TC 8526-01
FINAL REPORT

RECONNAISSANCE SURVEY OF LOWER COLUMBIA RIVER

TASK 1 REPORT: PROBLEM AREA AND DATA GAP IDENTIFICATION RANKING FRAMEWORK

AUGUST 22, 1991

Prepared For:
THE LOWