-inch high raised access floor for computer room.
3. Electronics work area to accommodate counters and open area for sawing.
4. Storage area could be in a shared storage room.

Table 1 DEPARTMENT: Management and Common Use Areas					
Staff	**Type**	**1992**	**1997**	**Unit SF**	**Total SF**
Manager	Office	1	1	120	120
Administrative Assistant	Workstation	1	2	100	200
Secretary	Workstation	1	1	80	80
Receptionist		0	1	80	80
Total Staff		3	5		480
Intra-Departmental Circulation at 35%					168
Subtotal Space Requirements					648
Support Function					
Display			1	900	900
Conference Room for 2-4			2	80	160
Conference Room for 6			2	120	240
Conference Room for 12			2	290	580
Conference Room for 50			1	600	600
Library			1	250	250
Lunch Room for 30			1	450	450
Staff Interaction Area			2	125	250
Office Supply			1	100	100
Mail Room			1	100	100
Copy Room			1	80	80
Copy Room			1	120	120
Coats			3	40	120
Women's Locker Room			1	275	275
Men's Locker Room			1	275	275
Women's Toilet Room			2	275	550
Men's Toilet Room			2	275	550
Total Support Function					5,600
Total Staff and Support Function					
Total Space Requirements					6,248
Comments: None					

Table 4 DEPARTMENT: Spill Response and Emergency Management					
Staff	**Type**	**1992**	**1997**	**Unit SF**	**Total SF**
Supervisor	Workstation	0	1	100	100
Staff	Workstation	3	5	80	400
Total Staff		3	6		500
Support Function					
Files			4	7.5	30
Microfiche Reader			1	25	25
Total Support Function					55
Total Staff and Support Function					
Subtotal Space Requirements					555
Intra-Departmental Circulation at 35%					194
Total Space Requirements					749
Comments: 1. Access to loading area.					

Table 3
DEPARTMENT: Industrial Pretreatment

Staff	Type	1992	1997	Unit SF	Total SF
Manager	Office	1	1	120	120
Supervisor	Workstation	2	4	100	400
Permit Manager	Workstation	8	12	80	960
Tech 1	Workstation	2	3	80	240
Total Staff		13	20		1,720
Support Function					
Microfiche Reader			1	25	25
Conference/Plan Room			1	120	120
Resource Room			1	220	220
Copy/Supply/Printers			1	96	96
Total Support Function					461
Total Staff and Support Function					
Subtotal Space Requirements					2,181
Intra-Departmental Circulation at 35%					763
Total Space Requirements					2,944

Comments:
1. Conference room also to be used for plan layout.
2. Resource room to locked. Location for 8 files, 4 bookcases, and 2 plan racks.

Table 6 DEPARTMENT: Analytical Laboratory					
Staff	**Type**	**1992**	**1997**	**Unit SF**	**Total SF**
Manager	Office	1	1	120	120
Supervisor	Workstation	1	5	100	500
Analysts	Workstation	5	36	40	1,440
Total Staff		7	42		2,060
Intra-Departmental Circulation at 35%					721
Subtotal Space Requirements					2,781
Support Function					
Lab Area: Biology			1	392	392
Toxicity/Bioassay			1	1,176	1,176
Microbiology			1	784	784
Physical Tests			1	196	196
Solids Tests			1	392	392
Inorganics I			1	196	196
Inorganics II			1	196	196
Nutrients			1	588	588
Metals			1	980	980
Organic Aggregates			1	784	784
Organics I			1	980	980
Organics II			1	1,568	1,568
Miscellaneous Tests			1	392	392
R&D			1	784	784
Data Processing			1	100	100
Record Storage			1	100	100
Laboratory Storage			1	500	500
Gas Cylinder Storage			2	50	100
Reagent Water System			1	50	50
Subtotal Support Function					10,258
Intra-Departmental Circulation at 15%					1,539
Subtotal Space Requirements					11,797
Total Staff and Support Function					
Total Space Requirements					14,578
Comments: 1. See Appendix B.					

Table 5
DEPARTMENT: Environmental Investigation and Sampling

Staff	Type	1992	1997	Unit SF	Total SF
Environmental Investigation Supervisor	Workstation	0	1	100	100
Environmental Investigation Staff	Workstation	2	4	80	320
Sampler Supervisor	Workstation	0	2	80	160
Sampler Staff	Workstation	0	8	40	320
Total Staff		2	15		900
Support Function					
Microfiche Reader			1	25	25
Sample Area: Covered Vehicle Bay			2	350	700
Boat Storage			2	350	700
Mud Room			1	120	120
Shop			1	200	200
Sample Receiving/Preparation			1	780	780
Sample Container Storage			1	100	100
Sample Equipment Storage			1	225	225
Sample Archiving:	Drying Room 12 X 12		1	144	144
	Dry Storage 15 X 15		1	225	225
	Cold Storage 10 X 12		1	120	120
Total Support Function					3,339
Total Staff and Support Function					
Subtotal Space Requirements					4,239
Intra-Departmental Circulation at 35%					1,484
Total Space Requirements					5,723

Comments:
1. Sampler workstations to be a desk with overhead book shelves.
2. Covered vehicle bay for two vehicles with garage door access.
3. Boat storage for two 19-foot boats to be covered and secure.
4. Mudroom to have washer and dryer and to be located adjacent to loading.
5. Shop to have provisions for sampler repair and equipment maintenance.
6. Sample receiving to provide for log-in, refrigeration, and scheduling, and sampler preparation.
8. Sample archiving: Drying room to have 3 oven dryers with sink and cabinet; cold storage to have two 30 cubic foot freezers and two 20 cubic foot refrigerators.

multiple story construction results in the following floor areas:

- 1-story facility — 60,000 SF
- 2-story facility — 30,000 SF
- 3-story facility — 20,000 SF

Section 3

Program Summary

WPC Laboratory Summary

Table 7 WPC Laboratory Summary (Not Co-Located)	
Laboratory Department	**Area SF**
Management and Common Use	6,248
Hydra Computer	1,982
Industrial Pretreatment	2,944
Spill Response and Emergency Management	749
Environmental Investigation and Sampling	5,723
Subtotal	17,646
Analytical Laboratory	14,578
Subtotal	32,224
[1]Efficiency Factor: 60%	21,483
Total Area	53,707
[1]See discussion in Appendix A.	

According to BES's Randy Tomsik, the Bureau is planning for a 20 percent growth in 5 years. It is appropriate that the WPC Laboratory plan envision a building that would accommodate an equal growth factor. A 20 percent expansion is included in the figures above in Table 7. Breaking the WPC Laboratory area down by single or multiple story construction results in the following site coverages:

- 1-story facility — 53,707 SF
- 2-story facility — 26,854 SF
- 3-story facility — 17,902 SF

Bureau Environmental Services Office Building

According to the Bureau's Randy Tomsik, the current 5-year plan calls for a 60,000 square foot BES office facility. Presenting the BES office building area by single or

WPC Laboratory and BES Offices Site Sizing (Co-Location)

The site sizing criteria for the co-located WPC Laboratory and the BES offices are shown in Table 9.

Table 9
Site Sizing Criteria for WPC Laboratory and BES Offices (Co-Located)

Element	1-Story, SF	2-Story, SF	3-Story, SF
Office Building Coverage	60,000	30,000	20,000
Laboratory Building Coverage	53,707	26,854	17,902
Subtotal Building Coverage	113,707	56,854	37,902
[1]BES Lab Vehicle Spaces: 20	7,000	7,000	7,000
[1]BES Office Vehicle Spaces: 90	31,500	31,500	31,500
[2]Code Required Lab Vehicle Spaces: 134	46,900	46,900	46,900
[2]Code Required Office Vehicle Spaces: 150	52,500	52,500	52,500
Subtotal Parking	137,900	137,900	137,900
Subtotal Building and Parking	251,607	194,754	175,802
Landscape Area at 15%	37,741	29,213	26,370
Total Area, SF	289,348	223,967	202,172
Total Area, Acres	6.65	5.15	4.65

Notes:
[1]BES vehicle parking at 350 SF per vehicle.
[2]Based on maximum building coverage at 350 SF per vehicle; zoning requires one space per 400 SF of gross building area. A variance may be possible, reducing the required number of parking spaces.

Site Requirements

Site Sizes

As calculated and shown in Tables 8 and 9, the site could range in size as presented below:

- WPC Laboratory only
  - 1.90 to 2.84 acres, or
  - 82,572 to 123,748 SF

Section 4

Site Criteria — New Building

Site Sizing Criteria

WPC Laboratory Site Sizing

The site sizing criteria for the WPC Laboratory are shown in Table 8.

Table 8
Site Sizing Criteria for WPC Laboratory (Not Co-Located)

Element	1-Story, SF	2-Story, SF	3-Story, SF
Building Coverage	53,707	26,854	17,902
[1]BES Lab Vehicle Spaces: 20	7,000	7,000	7,000
[2]Code Required Lab Vehicle Spaces: 134	46,900	46,900	46,900
Subtotal	107,607	80,754	71,802
Landscape Area at 15%	16,141	12,113	10,770
Total Area, SF	123,748	92,867	82,572
Total Area, Acres	2.84	2.13	1.90

Notes:
[1]BES vehicle parking at 350 SF per vehicle.
[2]Based on maximum building coverage at 350 SF per vehicle; zoning requires one space per 400 SF of gross building area. A variance may be possible, reducing the required number of parking spaces.

Based on the estimated 1992 square footage costs, the site costs would range as follows:

- WPC Laboratory only (82,572 to 123,748 SF)
  $330,288 to $494,992 or $660,576 to $989,984

- WPC Laboratory and BES Office Co-located (202,172 to 289,348 SF)
  $808,688 to $1,157,392 or $1,617,376 to $2,314,784

Other Site Requirements

Whether co-located or not, the new building housing the WPC Laboratory will require the following:

- ***Sewer*** — Preliminary information indicates that sewer facilities capable of handling an office would be adequate. This assumes that any acid waste from the laboratory would be neutralized prior to being discharged to the sewer system.

- ***Communications*** — US West phone systems with lease line capability would be preferred. According to BES staff, microwave transmission capability would not be a necessary site requirement.

- ***Water Supply*** — At least a 6-inch main line would be required for fire sprinkler and other building use needs.

- ***Utilidor*** — If a basement utility tunnel system is desired, there may be site requirements relative to the water table or soil conditions. A utilidor would not be an absolute necessity.

- ***Natural Gas*** — If available, natural gas would be preferred as a building heating source and optionally for laboratory bunsen burners and/or hot plates.

- ***Hazardous Material*** — To protect laboratory samples from contamination and BES from appearing as a polluter, the site should be free from pre-existing hazardous materials left by previous owners or others. For laboratory requirements, initial inquiries indicate that neither an explosion proof room nor a separate building with 80-foot clearance is required for potentially hazardous (flammable or explosive) materials or chemicals.

- ***Site Accessibility*** — Site access must be ample and planned to accommodate deliveries of samples and supplies, boat usage, potential tours by bussed school children, etc. This would include adequate maneuvering space along with secured storage.

- WPC Laboratory and BES Office Co-located

  - 4.65 to 6.65 acres, or
  - 202,172 to 289,348 SF

Zoning Constraints

As long as the predominant use of the new building is office, it would probably be characterized as an office building with a laboratory, rather than as a laboratory building. The nature and limited quantities of potentially hazardous materials to be used in the laboratory should rule out its classification as a Group H Occupancy according to the Uniform Building Code; instead, it should be classified as a Group B, Division 2 Occupancy with provisions for only a one-hour fire-resistive occupancy separation rather than the more restrictive requirements for Group H Occupancy. Group B, Division 2 Occupancy would be an allowable use in the following zones:

- Commercial Zone — CO2 and CG; Commercial Office Zone #2 and Commercial General. The Commercial General Zone would offer more flexibility for the zoning requirements.

- Employment and Industrial Zone — Probably the best zone to be in with the least restrictions. But while the office is an allowed use in an Employment Zone, it is a Conditional Use in an Industrial Zone.

- Any zoning considered should not abut a residential zone because that probably would require compliance with Chapter 33.262 (Special Conditions next to a residential zone) which would probably require Special Conditions to be met. The leading condition is odor.

- Significant quantities of hazardous materials, if present, would be a problem in any of these zones, not only from a Conditional Use perspective but also in consideration of the additional site area needed for a separate building required for storage of the hazardous materials.

Classification as a Group B, Division 2 Occupancy would significantly relax the zoning limitations.

Site Costs

Site costs within the close-in north/northeast or northwest areas of Portland for Commercial, Employment, and Industrial zoned land are on the order of $4.00 to $8.00 per square foot. The smaller the parcel, the higher the value; the larger the parcel, the more industrial within those geographical areas. Finding a suitable site would generally require a 3 to 4 week search by a real estate firm using BES site-specific information.

- ***Electrical*** — Electrical usage is a major factor. On-site uninteruptible power supply (UPS), power conditioning, and an emergency generator would be needed for laboratory and computer operations. Two substation sources of good quality (clean) power are preferred. A range of voltages should be available because the building may need 120, 208, 240, 277, and 480 volt service.

- ***Transportation Access*** — For the WPC Laboratory only, a location adjacent to bus or light rail transportation would not be necessary because most of the staff drive to the current laboratory to work or check out a van or assigned car to work in the field. With the WPC Laboratory co-located with BES offices, the office staff would require a location near a transit mall or light rail stop for a significant portion their staff transportation needs; parking would be downsized accordingly.

- ***Parking*** — In addition to zoning parking requirements, the "WPC Laboratory only" site needs spaces for 20 cars, pickups and vans and the co-location site needs an additional 90 spaces for BES vehicles.

The ideal site location would be close in north/northeast with easy freeway and river access. This location would be at the approximate center of the laboratory's geographical service coverage.

Zone III requirements. If a building has no lateral restraint system, an additional $8 to $12 per square foot will be needed to upgrade the building to Seismic Zone III requirements, a substantial cost impact to the building renovation project.

Other Requirements

In addition to specific code requirements, an existing building would probably need 15 to 16 feet floor-to-floor height to allow for adequate clearance for the necessary mechanical and electrical systems. Other requirements and issues are discussed in Appendix D.

Section 5

Renovated Building Criteria

Occupancy Classification

When one looks at potential building options, it is important that the occupancy classification of the WPC Laboratory be precisely defined with the Bureau of Buildings. The classification will be based on an evaluation of where the laboratory fits in relationship to the Uniform Building Code's Table 9A, Exempt Amounts of Hazardous Materials, Liquids, and Chemicals Presenting a Physical Hazard.

If the laboratory has less than the quantities listed in Table 9A, it should qualify as a Group B, Division 2 Occupancy or similar to an office building. If the laboratory has greater quantities, it would be a Group H Occupancy. H Occupancies are buildings whose primary use is storage and the aggregate quantity of hazardous materials is in excess of Table 9A. More than likely, if classified an H Occupancy, it would be a Division 3 or Division 7. Division 3 has quantities of materials that present a high fire or physical hazard. Division 7 has quantities of materials in excess of those listed in Table 9B that are health hazards.

Environmental laboratories similar in nature to the proposed WPC Laboratory are most often classified as Group B, Division 2 office building housing material quantities well under those specified in Table 9A. Further, those same laboratories, when properly managed, are classified as low hazard laboratories, Laboratory Unit Class C as determined by Table 2-2 in National Fire Protection Association (NFPA) Number 45, *Laboratories Using Chemicals*. The new Laboratory Standard of the Occupational Safety and Health Administration (OSHA) is enforcing good laboratory management practices.

The building's occupancy classification will have a direct affect on the basic allowable floor area in a building one-story in height, maximum height, and maximum height in stories based on the type of construction in the existing building. For example, an existing warehouse building classified as heavy timber construction (typical of old warehouses) and Type III one-hour construction would have the following area requirements: 18,000 square feet per floor; one-hour construction; 4-stories in height without any provisions for area increases or fire rating changes due to fire sprinkler conditions. If found, such a building would obviously accommodate the WPC Laboratory.

Seismic Requirements

If an existing building is used that does not have a Group B, Division 2 or an H Occupancy, an occupancy change would be required. Under the (soon to be adopted) code, a change of occupancy will require that the entire building be brought up to Seismic

Table 11
WPC Laboratory and BES Offices Costs (Co-Located) — 1992 Dollars

Item			Cost, $	Comments
Project Construction				
Analytical Area	14,578 SF	$225/SF	3,280,050	
Office & Support Area	99,129 SF	$100/SF	9,912,900	
Subtotal	113,707 SF		13,192,950	
Construction Contingency			1,319,295	10%
TOTAL PROBABLE CONSTRUCTION COST			14,512,245	
Equipment & Furniture				
Analytical Equipment			1,718,800	See Appendix C
Furniture & Furnishings "Rule-of-thumb"			1,160,980	8% of Construction
Subtotal Equipment & Furniture			2,879,780	
Design & Management				
A/E Fees Per Owner Agreement with Reimbursables			2,176,837	15% of Construction
Special Consultants			20,000	Acoustical, Lighting
Testing & Inspection (Concrete & Steel)			145,122	1% of Construction
Owner Administration (Project Mgr.) & Legal			2,176,837	15% of Construction
Surveying & Topography			24,000	Certified Survey
Soils (Core Samples & Soils Report)			12,000	Recommendations
Subtotal Design & Management			4,554,796	
Miscellaneous Project Costs				
Insurance "All Risk"			29,024	0.2% of Construction
Moving Costs			75,000	
Telecommunications			200,000	
Permits/Plan Review Process			108,842	0.75% of Construction
Sewer Equalization Fee			200,000	
Contribution to Art			193,013	1.33% of Construction
Subtotal Miscellaneous Project Costs			805,879	
TOTAL PROBABLE NON-CONSTRUCTION COST			8,240,455	
Owner's Contingency			824,046	10% of Non-Construction
Total Probable Construction Cost			14,512,245	From Above
TOTAL PROBABLE PROJECT COST			23,576,746	
Land & Other Costs				
Land	289,348 SF	$6.00/SF	1,736,088	Assume 1-Story, Mean $
Interim Financing			0	
Subtotal			1,736,088	
Bond Placement Fees			379,693	1.5% of Land + Project
TOTAL PROBABLE PROJECT & LAND COSTS			25,692,527	

Section 6

Preliminary Cost Estimate Summary

Table 10 WPC Laboratory Costs (Not Co-Located) — 1992 Dollars				
Item			**Cost, $**	**Comments**
Project Construction				
Analytical Area	14,578 SF	$225/SF	3,280,050	
Office & Support Area	39,129 SF	$100/SF	3,912,900	
Subtotal	53,707 SF		7,192,950	
Construction Contingency			719,295	10%
TOTAL PROBABLE CONSTRUCTION COST			7,912,245	
Equipment & Furniture				
Analytical Equipment			1,718,800	See Appendix C
Furniture & Furnishings "Rule-of-thumb"			632,980	8% of Construction
Subtotal Equipment & Furniture			2,351,780	
Design & Management				
A/E Fees Per Owner Agreement with Reimbursables			1,186,837	15% of Construction
Special Consultants			10,000	Acoustical, Lighting
Testing & Inspection (Concrete & Steel)			79,122	1% of Construction
Owner Administration (Project Mgr.) & Legal			1,186,837	15% of Construction
Surveying & Topography			12,000	Certified Survey
Soils (Core Samples & Soils Report)			12,000	Recommendations
Subtotal Design & Management			2,486,796	
Miscellaneous Project Costs				
Insurance "All Risk"			15,824	0.2% of Construction
Moving Costs			25,000	
Telecommunications			100,000	
Permits/Plan Review Process			59,342	0.75% of Construction
Sewer Equalization Fee			100,000	
Contribution to Art			105,233	1.33% of Construction
Subtotal Miscellaneous Project Costs			405,399	
TOTAL PROBABLE NON-CONSTRUCTION COST			5,243,975	
Owner's Contingency			524,398	10% of Non-Construction
Total Probable Construction Cost			7,912,245	From Above
TOTAL PROBABLE PROJECT COST			13,680,618	
Land & Other Costs				
Land	123,748 SF	$6.00/SF	742,488	Assume 1-Story, Mean $
Interim Financing			0	
Subtotal			742,488	
Bond Placement Fees			216,347	1.5% of Land + Project
TOTAL PROBABLE PROJECT & LAND COSTS			14,639,453	

calculated in a manner similar to Table 11. In effect, Appendix B calls for an 18,816 square foot laboratory facility saving $1,857,395 annually in outside laboratory testing (after labor, expenses, and 20-year amortization of building space and equipment). But the Appendix B laboratory facility, does not include "loaded costs" related to the efficiency factor, circulation, contingencies, fees, special consulting, etc. The "loaded costs" were developed after SERA Architects was retained for the study.

The following tables were developed using the same process as in previous report sections to determine the laboratory department costs and associated annual cost savings.

Table 12
Laboratory Department Only Summary (Not Co-Located)

Laboratory Department	Area SF
Analytical Laboratory	14,578
[1]Efficiency Factor: 60%	9,719
[2]Total Area	24,297

[1]See discussion in Appendix A.
[2]For analysis purposes only; results do not constitute a recommendation of this minimum laboratory.

The adjusted site sizing criteria for the Laboratory Department are shown in Table 13.

Table 13
Site Sizing Criteria for Laboratory Department Only (Not Co-Located)

Element	1-Story, SF
Building Coverage	24,297
[1]BES Lab Vehicle Spaces: 2	700
[2]Code Required Lab Vehicle Spaces: 61	21,350
Subtotal	46,347
Landscape Area at 15%	6,952
[3]Total Area, SF	53,299
Total Area, Acres	1.23

Notes:
[1]BES vehicle parking at 350 SF per vehicle.
[2]Based on maximum building coverage at 350 SF per vehicle; zoning requires one space per 400 SF of gross building area. A variance may be possible, reducing the required number of parking spaces.
[2]For analysis purposes only; results do not constitute a recommendation of this minimum laboratory.

Section 7

WPC Laboratory Options

Facility

The preceding cost summary assumes that all of the named departments will reside in the proposed laboratory facility. Costs savings could occur for this facility by deleting some of the departments and building a smaller facility. The deleted departments would continue to reside with the remainder of the BES offices, given a negative decision on co-location of the WPC laboratory and the BES offices.

BES staff has indicated that the priority departments for the new facility are the Analytical Laboratory and Environmental Investigation and Sampling Group. This part of the program accounts for 78 percent of the proposed square footage and would, therefore, require 78 percent of the site, or 2.21 acres for a 1-story building, and 78 percent of the "Total Probable Project and Land Costs", or $11,418,773 in 1992 dollars.

Addition of the Spill Response and Emergency Management and Hydra Computer departments would add about 11 percent to the costs. The Industrial Pretreatment department accounts for the remaining 11 percent.

Deleting departments will reduce costs only for the proposed facility. The reduced costs will be offset by comparable costs for space in another BES office facility.

Analytical Equipment and Furniture

Some initial cost savings can be afforded by phased purchase of analytical equipment as it is cost justified, rather than initial purchase coinciding with the building capital outlay. By phased purchases, the WPC Laboratory may be able to take advantage of trends in reduced costs for some of the analytical equipment (in a fashion similar to the current personal computer cost reductions).

Cost savings may result from phased purchasing of office furniture. Not all of the furniture would be needed on completion of the new facility because it initially will not be staffed to capacity.

Laboratory Department Only

Deleting all of the other departments from the proposed laboratory facility would result in more cost savings. While we are not recommending such a minimum facility, reducing its size in the costing process allows one to adjust the analytical laboratory cost justification figures found in Table 3 of Appendix B to reflect the current, "fully loaded costs"

The adjustments in the analytical laboratory cost justification figures from Table 3 of Appendix B reflecting the current, fully "loaded costs" are shown in Table 15.

Table 15
Adjusted Laboratory Department Only Costs (Not Co-Located) — 1992 Dollars

Item			Cost, $[1]	Comments
Construction				
Analytical Laboratory Project & Land Costs "Loaded"[2]			9,407,956	Table 14
Analytical Area	9,408 SF	$225/SF	2,116,800	Appendix B Area
Office & Support Area	9,408 SF	$100/SF	940,800	Appendix B Area
Subtotal "Unloaded Costs"[3]	18,816 SF		3,057,600	Appendix B Costs
Difference ("Loaded" minus "Unloaded" Costs)			6,350,356	Difference
Analytical Equipment Correction[4]			1,718,800	
Subtotal ("Loaded" minus "Unloaded" Costs)			4,631,556	
Annual Adjustment ("Loaded" minus "Unloaded" Costs)			231,578	20 Year Amortization
Annual Testing				
Annual Costs for Outside Testing ("Unloaded")			4,636,150	Appendix B, Table 3
Quality Control Correction[5]			231,808	5% of Outside Testing
Subtotal Outside Testing ("Unloaded")			4,867,958	
Annual Costs for In-House Testing ("Unloaded")			2,778,755	Appendix B, Table 3
Cost Savings ("Unloaded")			2,089,203	Difference
Annual Construction Adjustment			231,578	From Above
Adjusted Annual Cost Savings ("Loaded")			1,857,625	

[1]For analysis purposes only; results do not constitute a recommendation of this minimum laboratory.
[2]"Loaded" includes contingencies, percentages of construction, fees, etc.
[3]"Unloaded" does not include contingencies, percentages of construction, fees, etc., but does include construction and analytical equipment.
[4]Analytical equipment amortization over 10 years is included in the annual in-house testing costs.
[5]Quality control sample cost to assure outside testing data quality equivalent to in-house quality.

Thus, the laboratory facility that only contains the Laboratory Department would occupy 18,816 square feet costing $9,407,956 and saving $1,857,625 annually in outside laboratory testing costs (after labor, expenses, and 20-year amortization of space and equipment costs). The preceding analysis was made to determine annual cost savings rather than to make a recommendation on laboratory size.

The adjusted preliminary estimate for the Laboratory Department is shown in Table 14.

Table 14
Laboratory Department Only Costs (Not Co-Located) — 1992 Dollars

Item			[1]Cost, $	Comments
Project Construction				
Analytical Area	14,578 SF	$225/SF	3,280,050	
Office & Support Area	9,719 SF	$100/SF	971,900	
Subtotal	24,297 SF		4,251,950	
Construction Contingency			425,195	10%
TOTAL PROBABLE CONSTRUCTION COST			4,677,145	
Equipment & Furniture				
Analytical Equipment			1,718,800	See Appendix C
Furniture & Furnishings			100,000	
Subtotal Equipment & Furniture			1,818,800	
Design & Management				
A/E Fees Per Owner Agreement with Reimbursables			701,572	15% of Construction
Special Consultants			5,000	Acoustical, Lighting
Testing & Inspection (Concrete & Steel)			46,771	1% of Construction
Owner Administration (Project Mgr.) & Legal			701,572	15% of Construction
Surveying & Topography			6,000	Certified Survey
Soils (Core Samples & Soils Report)			6,000	Recommendations
Subtotal Design & Management			1,466,915	
Miscellaneous Project Costs				
Insurance "All Risk"			9,354	0.2% of Construction
Moving Costs			12,000	
Telecommunications			45,000	
Permits/Plan Review Process			35,079	0.75% of Construction
Sewer Equalization Fee			50,000	
Contribution to Art			62,206	1.33% of Construction
Subtotal Miscellaneous Project Costs			213,639	
TOTAL PROBABLE NON-CONSTRUCTION COST			3,499,354	
Owner's Contingency			349,935	10% of Non-Construction
Total Probable Construction Cost			4,677,145	From Above
TOTAL PROBABLE PROJECT COST			8,526,434	
Land & Other Costs				
Land	123,748 SF	$6.00/SF	742,488	Assume 1-Story, Mean $
Interim Financing			0	
Subtotal			742,488	
Bond Placement Fees			739,034	1.5% of Land + Total
TOTAL PROBABLE PROJECT & LAND COSTS			9,407,956	

[1]For analysis purposes only; results do not constitute a recommendation of this minimum laboratory.

Square Footage Background Calculations

In reviewing overall square footage projections for planning purposes, SERA Architects received the following information from Carl Urben at PAE Consulting Engineers and Bill Kionka at Cost Planners, Inc.

- PAE Engineering has been involved with the net to gross square footage factor of 55% of lab type space and a 70% factor for office space. Given this ratio, the building would be approximately:

Lab	14,578 SF	divided by 55% =	26,505 SF
Office	17,646 SF	divided by 70% =	25,209 SF
		Total	51,714 SF

- Cost Planners, Inc. state that on lab type buildings, the overall programmed space is about 60% of the total project, therefore, given this ratio, the building would be approximately:

Lab/office 32,224 SF divided by 60% = 53,707 SF

- As a third calculation, SERA Architects checked the square footages of the Fisheries Industrial Technology Center Building it designed for the University of Alaska. The ratio was 62% programmed space and 38% support space. Given this ratio, the building would be approximately:

Lab/office 32,224 SF divided by 62% = 51,974 SF

Until detailed programming can occur, SERA Architects proposes to use the most conservative 60% efficiency factor which develops a building of 53,445 SF. This added square footage is reasonable given the fact that it will be a necessity that 2 exits be provided for every lab which may mean a service oriented corridor with lab systems above and a public oriented corridor to be provided which would increase support spaces.

Appendix A

Square Footage Background Calculations

MEMORANDUM CH2M HILL

TO: Tom Bottenberg/PDXBES
Jim Cooke/PDXBES

COPIES: Mike Soderquist/PDX
Daria Wightman/PDX

FROM: Earl Hadfield/CVO

DATE: January 27, 1992

SUBJECT: Water Pollution Control (WPC) Laboratory--New Laboratory Space Requirements and Justification

PROJECT: PDX27865.82

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INTRODUCTION
SUMMARY
LABORATORY WORKLOAD
COSTS AND OTHER FACTORS
BREAKEVEN ANALYSIS
PROPOSED LABORATORY SPACES
APPENDIXES, A and B

INTRODUCTION

As part of a design project for a Portland Bureau of Environmental Services (BES) laboratory facility, CH2M HILL was asked to include elements from ***Columbia Boulevard Wastewater Treatment Plant Maintenance, Stores, Administration, and Laboratory Facilities, Basis of Design Report for the Portland Central Environmental Water Quality Laboratories, Master Plan Supplement No. 2***, prepared by Kramer, Chin, and Mayo (KCM) in December 1989. CH2M HILL was also asked to re-evaluate the report's space allocations and the need for including them in a new facility. This became necessary when testing programs were added after KCM's report

Appendix B

New WPC Laboratory Space Requirements and Justification

- Microbiology
- Physical Tests
- Solids
- Inorganics
- Nutrients
- Trace Metals
- Organic Aggregates
- Organic Parameters
- Bioassays
- Miscellaneous Hazardous Waste Tests (except asbestos)

- ***Contract Laboratory Testing.*** This testing is more economical than in-house laboratory testing for:

  - Biological Tests
  - Radiochemical Testing
  - Research and Development

- ***Biological and Research and Development Testing.*** These tests are recommended to be performed in-house:

  - Addition of expected virus testing will probably make the biological testing economical.

  - Data turnaround time requirements preclude most contract laboratory testing for research and development testing; lack of in-house capability is the exception.

- ***Analytical Space in Proposed Laboratory.*** Minimum recommended space is 9,400 square feet to house an estimated 36 analysts (professionals and technicians).

- ***Total Space in Proposed Laboratory.*** The total space needs to be determined through evaluation of the following:

  - Define administrative functions and support spaces and allocate square footage areas; the recommended minimum equals analytical space (9,400 square feet).

  - Define appropriate circulation space with architect guidance.

was published and because of a need to consider locating a new laboratory facility somewhere other than at the Columbia Boulevard Wastewater Treatment Plant (WTP).

This evaluation of WPC laboratory space needs consists of the following:

- Estimate future laboratory tests based on current workloads and projected program needs.
- Estimate staff, space, and equipment necessary to perform the laboratory tests in-house.
- Compare in-house laboratory costs with costs for outside contract laboratories performing the tests.

An initial evaluation ended in December of 1990 with a draft memorandum that identified staff, space, and equipment and concluded that in-house testing was more cost-effective than contracting to outside laboratories. Subsequent to the draft, BES staff provided new, more accurate, estimates of the testing workload that were significantly higher. This new data coupled with new information on equipment, space, and test times results in the re-evaluation contained in this memorandum.

This evaluation is not intended to be an in-depth study. It is a cursory evaluation using cost data borrowed from work performed by CH2M HILL for clients in Oregon and Arizona. While not necessarily accurate for this project, the results should be considered as "order-of-magnitude" estimates that should be appropriate for space planning decisions at the WPC laboratory. These estimates should also be appropriate for workload allocation decisions that potentially involve outside contract laboratories.

SUMMARY

This laboratory evaluation revealed the following results for these specific laboratory needs:

- ***Laboratory Workload.*** Based on BES projections, the WPC laboratory workload will increase dramatically.
- ***Current Laboratory Space.*** Current space is inadequate to perform <u>all</u> of the proposed tests at expected frequencies.
- ***In-house Testing.*** This testing is more economical than outside contract laboratory testing for:

Table 1
Estimated Annual Analyses Within 5 Years[a]

Tests/Testing Programs[b]	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Totals
Dissolved Oxygen							700								700
Conductivity			140				700								840
Turbidity							700					200			900
Hardness							500								500
Fluoride	404	404													808
Sulfate	404	404	40												848
pH	1,720	1,720	440	40			860	260		20	160	200		20	5,440
Total Solids	18	18	100	40			860	160		20	160	200		20	1,596
Total Volatile Solids								60				50			110
Total Dissolved Solids												200			200
Suspended Solids	870	870	100	40			860	100		20	160	200		20	3,240
Ammonia Nitrogen (N)	404	404	125	40			860	260		20	160	200		170	2,643
Nitrate-Nitrite N	404	404	125	40			860	260		20	160	200		170	2,643
Total Kjeldahl N							350	60				200			610
Total Phosphate							700	60				200			960
Ortho-Phosphate	404	404	125	40			860	200		20	160	200		170	2,583
Biochemical Oxygen Demand (BOD)	1,838	1,838	100	40			860	200		20	160	20		20	5,096
Chemical Oxygen Demand (COD)							700					200			900
Total Organic Carbon (TOC)							150								150
Oil & Grease	298	298	400				300	630				200			2,126
Fecal Coliform	50	50		125	1,375	125	1,700			125	125			125	3,800
Fecal Streptococcus	50	50		125	1,375	125	1,000			125	125			125	3,100
Enterococcus				125	1,375	125	1,700			125	125	200		125	3,900
Virus				25	275	25	200			25	25			25	600

- Define ancillary functions and allocate square footage areas with appropriate support space (shared or unique); these functions may include industrial pretreatment, stormwater monitoring, etc. hazardous waste, etc.

Increased emphasis on control of data quality, data turnaround times, and emergency response provides non-economic support for these laboratory development decisions.

Periodic updating of the cost analysis and breakeven analysis tables included in this memorandum provides important information for decisions such as when to test in-house, increase staff, procure equipment, expand space, or develop facilities.

For further evaluation of laboratory space needs, a meeting is suggested that would include our project manager, an architect, BES staff, and myself. A mechanical engineer should also attend because heating, ventilating, and air conditioning are a driving influence in laboratory space planning.

LABORATORY WORKLOAD

A summary of the projected laboratory workload appears in Table 1. The table was derived from data provided by BES staff that estimate workloads expected to occur 5 years from now. The estimates reflect 5-20 percent annual growth for current work and the addition of new testing programs. The estimates do not include internal BES R&D tests at the WPC Laboratory or operations control tests normally performed at the Columbia and Tryon Creek WTPs.

National trends indicate that the total annual laboratory tests seldom decreases even though monitoring programs are deleted or replaced with new programs. The experience of Seattle Metro Environmental Laboratories provides an example of these trends and their effects. Six years ago a staff of forty moved into the a 27,000-square-foot facility on the Lake Washington Ship Channel. Today decisions are pending on moving portions of the staff of eighty to less crowded facilities; moves would only involve Seattle Metro's non-analytical, mostly pretreatment staff that help generate the samples for the laboratory tests.

COSTS AND OTHER FACTORS

PROCESS

Appendix A is an order-of-magnitude cost analysis. The tests listed in the tables are grouped by similarity of analytical methods (i.e., the microbiological tests are grouped together), and each group has a pair of tables for ease of access to data. The parameters of each grouping are defined in the relevant tables. The paired tables summarize current and anticipated monitoring requirements by test groupings; estimated needs for staff, space, and equipment; and approximate internal and external costs to meet these needs. By comparing the internal and external costs, one can evaluate the feasibility of performing the group or subset of analyses. An overview of the cost analysis process in included in Appendix B.

Both the paired tables and report are prepared using the same, currently popular, word processing software, Word Perfect 5.1©. A copy of the file and a working knowledge of the software allows the tables to be used in the same manner as a typical spreadsheet program. Instructions for table alterations are included in Appendix A. If use of the same program is not possible, a study of Appendixes A and B will reveal the calculations used.

Examples of updating or projecting "what if" scenarios follow:

- Delete less-frequent tests (contract out non-routine tests)
- Increase/decrease test frequency to satisfy budget, public health, regulatory, or public's perceived needs
- Add tests responding to new operational, research, or regulatory requirements
- Change rates and factors for staff costs, square footage, quality control (QC) tests, supervision, contract administration, depreciation period, contract laboratory prices, etc.

ASSUMPTIONS

The cost tables in Appendix A reflect the following assumptions:

- Minimum tests will be needed to meet current and anticipated BES programs and regulatory monitoring requirements.
- Tests will be needed that are performed by similar laboratories (at a frequency of one per year to minimally impact cost calculations of BES projected programs).

Table 1
Estimated Annual Analyses Within 5 Years[a]

Tests/Testing Programs[b]	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Totals
Cyanide	553	553	100												1,206
Metals (6-8 per group)	3,887	3,887	3,800	240			4,560	5,028	30	120	960	100		120	22,732
Purgeable Halocarbon Organics (by GC)	499	499	40						30				300		1,368
Purgeable Aromatic Organics (by GC)	499	499	40						30				300		1,368
Volatile Organic Analyses (VOA by GC/MS)	250	250	540	20			300	670	30	10	80		300	110	2,560
Base/Neutral & Acid Extractable Organics (BNA by GC/MS)	265	265	540	20			300	670	30	10	80		300	110	2,590
Pesticide/PCBs			540	20			300	670	30	10	80		300	110	2,060
Dioxin Screen			210						10						220
RCRA Toxicity-TCLP			115					286	30						431
RCRA Ignitability			115					186	30						331
RCRA Corrosivity			115					186	30						331
RCRA Reactivity			115					186	30						331
Bioassays, 3 Chronic:1 Acute				20		16	80		30	10	80			10	246
Chlorophyll/Pheophyton							550								550
Asbestos			15						5						20
Totals	12,817	12,817	7,980	1,000	4,400	416	21,510	10,132	343	700	2,800	2,770	1,500	1,450	80,637

NOTES: [a]Based on data supplied by BES staff.
[b]Programs:
1. Environmental Compliance (Pretreatment)
2. Extra Strength
3. Environmental Investigations
4. Water Quality Planning/ Investigations
5. Stipulated Final Order Requirements
6. NPDES Permit (WTP Monitoring)
7. Storm Sewer NPDES
8. Sludges/Solids Characterization
9. Environmental Audit & Site Acquisition
10. Tualatin River Stipulated Order/Other Basins
11. In-Stream Water Quality/Sediment Monitoring
12. Erosion Control/On-Site Pollutant Control
13. TRE/TRI
14. Research & Development/Methods Testing

Table 2
Test Group Summary

Test Group Categories[a]	Annual Costs, $		Attributes	
	Outside Testing	In-House Testing	Staff[b] (FTE)	Area[c] (Sq Ft)
Inorganics II	44,447	40,391	0.6	392
Nutrient Parameters	179,783	129,165	1.9	1,176
Trace Metals	428,262	290,944	3.9	1,960
Organic Aggregates	284,346	237,340	3.7	1,568
Organics I	529,733	296,313	4.0	1,960
Organics II	2,179,301	1,051,378	10.1	3,136
Radiochemical Analyses	231	4,711	0.0	392
Toxicity/Bioassay	512,401	366,434	6.0	2,352
Miscellaneous Tests	38,231	36,998	0.5	784
Research & Development[d]	0	17,008	0.0	1,568
Totals	4,636,381	2,783,466	35.7	19,208

NOTES:
[a]See Appendix A for test group details and assumptions.
[b]Includes full time equivalent (FTE) analytical staff, but excludes administration and support staff.
[c]Includes non-analytical support space (50%) equal to analytical space, but excludes extra-ordinary circulation and non-analytical special purpose areas often included in laboratory buildings.
[d]Data turnaround time and project control precludes outside laboratory testing. Approximately half of costs are assumed equipment.

Please note that Table 2 is for comparison of test group categories; grand totals for costs, FTE, and area do not constitute final recommendations. Please remember that in-house testing includes cost of new space and equipment. For comparison of outside testing costs with in-house testing without these capital (fixed) cost burdens, please see the second of the paired tables in Appendix A. Our own comparison reveals that in-house operating (without capital) costs are less than outside testing costs for all test group categories, except research and development (R&D).

Even with the capital cost burden, most of the test group categories appear to be cost-effective for in-house testing. The test group categories that appear more cost-effective to contract to outside laboratories include: biological, radiochemical, and R&D categories.

Because of lack of information on test times and contract laboratory test charges, the biological category does not include the 600 annual virus tests listed in Table 1. Given this information, the author believes the economic analysis would favor in-house virus testing. Virus testing may require as much as 0.5 FTE and could be incorporated into the space currently assigned to biology and microbiology.

- New equipment and space (some items may be currently owned) will be needed.
- Widely used, EPA-approved test methodology will be standard.
- The anticipated Oregon laboratory certification program and appropriate QA/QC practices will be followed.
- Tests will be performed by laboratory analysts (some may be currently performed by treatment plant operators).
- For efficiency, computerization and automation will be used, where possible.
- Bioassays will be performed for BES waste treatment facilities as well as for other programs.
- Analytical areas include computation space in lieu of office space for laboratory analysts.
- Some high-volume testing may require weekend or second shift coverage, i.e. microbiology, organics, and bioassay.

The definition of "order-of-magnitude" and additional important assumptions precede the tables in Appendix A.

COST RESULTS

An overall summary of Appendix A can be found in Table 2. Table 2 also summarizes staff and space needs associated with each group of similar tests (test group category). A comparison of data shows the difference in costs for outside and in-house testing by test group categories. The names of the tests in the test group categories can be found in Appendix A.

Table 2
Test Group Summary

Test Group Categories[a]	Annual Costs, $		Attributes	
	Outside Testing	In-House Testing	Staff[b] (FTE)	Area[c] (Sq Ft)
Microbiological Parameters	220,391	162,714	2.8	1,568
Biological Parameters	17,325	25,386	0.3	784
Physical Parameters	85,184	37,373	0.6	392
Solids Tests	81,685	54,088	0.8	784
Inorganics I	35,061	33,223	0.5	392

Please note that Table 3 does not include laboratory FTE to perform a large number of tests that could be associated with research and special studies.

The total laboratory area divided by the total analytical staff in Table 3 yields 527 square feet per analyst. A general laboratory design rule-of-thumb for analytical and support space is 600 to 800 square feet per analyst. The calculation for the Seattle Metro Environmental Laboratories example cited earlier yields 675 square feet per analyst for its initial staff of 40. The square footage per analyst appears considerably lower for Table 3 laboratory, but the figure increases to 612 square feet per analyst when analytical staff occupancy is adjusted downward to reflect second shift and weekend coverage for microbiology, organic, and bioassay staff, totaling of 5 off-hour staff. Other square footage differences between Seattle Metro and that of Table 3 may be accounted for in space devoted to offices and circulation (halls, aisles).

The analytical space in Table 3 is 9,408 square feet (50 percent of the total). Dividing the analytical space by the adjusted analytical staff yields 306 square feet per analyst. This figure compares favorably with another general laboratory design rule-of-thumb that prescribes analytical space of 200 to 400 square feet per analyst.

Table 3 clearly shows that in-house testing is more economical than contracting to outside laboratories. The total cost savings computes to about 40 percent with individual test group categories ranging from 3 to 56 percent.

OTHER FACTORS

As important as it is, economics is not the only factor for consideration in decisions about development of in-house laboratory capabilities. Some other factors include:

- Degree of reliance on others for important data
- Knowledge and control of data quality
- Data turnaround time requirements
- Response for potential water quality problems
- Margin of safety afforded by more frequent monitoring than required

Using an outside laboratory generally reduces flexibility in acquiring data. Given the importance of the listed items above, outside laboratories should only be used when fully justified for economic or lack-of-capability reasons.

The premium cost of improved, and often necessary, turnaround time of data from contract laboratories has not been included in this evaluation. The cost of extraordinary turnaround time requirements is often double or triple that noted in the appended tables.

On many occasions when R&D tests for utilities like Portland BES are performed by outside laboratories, they do not meet time requirements for study purposes. For this reason, R&D space is recommended to be included without direct economic justification.

As footnoted in Table 2, the proposed staff needs do not include additional management personnel necessary for a larger organization. As staff size increases, management levels often center around specific areas, e.g. microbiology, wet chemistry, metals, organics, sampling, etc. Laboratory managers become laboratory directors of management structures. Additionally, full-time specialists will become necessary for QA, safety, data system management (hardware and software), and equipment and facilities maintenance. Support staff for data handling, word processing, telephone/reception, and other clerical help may be needed as well.

Deleting those test group categories found least cost-effective, or not likely to increase in cost-effectiveness to the point where near-term investment would be justified, yields the summary shown in Table 3.

Table 3
Selected Test Group Summary

Test Group Categories[a]	Annual Costs, $		Attributes	
	Outside Testing	In-House Testing	Staff[b] (FTE)	Area[c] (Sq Ft)
Microbiological Parameters	220,391	162,714	2.8	1,568
Biological Parameters	17,325	25,386	0.3	784
Physical Parameters	85,184	37,373	0.6	392
Solids Tests	81,685	54,088	0.8	784
Inorganics I	35,061	33,223	0.5	392
Inorganics II	44,447	40,391	0.6	392
Nutrient Parameters	179,783	129,165	1.9	1,176
Trace Metals	428,262	290,944	3.9	1,960
Organic Aggregates	284,346	237,340	3.7	1,568
Organics I	529,733	296,313	4.0	1,960
Organics II	2,179,301	1,051,378	10.1	3,136
Toxicity/Bioassay	512,401	366,434	6.0	2,352
Miscellaneous Tests	38,231	36,998	0.5	784
Research & Development	0	17,008	0.0	1,568
Totals	4,636,150	2,778,755	35.7	18,816

NOTES:
[a]See Appendix A for test group details and assumptions.
[b]Includes full time equivalent (FTE) analytical staff, but excludes administration and support staff.
[c]Includes non-analytical support space (50%) equal to analytical space, but excludes extra-ordinary circulation and non-analytical special purpose areas often included in laboratories.

BREAKEVEN ANALYSIS

Breakeven refers to the quantity of tests necessary for in-house testing to become cost-effective (i.e., for in-house test costs to equal outside test costs). Cost-effectiveness increases as the quantity of tests expands beyond the breakeven point. An overview and graphical representation of breakeven analysis can be found in Appendix B.

The breakeven quantity can be determined by adjusting the quantities of tests in the test group tables in Appendix A until in-house testing equals outside testing in a manner consistent with projected future testing loads. In a simpler process, an estimate of the breakeven quantity can be computed as shown in Appendix B, provided certain assumptions are made. Assumptions are necessary because the variability of test times (hours per test) and outside laboratory unit costs within each test group precludes a simple calculation.

For the WPC laboratory, the most important analytical capability decisions involve tests for the trace metals, organics I, and organics II groups. To estimate breakeven quantities for these groups, assume the following to obtain the results shown in Table 4:

- Trace metals--These refer to tests for individual metals rather than to suites of metals. Results can be converted back to samples by assuming a certain number of trace metals per sample and dividing by that number (e.g., 10).
- Organics I--The outside laboratory costs and test times are averages.
- Organics II--The outside laboratory costs and test times are the sum of the volatile and semi-volatile tests performed on every sample.

Table 4
Breakeven Analysis

Test Group Categories[a]	Lab List Price	Hours Per Test	Costs Per Hour	Annual Capital Cost	Annual Breakeven Quantity
Metals	15.00	0.2	31	51,655	5,870
Organics I	130.00	2.0	33	31,125	486
Organics II	675.00	4.0	47	110,720	227

NOTES:
[a]See Appendix A for test group details and assumptions.

Appendix A
ORDER-OF-MAGNITUDE COST ANALYSIS

ASSUMPTIONS FOR THE FOLLOWING TABLES:

1. For guidance in evaluations, cost estimates are based on current information. These estimates are "order-of-magnitude" estimates, defined by the American National Standards Institute (ANSI) and the American Association of Cost Engineers (AACE) as "an approximate estimate made without detailed engineering data. It is normally expected to be accurate within plus 50 percent or minus 30 percent." Final feasibility and funding needs must be carefully reviewed prior to making specific financial decisions to help assure proper evaluation and adequate funding.

2. Contract laboratory testing costs are based on CH2M HILL's judgment of the current market price for high-quality analytical data.

3. Contract laboratory testing costs are increased by 5 percent to cover the cost of administering the laboratory contract. The test costs are identified in the tables.

4. The analytical equipment is assumed to have a 10-year life. The equipment may have a shorter (or longer) real or technological life. The annual cost is the result of a 10-year, straight-line depreciation.

5. The laboratory building is assumed to have a 20-year life. The annual cost is the result of a 20-year, straight-line depreciation.

6. Space costs are based on standard curves and judgment. Costs are adjusted to local conditions (Portland--100.0 percent of average), but do not include contingencies. Nor do the costs include administration, engineering, and legal costs (often estimated at 35 percent.)

   a. Analytical space is computed at $225.00 per square foot (Enclosure $65, Electrical/Mechanical/Special $98, Casework $62).

   b. Support space (rest room, supervisory space, etc.) is computed at $100.00 per square foot (Enclosure $65, Remainder $35). Support space is assumed to be 100 percent of analytical space (50 percent of total space).

7. Space estimates do not include facility site, internal circulation, and non-analytical special purpose spaces. A predesign study should identify and total these types of areas to determine an overall order-of-magnitude cost estimate.

8. Operating expenses are based on a proportion of a normal 2,000-hour work year and vary with the type of testing. They include hourly charges to cover chemicals, miscellaneous supplies, service contracts, etc., according to CH2M HILL's experience.

9. Laboratory test times are based on CH2M HILL's judgment.

Tables 2, 3 and 4 can be updated using Word Perfect 5.1© in a manner similar to that used in the tables in Appendix A.

PROPOSED LABORATORY SPACES

Thus far in this evaluation, laboratory spaces have been defined by specific types of testing in order to determine the total analytical space. Individual test spaces should not be considered to be individual areas or rooms because many will be grouped and rearranged in the laboratory design process. The laboratory design process will also consider support spaces which, in the cost analysis, were considered to be equal to the total of the analytical spaces, 9,408 square feet each. In reality, laboratory support spaces may be somewhat smaller, or more often larger, than the total analytical space depending on the functions to be included.

Support space determination requires support function definition with appropriate area allocation that allows for circulation. Appendix C contains a memorandum that identifies potential support functions often found in environmental testing laboratories. The memorandum lists various spaces in a tabular format that provides for listing of staff occupancy and square footage. The table could be used as a basis for further defining the area needed for the WPC laboratory.

In addition to analytical and support functions, laboratory facilities often house non-laboratory functions as well. These functions may be dependent on laboratory analyses, e.g. programs for industrial pretreatment, stormwater monitoring, hazardous waste, etc. Addition of these ancillary functions will require expansion of shared support space (rest rooms, mechanical) and may require their own unique support space as well, e.g. conference areas, public access, etc.

The memorandum in Appendix C calls for a general laboratory space planning meeting. It asks potential meeting participants to consider some questions and to think about functions that may or may not be listed in order for the laboratory space planning process can continue in an efficient manner. CH2M HILL recommends implementation of the memorandum's course of action.

ACKNOWLEDGEMENT

The author wishes to thank BES staff, Tom, Jim, and David Ball, for their hospitality during his visits to the office and laboratory and for their provision of information for this memorandum.

10. Staff costs (raw salary and overheads including fringe benefits) are assumed to be a budget rate of $19.00 per hour, except for the mass spectroscopist, assumed to be $27.00 per hour. The higher salary reflects the level of expertise and the demand for these special analysts. The BES budget rate may vary from the assumption of $19.00 per hour.

11. Staff costs are escalated 10 percent to cover supervision and quality control. The hourly rates in item 10 above are rounded to become $21.00 and $30.00 respectively.

12. The laboratory equipment costs are based on "big ticket items," plus a miscellaneous equipment allowance for replacing or adding to existing inventory.

13. Though accreditation/certification fees are not required to date, they are expected when the state program develops. They are assumed to be $500 selectively applied to test groups as in other states. These fixed annual costs are noted under capital costs (but not amortized).

14. A contingency factor could be applied as a conservative measure to cover potential cost additions. As noted, no contingencies are used in this order-of-magnitude cost analysis.

INSTRUCTIONS FOR ALTERING TABLES:

1. The tables are prepared using Word Perfect 5.1© (WP5.1). They contain program codes and formulas that can be edited using WP5.1.

2. When editing, be careful in altering or deleting WP5.1 program codes. Some changes could alter results or cause data to disappear altogether. Retain a copy of the original unedited file as insurance.

3. Make changes on the first of the test group paired tables.

4. Enter the WP5.1 Table Function and perform the calculation for the first table.

5. Make changes in appropriate data on the second of the test group paired tables. Be sure that the second table matches the first table in the following categories:

   a. Annual tests.
   b. Annual O&M costs (not O&M plus Capital).
   c. Total hours.

6. Enter the WP5.1 Table Function and perform the calculation for the second table.

7. Transfer the appropriate data to the summary table (Example Table A) at the end of this appendix and perform the calculation as above.

8. Enter any new data in the breakeven analysis table (Example Table B) at the end of this appendix and perform the calculation as above.

TABLE A-2
TEST GROUP: MICROBIOLOGICAL PARAMETERS

OPTION[a]	OUTSIDE TESTING[b]			IN-HOUSE TESTING[c]		
TEST IDENTIFICATION	ANNUAL TESTS	UNIT COST, $	ANNUAL COST, $	ANNUAL O & M COST, $[d]	TOTAL HOUR	STAFF FTE
Total Coliform, Distribution	1	15.00	16	0	0	0.0
Total Coliform, Process	1	15.00	16	0	0	0.0
Fecal Coliform	3,800	20.00	79,800	47,424	1,824	0.9
Fecal Streptococcus, MF Method	3,100	18.00	58,590	38,688	1,488	0.7
Enterococcus, MF Method	3,900	20.00	81,900	60,840	2,340	1.2
Heterotrophic Plate Count (HPC), Distribution	1	20.00	21	26	1	0.0
Heterotrophic Plate Count (HPC), Process	1	30.00	32	26	1	0.0
Presence-Absence (P-A) Test	1	15.00	16	0	0	0.0
TOTALS	10,805		220,391	147,004	5,654	2.8

NOTES: [a]See text for assumptions.
[b]Includes 5% markup for administration.
[c]Includes 20% for QC tests (duplicate & control sample).
[d]Does not include annual capital costs.

TABLE A-1
TEST GROUP: MICROBIOLOGICAL PARAMETERS

O & M COSTS (LABOR AND EXPENSES)	ANNUAL TESTS	HOURS PER TEST	TOTAL HOURS[a]	$ PER HOUR[b]	ANNUAL COST, $[c]
Total Coliform, MF Method Distribution	1	0.3	0	26	0
Total Coliform, MF Method Process	1	0.3	0	26	0
Fecal Coliform, MF Method	3,800	0.4	1,824	26	47,424
Fecal Streptococcus, MF Method	3,100	0.4	1,488	26	38,688
Enterococcus, MF	3,900	0.5	2,340	26	60,840
Heterotrophic Plate Count (HPC) Distribution	1	0.7	1	26	26
Heterotrophic Plate Count (HPC) Process	1	0.7	1	26	26
Presence-Absence (P-A) Test	1	0.3	0	26	0
TOTAL O & M	10,805		5,654		147,004

CAPITAL COSTS	UNIT QTY	UNIT COST, $	TOTAL COST, $	YEAR LIFE	ANNUAL COST, $
Analytical Area, ft² (W)	784	225	176,400	20	8,820
Support Area, ft² (W)	784	100	78,400	20	3,920
Stereo Dissecting Microscope	1	1,200	1,200	10	120
Autoclave, Benchtop	2	5,500	11,000	10	1,100
Air Incubator, Full Size	2	3,500	7,000	10	700
Block Incubator	1	1,800	1,800	10	180
Water Bath Incubator	1	1,700	1,700	10	170
Accreditation/Certification	1	500	500	1	500
Miscellaneous Equipment Allowance	1	2,000	2,000	10	200
TOTAL CAPITAL			280,000		15,710
TOTAL CAPITAL PLUS O & M COSTS					162,714

NOTES: [a]Includes 0.00% for QC tests duplicate & control sample
[b]Estimated hourly labor ($21) plus estimated hourly expenses ($5).
[c]See text for other assumptions

TABLE A-4
TEST GROUP: BIOLOGICAL PARAMETERS

OPTION[a]	OUTSIDE TESTING[b]			IN-HOUSE TESTING[c]		
TEST IDENTIFICATION	ANNUAL TESTS	UNIT COST, $	ANNUAL COST, $	ANNUAL O & M COST, $[d]	TOTAL HOUR	STAFF FTE
Algae/Plankton	1	*	0	26	1	0.0
Chlorophyll/Pheophyton	550	30.00	17,325	14,300	550	0.3
Enteric Viruses	600	*	0	0	?	0.0
TOTALS	1,151		17,325	14,326	551	0.3

NOTES: [a]See text for assumptions.
[b]Includes 5% markup for administration.
[c]Does not include a % for QC tests (spike, duplicate, & control sample).
[d]Does not include annual capital costs.
*Request quotation for non-routine contract laboratory tests.

TABLE A-3
TEST GROUP: BIOLOGICAL PARAMETERS

O & M COSTS (LABOR AND EXPENSES)	ANNUAL TESTS	HOURS PER TEST	TOTAL HOURS[a]	$ PER HOUR[b]	ANNUAL COST, $[c]
Algae/Plankton	1	0.7	1	26	26
Chlorophyll/Pheophyton	550	1.0	550	26	14,300
Enteric Viruses	600	?	0	26	0
TOTAL O & M	1,151		551		14,326
CAPITAL COSTS	UNIT QTY	UNIT COST, $	TOTAL COST, $	YEAR LIFE	ANNUAL COST, $
Analytical Area, ft²	392	225	88,200	20	4,410
Support Area, ft²	392	100	39,200	20	1,960
Phase-contrast & Epifluorescence Microscope	1	15,000	15,000	10	1,500
Fluorometer	1	6,000	6,000	10	600
Centrifuge, Benchtop Refrigerated Type	1	8,000	8,000	10	800
Biohazard Hood	1	8,900	8,900	10	890
Accreditation/Certification	1	500	500	1	500
Miscellaneous Equipment Allowance	1	4,000	4,000	10	400
TOTAL CAPITAL			169,800		11,060
TOTAL CAPITAL PLUS O & M COSTS					25,386

NOTES: [a]Does not include a % for QC tests (spike, duplicate, & control sample).
[b]Estimated hourly labor ($21) plus estimated hourly expenses ($5).
[c]See text for other assumptions.

TABLE A-6
TEST GROUP: PHYSICAL PARAMETERS

OPTION[a]	OUTSIDE TESTING[b]			IN-HOUSE TESTING[c]		
TEST IDENTIFICATION	ANNUAL TESTS	UNIT COST, $	ANNUAL COST, $	ANNUAL O & M COST, $[d]	TOTAL HOUR	STAFF FTE
pH	5,440	10.00	57,120	18,284	653	0.3
Color	1	12.00	13	0	0	0.0
Turbidity	900	12.00	11,340	6,048	216	0.1
Conductivity	840	10.00	8,820	5,656	202	0.1
Alkalinity	1	15.00	16	0	0	0.0
Hardness	500	15.00	7,875	3,360	120	0.1
TOTALS	7,682		85,184	33,348	1,191	0.6

NOTES: [a]See text for assumptions.
[b]Includes 5% markup for administration.
[c]Includes 20% for QC tests (duplicate & control sample).
[d]Does not include annual capital costs.
[e]Request quotation for non-routine contract laboratory tests.

TABLE A-5
TEST GROUP: PHYSICAL PARAMETERS

O & M COSTS (LABOR AND EXPENSES)	ANNUAL TESTS	HOURS PER TEST	TOTAL HOURS[a]	$ PER HOUR[b]	ANNUAL COST, $[c]
pH	5,440	0.1	653	28	18,284
Color	1	0.2	0	28	0
Turbidity	900	0.2	216	28	6,048
Conductivity	840	0.2	202	28	5,656
Alkalinity	1	0.2	0	28	0
Hardness	500	0.2	120	28	3,360
TOTAL O & M	7,682		1,191		33,348
CAPITAL COSTS	UNIT QTY	UNIT COST, $	TOTAL COST, $	YEAR LIFE	ANNUAL COST, $
Analytical Area, ft^2	196	225	44,100	20	2,205
Support Area, ft^2	196	100	19,600	20	980
pH Meter	1	900	900	10	90
Turbidimeter, Ratio	1	1,500	1,500	10	150
Conductivity Meter	1	500	500	10	50
Accreditation/Certification	1	500	500	1	500
Miscellaneous Equipment Allowance	1	500	500	10	50
TOTAL CAPITAL			67,600		4,025
TOTAL CAPITAL PLUS O & M COSTS					37,373

NOTES: [a]Includes 20% for QC tests (duplicate & control sample).
[b]Estimated hourly labor ($21) plus estimated hourly expenses ($7).
[c]See text for other assumptions.

TABLE A-8
TEST GROUP: SOLIDS TESTS

OPTION[a]	OUTSIDE TESTING[b]			IN-HOUSE TESTING[c]		
TEST IDENTIFICATION	ANNUAL TESTS	UNIT COST, $	ANNUAL COST, $	ANNUAL O & M COST, $[d]	TOTAL HOUR	STAFF FTE
Total Solids	1,596	15.00	25,137	10,724	383	0.2
Total Volatile Solids	110	20.00	2,310	1,120	40	0.0
Total Dissolved Solids	200	15.00	3,150	2,016	72	0.0
Volatile Dissolved Solids	1	20.00	21	0	0	0.0
Total Suspended Solids	3,240	15.00	51,030	32,648	1,166	0.6
Volatile Suspended Solids	1	20.00	21	0	0	0.0
Settleable Solids	1	15.00	16	0	0	0.0
TOTALS	5,149		81,685	46,508	1,661	0.8

NOTES: [a]See text for assumptions.
[b]Includes 5% markup for administration.
[c]Includes 20% for QC tests (duplicate & control sample).
[d]Does not include annual capital costs.

TABLE A-7
TEST GROUP: SOLIDS TESTS

O & M COSTS (LABOR AND EXPENSES)	ANNUAL TESTS	HOURS PER TEST	TOTAL HOURS[a]	$ PER HOUR[b]	ANNUAL COST, $[c]
Total Solids	1,596	0.2	383	28	10,724
Total Volatile Solids	110	0.3	40	28	1,120
Total Dissolved Solids	200	0.3	72	28	2,016
Volatile Dissolved Solids	1	0.4	0	28	0
Total Suspended Solids	3,240	0.3	1,166	28	32,648
Volatile Suspended Solids	1	0.4	0	28	0
Settleable Solids	1	0.4	0	28	0
TOTAL O & M	5,149		1,661		46,508
CAPITAL COSTS	UNIT QTY	UNIT COST, $	TOTAL COST, $	YEAR LIFE	ANNUAL COST, $
Analytical Area, ft^2	392	225	88,200	20	4,410
Support Area, ft^2	392	100	39,200	20	1,960
Oven	1	2,400	2,400	10	240
Furnace	1	1,800	1,800	10	180
Balance	2	3,700	7,400	10	740
Miscellaneous Equipment Allowance	1	500	500	10	50
TOTAL CAPITAL			139,500		7,580
TOTAL CAPITAL PLUS O & M COSTS					54,088

NOTES: [a]Includes 20% for QC tests (duplicate & control sample).
[b]Estimated hourly labor ($21) plus estimated hourly expenses ($7).
[c]See text for other assumptions.

TABLE A-10
TEST GROUP: INORGANICS I

OPTION[a]	OUTSIDE TESTING[b]			IN-HOUSE TESTING[c]		
TEST IDENTIFICATION	ANNUAL TESTS	UNIT COST, $	ANNUAL COST, $	ANNUAL O & M COST, $[d]	TOTAL HOUR	STAFF FTE
Chlorine & Combined Forms	1	15.00	16	0	0	0.0
Chlorine Demand	1	75.00	79	56	2	0.0
Dissolved Oxygen	700	12.00	8,820	5,096	182	0.1
Fluoride	808	15.00	12,726	11,760	420	0.2
Carbon Dioxide	1	15.00	16	0	0	0.0
Chloride	1	15.00	16	0	0	0.0
Sulfate	848	15.00	13,356	9,268	331	0.2
Oxygen Uptake Rate	1	30.00	32	28	1	0.0
TOTALS	2,361		35,061	26,208	936	0.5

NOTES: [a]See text for assumptions.
[b]Includes 5% markup for administration.
[c]Includes 30% for QC tests (spike, duplicate, & control sample).
[d]Does not include annual capital costs.

TABLE A-9
TEST GROUP: INORGANICS I

O & M COSTS (LABOR AND EXPENSES)	ANNUAL TESTS	HOURS PER TEST	TOTAL HOURS[a]	$ PER HOUR[b]	ANNUAL COST, $[c]
Chlorine & Combined Forms	1	0.3	0	28	0
Chlorine Demand	1	1.5	2	28	56
Dissolved Oxygen	700	0.2	182	28	5,096
Fluoride	808	0.4	420	28	11,760
Carbon Dioxide	1	0.3	0	28	0
Chloride	1	0.2	0	28	0
Sulfate	848	0.3	331	28	9,268
Oxygen Uptake Rate	1	0.7	1	28	28
TOTAL O & M	2,361		936		26,208
CAPITAL COSTS	UNIT QTY	UNIT COST, $	TOTAL COST, $	YEAR LIFE	ANNUAL COST, $
Analytical Area, ft²	196	225	44,100	20	2,205
Support Area, ft²	196	100	19,600	20	980
Amperometric Titrator	1	1,500	1,500	10	150
Ion Specific Electrode (ISE) Meter	1	2,100	2,100	10	210
Ion Chromatograph	1	22,000	22,000	10	2,200
Dissolved Oxygen Meter & Probes	1	2,700	2,700	10	270
Computer Data System	1	8,000	8,000	10	800
Miscellaneous Equipment Allowance	1	2,000	2,000	10	200
TOTAL CAPITAL			102,000		7,015
TOTAL CAPITAL PLUS O & M COSTS					33,223

NOTES: [a]Includes 30% for QC tests (spike, duplicate, & control sample).
[b]Estimated hourly labor ($21) plus estimated hourly expenses ($7).
[c]See text for other assumptions.

TABLE A-12
TEST GROUP: INORGANICS II

OPTION[a]	OUTSIDE TESTING[b]			IN-HOUSE TESTING[c]		
TEST IDENTIFICATION	ANNUAL TESTS	UNIT COST,$	ANNUAL COST, $	ANNUAL O & M COST, $[d]	TOTAL HOUR	STAFF FTE
Cyanide	1,206	35.00	44,321	35,112	1,254	0.6
Cyanide Amenable to Chlorination	1	45.00	47	28	1	0.0
Bromide	1	15.00	16	0	0	0.0
Sulfide	1	20.00	21	28	1	0.0
Sulfite	1	15.00	16	0	0	0.0
Hexavalent Chromium	1	25.00	26	28	1	0.0
TOTALS	1,211		44,447	35,196	1,257	0.6

NOTES: [a]See text for assumptions.
[b]Includes 5% markup for administration.
[c]Includes 30% for QC tests (spike, duplicate, & control sample).
[d]Does not include annual capital costs.

TABLE A-11
TEST GROUP: INORGANICS II

O & M COSTS (LABOR AND EXPENSES)	ANNUAL TESTS	HOURS PER TEST	TOTAL HOURS[a]	$ PER HOUR[b]	ANNUAL COST, $[c]
Cyanide	1,206	0.8	1,254	28	35,112
Cyanide Amenable to Chlorination	1	1.0	1	28	28
Bromide	1	0.3	0	28	0
Sulfide	1	0.4	1	28	28
Sulfite	1	0.3	0	28	0
Hexavalent Chromium	1	0.5	1	28	28
TOTAL O & M	1,211		1,257		35,196
CAPITAL COSTS	UNIT QTY	UNIT COST, $	TOTAL COST, $	YEAR LIFE	ANNUAL COST, $
Analytical Area, ft^2	196	225	44,100	20	2,205
Support Area, ft^2	196	100	19,600	20	980
Distillation Apparatus & Glassware	1	3,100	3,100	10	310
Spectrophotometer	1	16,000	16,000	10	1,600
Miscellaneous Equipment Allowance	1	1,000	1,000	10	100
TOTAL CAPITAL			83,800		5,195
TOTAL CAPITAL PLUS O & M COSTS					40,391

NOTES: [a]Includes 30% for QC tests (spike, duplicate, & control sample).
[b]Estimated hourly labor ($21) plus estimated hourly expenses ($7).
[c]See text for other assumptions.

TABLE A-14
TEST GROUP: NUTRIENT PARAMETERS

OPTION[a]	OUTSIDE TESTING[b]			IN-HOUSE TESTING[c]		
TEST IDENTIFICATION	ANNUAL TESTS	UNIT COST, $	ANNUAL COST, $	ANNUAL O & M COST, $[d]	TOTAL HOUR	STAFF FTE
Ammonia Nitrogen	2,643	20.00	55,503	28,868	1,031	0.5
Total Kjeldahl Nitrogen (TKN)	610	25.00	16,013	11,116	397	0.2
Nitrate-Nitrite Nitrogen	2,643	20.00	55,503	38,472	1,374	0.7
Nitrite Nitrogen	1	15.00	16	0	0	0.0
Ortho Phosphate	2,583	12.00	32,546	18,816	672	0.3
Hyrolyzeable Phosphate	1	15.00	16	28	1	0.0
Total Phosphate	960	20.00	20,160	13,972	499	0.2
Silica	1	26.00	26	28	1	0.0
TOTALS	9,442		179,783	111,300	3,975	1.9

NOTES: [a]See text for assumptions.
[b]Includes 5% markup for administration.
[c]Includes 30% for QC tests (spike, duplicate, & control sample).
[d]Does not include annual capital costs.

TABLE A-13
TEST GROUP: NUTRIENT PARAMETERS

O & M COSTS (LABOR AND EXPENSES)	ANNUAL TESTS	HOURS PER TEST	TOTAL HOURS[a]	$ PER HOUR[b]	ANNUAL COST, $[c]
Ammonia Nitrogen	2,643	0.3	1,031	28	28,868
Total Kjeldahl Nitrogen (TKN)	610	0.5	397	28	11,116
Nitrate-Nitrite Nitrogen	2,643	0.4	1,374	28	38,472
Nitrite Nitrogen	1	0.3	0	28	0
Ortho Phosphate	2,583	0.2	672	28	18,816
Hydrolyzeable Phosphate	1	0.4	1	28	28
Total Phosphate	960	0.4	499	28	13,972
Silica	1	0.5	1	28	28
TOTAL O & M	9,442		3,975		111,300
CAPITAL COSTS	UNIT QTY	UNIT COST, $	TOTAL COST, $	YEAR LIFE	ANNUAL COST, $
Analytical Area, ft² (Including 196 ft² Prep. Area)	588	225	132,300	20	6,615
Support Area, ft²	588	100	58,800	20	2,940
Block Digestion Apparatus & Fume Manifold	1	6,100	6,100	10	610
Flow Injection Analyzer (FIA)	1	62,000	62,000	10	6,200
Computer Data System	1	8,000	8,000	10	800
Accreditation/Certification	1	500	500	1	500
Miscellaneous Equipment Allowance	1	2,000	2,000	10	200
TOTAL CAPITAL			269,700		17,865
TOTAL CAPITAL PLUS O & M COSTS					129,165

NOTES: [a]Includes 30% for QC tests (spike, duplicate, & control sample).
[b]Estimated hourly labor ($21) plus estimated hourly expenses ($7).
[c]See text for other assumptions.

TABLE A-16
TEST GROUP: TRACE METALS

OPTION[a]	OUTSIDE TESTING[b]			IN-HOUSE TESTING[c]		
TEST IDENTIFICATION	ANNUAL TESTS	UNIT COST,$	ANNUAL COST, $	ANNUAL O & M COST, $[d]	TOTAL HOUR	STAFF FTE
SDWA Metals (8)	1	96.00	101	93	3	0.0
Heavy Metals (6-8 per Group)	22,732	15.00	358,029	183,210	5,910	3.0
Priority Pollutant Metals (13)	1	250.00	263	217	7	0.0
TCLP Metals (8) RCRA Solids (Mtd. of Additions)	431	154.00	69,693	55,583	1,793	0.9
SDWA Secondary Metals (Fe, Mn, Cu, Zn)	1	48.00	50	62	2	0.0
SDWA Proposed Metals (Ag, Al, B, Be, Mo, Na, Ni, Sr, Tl, V)	1	120.00	126	124	4	0.0
TOTALS	23,167		428,262	239,289	7,719	3.9

NOTES: [a]See text for assumptions.
[b]Includes 5% markup for administration.
[c]Includes 30% for QC tests (spike, duplicate, & control sample).
[d]Does not include annual capital costs.

TABLE A-15
TEST GROUP: TRACE METALS

O & M COSTS (LABOR AND EXPENSES)	ANNUAL TESTS	HOURS PER TEST	TOTAL HOURS[a]	$ PER HOUR[b]	ANNUAL COST, $[c]
SDWA Metals (8)	1	2.4	3	31	93
Heavy Metals (6-8 per Group)	22,732	0.2	5,910	31	183,210
Priority Pollutant Metals (13)	1	5.2	7	31	217
TCLP Metals (8) RCRA Sludge (Mtd. of Additions)	431	3.2	1,793	31	55,583
SDWA Secondary Metals (Fe, Mn, Cu, Zn)	1	1.2	2	31	62
SDWA Proposed Metals (Ag, Al, B, Be, Mo, Na, Ni, Sr, Tl, V)	1	3.0	4	31	124
TOTAL O & M	23,167		7,719		239,289
CAPITAL COSTS	UNIT QTY	UNIT COST, $	TOTAL COST, $	YEAR LIFE	ANNUAL COST, $
Analytical Area, ft² (Including 196 ft² Prep. Area)	980	225	220,500	20	11,025
Support Area, ft²	980	100	98,000	20	4,900
Atomic Absorption (AA) Zeeman Spectrophotometer	1	115,000	115,000	10	11,500
AA Mercury/Hydride Device or Separate Mercometer AA	1	9,800	9,800	10	980
TCLP Extraction Device	1	2,000	2,000	10	200
Microwave Sample Digestion System	1	12,000	12,000	10	1,200
Sample Grinding Mill	1	1,500	1,500	10	150
Computer Data System	1	8,000	8,000	10	800
Inductively Coupled Plasma (ICP-23 metals)	1	200,000	200,000	10	20,000
ICP/Mass Spectrometer (ICP/MS) (Future trace level)	*	350,000	0	10	0
Accreditation/Certification	1	500	500	1	500
Miscellaneous Equipment Allowance	1	4,000	4,000	10	400
TOTAL CAPITAL			671,300		51,655
TOTAL CAPITAL PLUS O & M COSTS					290,944

NOTES: [a]Includes 30% for QC tests (spike, duplicate & control sample).
[b]Estimated hourly labor ($21) plus estimated hourly expenses ($10).
[c]See text for other assumptions.
*Future automation options.

TABLE A-18
TEST GROUP: ORGANIC AGGREGATES

OPTION[a]	OUTSIDE TESTING[b]			IN-HOUSE TESTING[c]		
TEST IDENTIFICATION	ANNUAL TESTS	UNIT COST, $	ANNUAL COST, $	ANNUAL O & M COST, $[d]	TOTAL HOUR	STAFF FTE
Total Organic Carbon (TOC)	150	40.00	6,300	5,040	180	0.1
Total Organic Halide (TOX)	1	40.00	42	28	1	0.0
Oil & Grease	2,126	30.00	66,969	50,008	1,786	0.9
Total Petroleum Hydrocarbons (TPH)	1	50.00	53	28	1	0.0
Biochemical Oxygen Demand (BOD)	5,096	35.00	187,278	136,976	4,892	2.4
Chemical Oxygen Demand (COD)	900	25.00	23,625	18,144	648	0.3
Phenols Group	1	45.00	47	28	1	0.0
Methylene Blue Active Substances (Surfactants)	1	30.00	32	28	1	0.0
TOTALS	8,276		284,346	210,280	7,510	3.7

NOTES: [a]See text for assumptions.
[b]Includes 5% markup for administration.
[c]Includes 20% for QC tests (duplicate & control sample).
[d]Does not include annual capital costs.

TABLE A-17
TEST GROUP: ORGANIC AGGREGATES

O & M COSTS (LABOR AND EXPENSES)	ANNUAL TESTS	HOURS PER TEST	TOTAL HOURS[a]	$ PER HOUR[b]	ANNUAL COST, $[c]
Total Organic Carbon (TOC)	150	1.0	180	28	5,040
Total Organic Halide (TOX)	1	1.2	1	28	28
Oil & Grease	2,126	0.7	1,786	28	50,008
Total Petroleum Hydrocarbons (TPH)	1	1.2	1	28	28
Biochemical Oxygen Demand (BOD)	5,096	0.8	4,892	28	136,976
Chemical Oxygen Demand (COD)	900	0.6	648	28	18,144
Phenols Group	1	1.0	1	28	28
Methylene Blue Active Substances (Surfactants)	1	0.7	1	28	28
TOTAL O & M	8,276		7,510		210,280

CAPITAL COSTS	UNIT QTY	UNIT COST, $	TOTAL COST, $	YEAR LIFE	ANNUAL COST, $
Analytical Area, ft²	784	225	176,400	20	8,820
Support Area, ft²	784	100	78,400	20	3,920
BOD Incubator, Walk-in Type	1	44,000	44,000	10	4,400
TOC Analyzer, Water (Low Concentration)	1	21,000	21,000	10	2,100
TOC Analyzer, Wastewater (High Concentration)	1	29,000	29,000	10	2,900
TOX Analyzer	1	18,200	18,200	10	1,820
Infrared (IR) Hydrocarbon Analyzer	1	8,000	8,000	10	800
Computer Data System	2	8,000	16,000	10	1,600
Accreditation/Certification	1	500	500	1	500
Miscellaneous Equipment Allowance	1	2,000	2,000	10	200
TOTAL CAPITAL			393,500		27,060
TOTAL CAPITAL PLUS O & M COSTS					237,340

NOTES: [a]Includes 20% for QC tests (duplicate & control sample).
[b]Estimated hourly labor ($21) plus estimated hourly expenses ($7).
[c]See text for other assumptions.

TABLE A-20
TEST GROUP: ORGANICS I

OPTION[a]	OUTSIDE TESTING[b]			IN-HOUSE TESTING[c]		
TEST IDENTIFICATION	ANNUAL TESTS	UNIT COST, $	ANNUAL COST, $	ANNUAL O & M COST, $[d]	TOTAL HOUR	STAFF FTE
Trihalomethanes (THM)	1	75.00	79	33	1	0.0
Organochlorine Pesticides &/or PCBs	2,060	125.00	270,375	176,748	5,356	2.7
Purgeable Halocarbons	1,368	100.00	143,640	46,959	1,423	0.7
Purgeable Aromatics	1,368	80.00	114,912	41,085	1,245	0.6
EDB/DBCP	1	90.00	95	66	2	0.0
Chlorinated Phenoxy Herbicides	1	150.00	158	99	3	0.0
Organophosphorus Pesticides	1	150.00	158	66	2	0.0
Phenols	1	150.00	158	66	2	0.0
Polynuclear Aromatic Hydrocarbons (PAH)	1	150.00	158	66	2	0.0
TOTALS	4,802		529,733	265,188	8,036	4.0

NOTES: [a]See text for assumptions.
[b]Includes 5% markup for administration.
[c]Includes 30% for QC tests (spike, duplicate, & control sample).
[d]Does not include annual capital costs.

TABLE A-19
TEST GROUP: ORGANICS I

O & M COSTS (LABOR AND EXPENSES)	ANNUAL TESTS	HOURS PER TEST	TOTAL HOURS[a]	$ PER HOUR[b]	ANNUAL COST, $[c]
Trihalomethanes (THM)	1	1.0	1	33	33
Organochlorine Pesticides &/or PCBs	2,060	2.0	5,356	33	176,748
Purgeable Halocarbons	1,368	0.8	1,423	33	46,959
Purgeable Aromatics	1,368	0.7	1,245	33	41,085
EDB/DBCP	1	1.2	2	33	66
Chlorinated Phenoxy Herbicides	1	2.0	3	33	99
Organophosphorus Pesticides	1	1.8	2	33	66
Phenols	1	1.7	2	33	66
Polynuclear Aromatic Hydrocarbons (PAH)	1	1.8	2	33	66
TOTAL O & M	4,802		8,036		265,188

CAPITAL COSTS	UNIT QTY	UNIT COST, $	TOTAL COST, $	YEAR LIFE	ANNUAL COST, $
Analytical Area, ft² (Including 196 ft² Prep. Area)	980	225	220,500	20	11,025
Support Area, ft²	980	100	98,000	20	4,900
Gas Chromatograph (GC) Systems	3	30,000	90,000	10	9,000
VOC System (P & T, Sampler, GC, Detectors, Software)	1	33,000	33,000	10	3,300
Computer Data System	2	10,000	20,000	10	2,000
Accreditation/Certification	1	500	500	1	500
Miscellaneous Equipment Allowance	1	4,000	4,000	10	400
TOTAL CAPITAL			466,000		31,125
TOTAL CAPITAL PLUS O & M COSTS					296,313

NOTES: [a]Includes 30% for QC tests (spike, duplicate, & control sample).
[b]Estimated hourly labor ($21) plus estimated hourly expenses ($12).
[c]See text for other assumptions.

TABLE A-22
TEST GROUP: ORGANICS II

OPTION[a]	OUTSIDE TESTING[b]			IN-HOUSE TESTING[c]		
TEST IDENTIFICATION	ANNUAL TESTS	UNIT COST, $	ANNUAL COST, $	ANNUAL O & M COST, $[d]	TOTAL HOUR	STAFF FTE
Volatile Organic Analyses (VOA)	2,560	225.00	604,800	250,275	5,325	2.7
Semivolatile Organic Analyses, Base/Neutral & Acid Extractables (BNA)	2,590	450.00	1,223,775	506,378	10,774	5.4
Dioxins	220	*	0	47,047	1,001	0.5
TCLP VOAs & BNAs on RCRA Solids (Extract & Analysis)	431	775.00	350,726	136,958	2,914	1.5
TOTALS	5,801		2,179,301	940,658	20,014	10.1

NOTES: [a]See text for assumptions.
[b]Includes 5% markup for administration.
[c]Includes 30% for QC tests (spike, duplicate, & control sample).
[d]Does not include annual capital costs.
*Request quotation for non-routine contract laboratory tests.

TABLE A-21
TEST GROUP: ORGANICS II

O & M COSTS (LABOR AND EXPENSES)	ANNUAL TESTS	HOURS PER TEST	TOTAL HOURS[a]	$ PER HOUR[b]	ANNUAL COST, $[c]
Volatile Organic Analyses (VOA)	2,560	1.6	5,325	47	250,275
Semivolatile Organic Analyses, Base/Neutral & Acid Extractables (BNA)	2,590	3.2	10,774	47	506,378
Dioxins (Hazardous; screen only; contract out)	220	3.5	1,001	47	47,047
TCLP VOAs & BNAs on RCRA Solids (Extract & Analysis)	431	5.2	2,914	47	136,958
TOTAL O & M	5,801		20,014		940,658
CAPITAL COSTS	UNIT QTY	UNIT COST, $	TOTAL COST, $	YEAR LIFE	ANNUAL COST, $
Analytical Area, ft² (Including 392 ft² Prep. Area)	1,568	225	352,800	20	17,640
Support Area, ft²	1,568	100	156,800	20	7,840
Gas Chromatograph/Mass Spectrometer	4	175,000	700,000	10	70,000
Computer Data System	4	20,000	80,000	10	8,000
Purge & Trap Device for Multiple Samples	1	26,200	26,200	10	2,620
Ultrasound Extraction Device	1	3,200	3,200	10	320
TCLP Extraction Device With Zero Head Space	1	8,000	8,000	10	800
Accreditation/Certification	1	500	500	1	500
Miscellaneous Equipment Allowance	1	30,000	30,000	10	3,000
TOTAL CAPITAL			1,357,500		110,720
TOTAL CAPITAL PLUS O & M COSTS					1,051,378

NOTES: [a]Includes 30% for QC tests (spike, duplicate, & control sample).
[b]Estimated hourly labor ($30) plus estimated hourly expenses ($17).
[c]See text for other assumptions.

TABLE A-24
TEST GROUP: RADIOCHEMICAL ANALYSES

OPTION[a]	OUTSIDE TESTING[b]			IN-HOUSE TESTING[c]		
TEST IDENTIFICATION	ANNUAL TESTS	UNIT COST,$	ANNUAL COST, $	ANNUAL O & M COST, $[d]	TOTAL HOUR	STAFF FTE
Gross Alpha	1	45.00	47	26	1	0.0
Gross Beta	1	45.00	47	26	1	0.0
Radium 226/228 (If Required by Gross Alpha)	1	130.00	137	104	4	0.0
TOTALS[e]	3		231	156	6	0.0

NOTES: [a]See text for assumptions.
[b]Includes 5% markup for administration.
[c]Includes 20% for QC tests (duplicate & control sample).
[d]Does not include annual capital costs.
[e]Divide totals by 4 for annual cost comparison.

TABLE A-23
TEST GROUP: RADIOCHEMICAL ANALYSES

O & M COSTS (LABOR AND EXPENSES)	ANNUAL TESTS	HOURS PER TEST	TOTAL HOURS[a]	$ PER HOUR[b]	ANNUAL COST, $[c]
Gross Alpha	1	1.1	1	26	26
Gross Beta	1	0.7	1	26	26
Radium 226/228 (If Required by Gross Alpha)	1	3.2	4	26	104
TOTAL O & M	3		6		156
CAPITAL COSTS	UNIT QTY	UNIT COST, $	TOTAL COST, $	YEAR LIFE	ANNUAL COST, $
Analytical Area, ft^2	196	225	44,100	20	2,205
Support Area, ft^2	196	100	19,600	20	980
Proportional Counter	1	8,200	8,200	10	820
Accreditation/Certification	1	500	500	1	500
Miscellaneous Equipment Allowance	1	500	500	10	50
TOTAL CAPITAL			72,900		4,555
TOTAL CAPITAL PLUS O & M COSTS					4,711

NOTES: [a]Includes 20% for QC tests (duplicate & control sample).
[b]Estimated hourly labor ($21) plus estimated hourly expenses ($5).
[c]See text for other assumptions.

TABLE A-26
TEST GROUP: TOXICITY/BIOASSAY

OPTION[a]	OUTSIDE TESTING[b]			IN-HOUSE TESTING[c]		
TEST IDENTIFICATION	ANNUAL TESTS	UNIT COST, $	ANNUAL COST, $	ANNUAL O & M COST, $[d]	TOTAL HOUR	STAFF FTE
Acute Ceriodaphnia dubia, 5 Dilutions	61	350.00	22,418	15,372	549	0.3
Acute Fathead Minnow, 5 Dilutions	61	450.00	28,823	18,788	671	0.3
Chronic Ceriodaphnia dubia, 5 Dilutions	183	1,200.00	230,580	153,720	5,490	2.7
Chronic Fathead Minnow, 5 Dilutions	183	1,200.00	230,580	153,720	5,490	2.7
MicroTox Screen	1	*	0	84	3	0.0
TOTALS	489		512,401	341,684	12,203	6.0

NOTES: [a]See text for assumptions.
[b]Includes 5% markup for administration.
[c]Includes 30% for QC tests (spike, duplicate, & control sample).
[d]Does not include annual capital costs.
*Request quotation for non-routine contract laboratory tests.

TABLE A-25
TEST GROUP: TOXICITY/BIOASSAY

O & M COSTS (LABOR AND EXPENSES)	ANNUAL TESTS	HOURS PER TEST	TOTAL HOURS[a]	$ PER HOUR[b]	ANNUAL COST, $[c]
Acute Ceriodaphnia dubia, 5 Dilutions, 2 X 2 Plants + 57	61	9.0	549	28	15,372
Acute Fathead Minnow, 5 Dilutions, 2 X 2 Plants + 57	61	11.0	671	28	18,788
Chronic Ceriodaphnia dubia, 5 Dilutions, 6 X 2 Plants + 171	183	30.0	5,490	28	153,720
Chronic Fathead Minnow, 5 Dilutions, 6 X 2 Plants + 171	183	30.0	5,490	28	153,720
MicroTox Screen	1	3.0	3	28	84
TOTAL O & M	489		12,203		341,684

CAPITAL COSTS	UNIT QTY	UNIT COST, $	TOTAL COST, $	YEAR LIFE	ANNUAL COST, $
Analytical Area, ft²	1,176	225	264,600	20	13,230
Support Area, ft²	1,176	100	117,600	20	5,880
Incubator, Testing/Culture	2	7,200	14,400	10	1,440
Incubator, Water Trough with Heater/Chiller	2	2,500	5,000	10	500
MicroTox Screening System	1	20,000	20,000	10	2,000
Computer Data System	1	8,000	8,000	10	800
Accreditation/Certification	1	500	500	1	500
Miscellaneous Equipment Allowance	1	4,000	4,000	10	400
TOTAL CAPITAL			434,100		24,750
TOTAL CAPITAL PLUS O & M COSTS					366,434

NOTES: [a]Does not include a % for QC tests spike duplicate & control sample
[b]Estimated hourly labor $0.00 plus estimated hourly expenses $
[c]See text for other assumptions

TABLE A-28
TEST GROUP: MISCELLANEOUS TESTS

OPTION[a]	OUTSIDE TESTING[b]			IN-HOUSE TESTING[c]		
TEST IDENTIFICATION	ANNUAL TESTS	UNIT COST, $	ANNUAL COST, $	ANNUAL O & M COST, $[d]	TOTAL HOUR	STAFF FTE
Asbestos	20	*	0	0	0	0.0
RCRA Ignitability	331	40.00	13,902	9,268	331	0.2
RCRA Corrosivity	331	10.00	3,476	1,848	66	0.0
RCRA Reactivity	331	60.00	20,853	17,612	629	0.3
TOTALS	1,013		38,231	28,728	1,026	0.5

NOTES: [a]See text for assumptions.
[b]Includes 5% markup for administration.
[c]Does not includes a % for QC tests (duplicate or control sample).
[d]Does not include annual capital costs.
*Request quotation for non-routine contract laboratory tests.

TABLE A-27
TEST GROUP: MISCELLANEOUS TESTS

O & M COSTS (LABOR AND EXPENSES)	ANNUAL TESTS	HOURS PER TEST	TOTAL HOURS[a]	$ PER HOUR[b]	ANNUAL COST, $[c]
Asbestos	20	?	0	28	0
RCRA Ignitability (Flash Point)	331	1.0	331	28	9,268
RCRA Corrosivity (pH)	331	0.2	66	28	1,848
RCRA Reactivity (Cyanide/Sulfide)	331	1.9	629	28	17,612
TOTAL O & M	1,013		1,026		28,728
CAPITAL COSTS	UNIT QTY	UNIT COST, $	TOTAL COST, $	YEAR LIFE	ANNUAL COST, $
Analytical Area, ft²	392	225	88,200	20	4,410
Support Area, ft²	392	100	39,200	20	1,960
Phase-contrast Microscope, Upright (Shared Biological)	*	10,000	0	10	0
Transmission Electron Microscope (TEM)	*	500,000	0	10	0
Pensky-Martins Flash Point Apparatus	1	12,000	12,000	10	1,200
Accreditation/Certification	1	500	500	1	500
Miscellaneous Equipment Allowance	1	2,000	2,000	10	200
TOTAL CAPITAL			141,900		8,270
TOTAL CAPITAL PLUS O & M COSTS					36,998

NOTES: [a]Does not include a % for QC tests (spike, duplicate, & control sample).
[b]Estimated hourly labor ($21) plus estimated hourly expenses ($7).
[c]See text for other assumptions.
*Future option.

TABLE A-30
TEST GROUP: RESEARCH & DEVELOPMENT TESTS

OPTION[a]	OUTSIDE TESTING[b]			IN-HOUSE TESTING[c]		
TEST IDENTIFICATION	ANNUAL TESTS	UNIT COST, $	ANNUAL COST, $	ANNUAL O & M COST, $[d]	TOTAL HOUR	STAFF FTE
Jar Test (Flocculation)	1	*	0	26	1	0.0
Viscosity (Sludge)	1	*	0	26	1	0.0
Microwave Solids (Sludge)	1	*	0	0	0	0.0
Sludge Volume Index (SVI)	1	*	0	26	1	0.0
Capillary Suction Time (CST)	1	*	0	0	0	0.0
TOTALS	5		0	78	3	0.0

NOTES: [a]See text for assumptions.
[b]Includes 5% markup for administration.
[c]Includes 10% for QC tests (duplicate or control sample).
[d]Does not include annual capital costs.
*Request quotation for non-routine contract laboratory tests.

TABLE A-29
TEST GROUP: RESEARCH & DEVELOPMENT TESTS

O & M COSTS (LABOR AND EXPENSES)	ANNUAL TESTS	HOURS PER TEST	TOTAL HOURS[a]	$ PER HOUR[b]	ANNUAL COST, $[c]
Jar Test (Flocculation)	1	1.0	1	26	26
Viscosity (Sludge)	1	0.5	1	26	26
Microwave Solids (Sludge)	1	0.2	0	26	0
Sludge Volume Index (SVI)	1	0.5	1	26	26
Capillary Suction Time (CST)	1	0.2	0	26	0
TOTAL O & M	5		3		78
CAPITAL COSTS	UNIT QTY	UNIT COST, $	TOTAL COST, $	YEAR LIFE	ANNUAL COST, $
Analytical Area, ft²	784	225	176,400	20	8,820
Support Area, ft²	784	100	78,400	20	3,920
Jar Stirrer & Floc Jars	1	1,000	1,000	10	100
Viscometer	1	2,000	2,000	10	200
Microwave Drying System	1	35,000	35,000	10	3,500
CST Meter	1	1,900	1,900	10	190
Miscellaneous Equipment Allowance	1	2,000	2,000	10	200
TOTAL CAPITAL			296,700		16,930
TOTAL CAPITAL PLUS O & M COSTS					17,008

NOTES: [a]Includes 10% for QC tests (duplicate or control sample).
[b]Estimated hourly labor ($21) plus estimated hourly expenses ($5).
[c]See text for other assumptions.

EXAMPLE Table B					
Breakeven Analysis					
Test Group Categories[a]	**Lab List Price**	**Hours Per Test**	**Costs Per Hour**	**Annual Capital Cost**	**Annual Breakeven Quantity**

NOTES:
[a]See Appendix __ for test group details and assumptions.

EXAMPLE Table A

Test Group Summary

Test Group Categories[a]	Annual Costs, $		Attributes	
	Outside Testing	In-House Testing	Staff[b] (FTE)	Area[c] (Ft^2)
Microbiological Parameters				
Biological Parameters				
Physical Parameters				
Solids Tests				
Inorganic Parameters				
Other Inorganics				
Nutrient Parameters				
Trace Metals				
Organic Aggregates				
Organics I				
Organics II				
Radiochemical Analyses				
Toxicity/Bioassay Tests				
Miscellaneous Tests				
Operations Tests[d]				
Totals	0	0	0.0	0

NOTES:
[a]See Appendix __ for test group details and assumptions.
[b]Includes analytical staff, but excludes administration and support staff.
[c]Includes support space, but excludes circulation and non-analytical special purpose areas.
[d]Data turnaround time precludes outside testing.

Appendix B
COST ANALYSIS PROCESS

1. DETERMINE TOTAL ANNUAL OUTSIDE LAB COSTS--BY GROUP

- ANALYSIS--$/TEST
- SHIPPING & HANDLING
- CONTRACT ADMINISTRATION--5%
- QA/QC--30% FOR DUPLICATE, SPIKE, & CONTROL SAMPLE OR LESSER COMBINATIONS OF THESE AS REQUIRED BY THE TESTS

2. DETERMINE TOTAL ANNUAL SELF TESTING COSTS--BY GROUP

- AMORTIZED CAPITAL COSTS (ANNUAL DEPRECIATION OR LEASE)
  - FACILITY = $\frac{FT^2 \times \$/FT^2}{20 \text{ YR EXPECTED LIFE}}$
  - EQUIPMENT = $\frac{\$ \text{ (ITEM + OPTIONS + DATA SYSTEM)}}{\text{YR EXPECTED LIFE (TECHNOLOGICAL)}}$
- ANNUAL O & M
  - MANHOUR LABOR--TECHNICAL, SUPERVISORY, QA/QC (INCLUDE ALL LABOR OVERHEAD--FRINGE, ETC.)
  - HOURLY EXPENSE--CHEMICALS, SUPPLIES, EQUIPMENT (INCLUDE ALL EXPENSE OVERHEAD--SHIPPING, ETC.)

3. FORMULAS:

- STAFF SIZE = $\frac{\text{TESTS X HR/TEST}}{\text{2000 HR/PERSON}}$
- CAPITAL COST = FACILITY + EQUIPMENT (AMORTIZED)
- LABOR COST = TESTS X HR/TEST X $/HR
- EXPENSE COST = TESTS X HR/TEST X $/HR
- O & M COSTS = LABOR COSTS + EXPENSE COSTS
- TOTAL COSTS = CAPITAL + O & M

4. BREAKEVEN ANALYSIS

IN-HOUSE TEST COST $ = OUTSIDE TEST COST $

VARIABLE COST $ + FIXED COST $ = OUTSIDE TEST $

ANNUAL O & M $ + CAPITAL COST $ = OUTSIDE TEST $

SUBSTITUTE AND SOLVE FOR BREAKEVEN TESTS

(TESTS X HR/TEST X $/HR) + CAPITAL $ = (TESTS X $/TEST)

CAPITAL $ = (TESTS X $/TEST) - (TESTS X HR/TEST X $/HR)

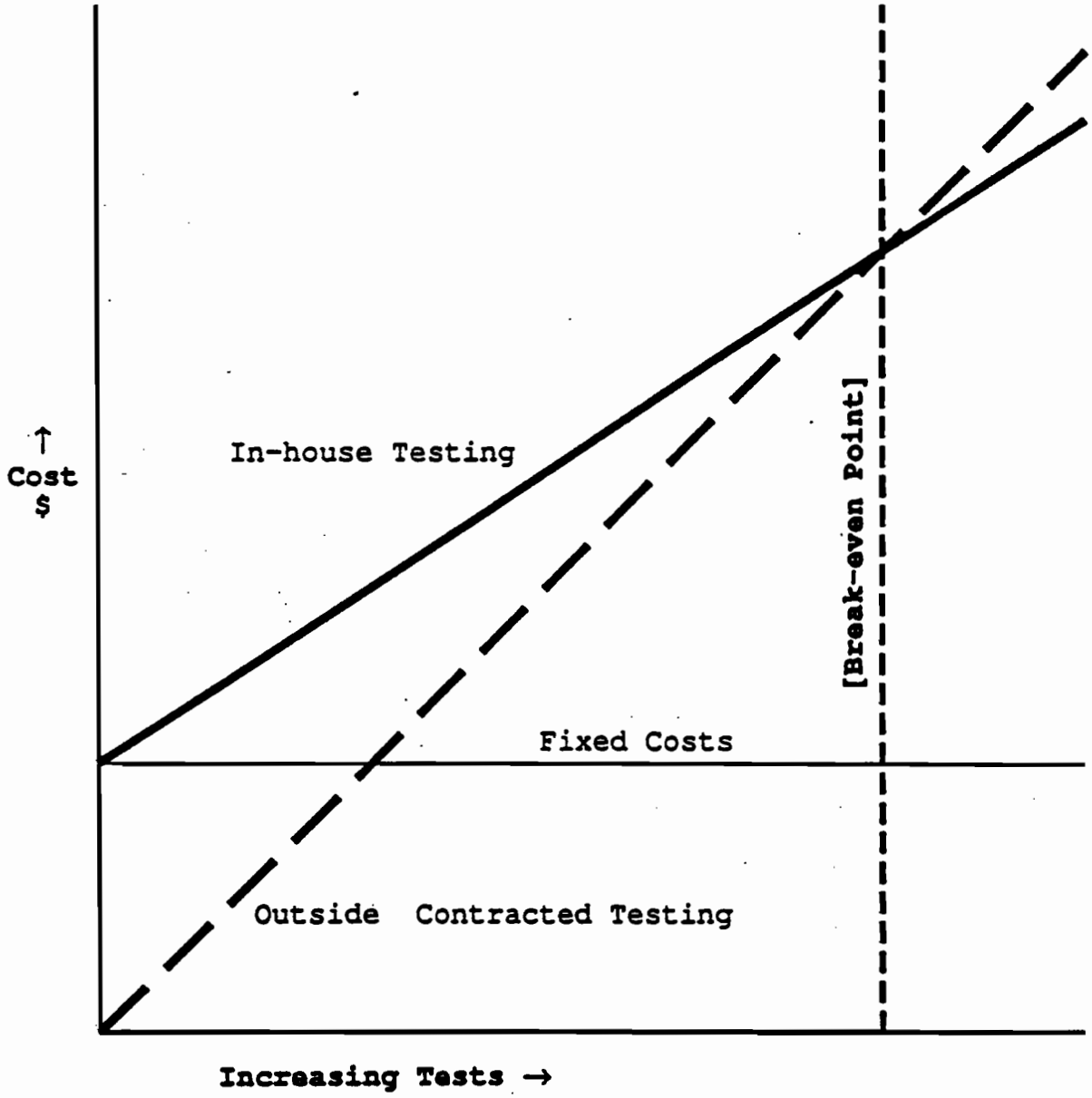
CAPITAL $ = TESTS [$/TEST - (HR/TEST X $/HR)]

TESTS = CAPITAL $ ÷ [$/TEST - (HR/TEST X $/HR)]

CAPITAL $ ÷ [OUTSIDE - IN-HOUSE]

BREAKEVEN ANALYSIS

$$\text{Total} = \underset{\text{[Capital]}}{\text{Fixed}} + \underset{\text{[O \& M]}}{\text{Variable}}$$



Appendix C
LABORATORY SPACE PLANNING

M E M O R A N D U M

TO:

FROM: Earl Hadfield/CH2M HILL CVO

DATE: January 24, 1992

SUBJECT: Laboratory Space Planning

PROJECT: PDX27865.82

This memorandum contains material that should prove useful for a general laboratory space planning meeting. It contains some general questions and a list of potential functional areas.

Potential meeting participants are asked to think about the material and bring their ideas, comments, questions, and concerns to the meeting. In this way, we can have a productive meeting, defining building space requirements and identifying remaining policy decisions that would effect the outcome of the laboratory planning process.

The proposed new laboratory facility will house:

- What analytical activities or programs?
- What administrative activities?
- What other activities, programs, or groups? (e.g. Engineering, R & D, Samplers)

The functional areas listed in the attached table are those often found in similar environmental testing laboratories. The functional areas do not have to be individual rooms, in fact many areas can be combined into common areas. The purpose of listing the areas is to delineate the laboratory building functions and area totals so that the information can be used, along with other programming information, in the eventual preparation of schematic drawings. (Companion memoranda can be provided to further define the laboratory space.)

For simplicity, the areas are arranged by general categories. Adjacencies, proximities, and separations are not to be implied from the categories. Not all areas or categories are needed in a given laboratory; nor are all of the categorical arrangements shown appropriate for that same laboratory. In your thinking, please focus on the functional areas and associated staff rather than the square footage required.

POTENTIAL LABORATORY AREAS

AREA DESIGNATION		TYPE*	STAFF*	FT²
1.	Sample Support			
a.	Covered Vehicle Bay			
b.	Loading Dock			
c.	Boat Storage			
d.	Mud Room			
e.	Sampler Preparation			
f.	Sample Receiving/Log-in			
g.	Walk-in Refrigerator			
h.	Sample Container Storage			
i.	Sample Equipment Storage			
j.	Sample Equipment Maintenance			
k.	Sample Archiving			
	Sample Area Subtotals		0	0
2.	Analytical Support			
a.	Reagent Water System			
b.	Hazardous Waste Storage			
c.	Gas Cylinders-Oxidants			
d.	Gas Cylinders-Flammables			
e.	Equipment Repair/Glass Blowing			
	Analytical Support Subtotals		0	0
3.	Building Support			
a.	Mechanical-HVAC			
b.	Mechanical-Air/Vacuum Compressors			
c.	Communications-Telephone			
d.	Electrical			
e.	Stand-by Power/UPS			
f.	Tool Room/Shop			
g.	Janitor			
h.	Maintenance Office			
	Building Support Subtotals		0	0
4.	Management & Office Support			
a.	Lab Manager Office			
b.	Lab Supervisor-Biology Office			
c.	Lab Supervisor-Microbiology Office			
d.	Lab Supervisor-Inorganic Office			
e.	Lab Supervisor-Organic Office			
f.	Lab Supervisor-Sampling Office			
g.	QA/QC Manager Office			
h.	Engineer Office			
i.	Senior Analyst Offices/Carrels			
j.	Analyst Carrels (Adjacent to Work?)			
k.	Data Management Office			
l.	Data Processing			
m.	Record Storage			
n.	Reception			
o.	Word Processing/Clerical			
p.	Schedule Area			
q.	Purchasing			
r.	Conference Room			
s.	Library			
t.	Training Area			

POTENTIAL LABORATORY AREAS

AREA DESIGNATION		TYPE[a]	STAFF[b]	FT²
u.	Lunch/Break Room			
v.	Staff Interaction Area			
w.	Computer Room			
x.	Office Supply			
y.	Mail Room			
z.	Copy Center			
aa.	First Aid			
ab.	Women's Rest Room			
ac.	Men's Rest Room			
ad.	Unisex Rest Room			
ae.	Women's Locker Room			
af.	Men's Locker Room			
	Management & Office Support Subtotals		0	0
5.	Analytical Area			
a.	Biology			
b.	Toxicity/Bioassay			
c.	Microbiology			
d.	Physical Tests			
e.	Solids Tests			
f.	Inorganics I			
g.	Inorganics II			
h.	Nutrients			
i.	Metals Preparation			
j.	Metals			
k.	Organic Aggregates			
l.	Organics Preparation			
m.	Organics I			
n.	Organics II			
o.	Operations Control Testing (All @ plants?)			
p.	Radiological Testing (Not justified!)			
q.	Virus/Parasite			
r.	Miscellaneous Tests			
s.	Research & Development			
t.	Pilot Testing			
u.	Standards Preparation			
v.	QC Sample Preparation			
	Analytical Area Subtotals		0	0
6.	Equipment, Chemicals, & Supplies Storage			
a.	Near Term Storage			
b.	Long Term Storage/Warehouse			
c.	Hazardous Waste Storage			
d.	Chemical Storage			
e.	Solvent Storage			
	Equipment & Supplies Storage Subtotal		0	0
Totals			0	0
7.	Circulation (X Percent)			0
Area Total				0

NOTES: [a]Types: O=Office, S=Storage, W=Work
[b]Staff refers to number of occupants in the area.

Appendix C
Laboratory Equipment Costs

MEMORANDUM CH2M HILL

TO: Steve Hennebery/SERA Architects

COPIES: File

FROM: Earl Hadfield/CH2M HILL/CVO

DATE: April 3, 1992

SUBJECT: Laboratory Equipment Costs

PROJECT: PDX27865.82

The following table lists the laboratory equipment costs to accompany the laboratory space costs for Portland BES's new Water Pollution Control (WPC) Laboratory. The costs are excerpted from my January 27, 1992 memorandum on space requirements for the laboratory. The table does not include costs for laboratory casework, fume hoods, and built-in equipment normally shown on plans and elevations; these are included in separate cost per square foot for analytical space.

PROPOSED WPC LABORATORY EQUIPMENT[1]

Item Description	Qty	Unit Cost, $	Total Cost, $
Stereo dissecting microscope	1	1,200	1,200
Autoclave, bench top	2	5,500	11,000
Air microbiological incubator	2	3,500	7,000
Block incubator	1	1,800	1,800
Water bath incubator	1	1,700	1,700
Phase contrast & epifluorescence microscope	1	15,000	15,000
Fluorometer	1	6,000	6,000
Centrifuge, bench top refrigerated	1	8,000	8,000
Biohazard hood	1	8,900	8,900
pH meter	1	900	900
Turbidimeter, ratio	1	1,500	1,500
Conductivity meter	1	500	500
Oven	1	2,400	2,400
Furnace	1	1,800	1,800
Balance	2	3,700	7,400

PROPOSED WPC LABORATORY EQUIPMENT[1]

Item Description	Qty	Unit Cost, $	Total Cost, $
Amperometric titrator	1	1,500	1,500
Ion specific electrode meter	1	2,100	2,100
Ion chromatograph	1	22,000	22,000
Dissolved oxygen meter and probes	1	2,700	2,700
Inorganics computer data system	1	8,000	8,000
Cyanide distillation apparatus and glassware	1	3,100	3,100
Spectrophotometer	1	16,000	16,000
Block digestion apparatus and fume manifold	1	6,100	6,100
Flow injection analyzer	1	62,000	62,000
Nutrient computer data system	1	8,000	8,000
Atomic absorption zeeman spectrophotometer	1	115,000	115,000
Mercury analyzer	1	9,800	9,800
TCLP extraction device	1	2,000	2,000
Microwave sample digestion system	1	12,000	12,000
Sample grinding mill	1	1,500	1,500
Metals computer data system	1	8,000	8,000
Inductively coupled plasma	1	200,000	200,000
BOD incubator	4	3,000	12,000
TOC analyzer, low concentration	1	21,000	21,000
TOC analyzer, high concentration	1	29,000	29,000
TOX analyzer	1	18,200	18,200
Infrared hydrocarbon analyzer (oil and grease)	1	8,000	8,000
Organic aggregate computer data system	2	8,000	16,000
Gas chromatograph (GC) system	3	30,000	90,000
VOC GC system	1	33,000	33,000
GC computer data system	2	10,000	20,000
Gas chromatograph/mass spectrometer (GC/MS)	4	175,000	700,000

PROPOSED WPC LABORATORY EQUIPMENT[1]

Item Description	Qty	Unit Cost, $	Total Cost, $
GC/MS computer data system	4	20,000	80,000
Purge & trap device for multiple samples	1	26,200	26,200
Ultrasound extraction device	1	3,200	3,200
TCLP extraction device with zero head space	1	8,000	8,000
Toxicity incubator, testing/culture	2	7,200	14,400
Incubator, water trough with heater/chiller	2	2,500	5,000
Microtox toxicity screening system	1	20,000	20,000
Toxicity/bioassay computer data system	1	8,000	8,000
Pensky-Martens flash point apparatus	1	12,000	12,000
Jar stirrer and flocculation jars	1	1,000	1,000
Viscometer	1	2,000	2,000
Microwave drying system	1	35,000	35,000
CST meter	1	1,900	1,900
Total			1,718,800

[1]Derived from CH2M HILL's January 27, 1992 memorandum entitled "Space Requirements for New Water Pollution Control Laboratory." Use data only for budget purposes because changes in analytical technology will make the above data inaccurate for specific equipment — some equipment will cost more as a result of new technology; other equipment will cost less as a result of maturing technology (e.g. microcomputers).

Appendix D
Laboratory Co-Location Issues

MEMORANDUM CH2M HILL

TO: Steve Hennebery/SERA

COPIES: File

FROM: Earl Hadfield/CH2M HILL/CVO

DATE: April 7, 1992

SUBJECT: Laboratory Co-location Issues

PROJECT: PDX27865.82

This memorandum addresses issues related to co-locating the Portland Bureau of Environmental Services (BES) Water Pollution Control (WPC) Laboratory with the total BES operation when it leaves the Portland Building.

Co-locating the WPC Laboratory with the remainder of the BES has the obvious advantage of nearly direct communication among all elements of the BES organization. Having all staff under one roof facilitates all potential interactions. However, there are factors that require addressing in order to house relatively disparate laboratory functions in a common facility with the Bureau's office functions. The factors described below are provided from a laboratory perspective. An office perspective would probably yield additional co-location factors to address.

With proper planning, the factors below can be successfully addressed, but not without initial or ongoing cost in dollars (or potentially compromised function). The planning process should reconcile differences in laboratory needs and office needs. The additional costs associated with co-location would vary with the location of the common facility. For example, the cost of dedicated laboratory expansion space would most often be higher for a downtown office building than an undeveloped lot.

Factors to address in co-location decisions include the following:

- Timing — BES laboratory and office move-in dates may not coincide; delays for one function could effect the other function.
- Accessibility
  - Sampling crews and suppliers need exclusive off-street shipping and receiving area, including loading dock capable of handling large equipment (not shared with food for restaurant or lunch room).

- Outside agencies, regulated community (industries), and vendors need parking for quick access to the laboratory.

- Growth — Laboratory needs flexibility for the future expansion in pre-designated areas through additions, set-aside space, or pre-planned conversion of non-laboratory space to laboratory space.

- Safety — Though rated as office building occupancy, the laboratory has:

  - Potential chemical and fire hazards.

  - Dangers for general public access.

  - Nuisance odor episodes that give non-technical office staff false impression of safety problems.

- Security — Regulatory agencies and legal concerns require limiting public access to samples and data from sample collection to report generation.

- Separation of Systems

  - HVAC — Laboratory needs non-recirculating air handling system for reasons of safety and sample contamination; office needs recirculating system for reasons of cost; laboratory also has concerns for clean air supply and exhausts isolated from air supply intakes and public areas.

  - Plumbing — Laboratory needs back flow prevention to protect non-laboratory areas from chemical or microbial contamination.

  - Power — Laboratory needs separate, conditioned, and sometimes uninteruptible, power supply system.

  - Drainage — Laboratory needs isolated drains for potential chemical spills and their neutralization.

- Retrofit of Existing Building

  - Demolition and renovation has special problems that can result in more cost than new laboratory space.

- HVAC system needs space for equipment, shafts, and ducts.
- Floor to floor clearance needs to be 15-16 ft. to allow for ducting and building service distribution.
- Circulation patterns need to be flexible for change.
- Existing structural systems often force compromises in function or inefficient use of space.

If you have any questions, comments, concerns, or contributions to the preceding, please communicate them to me.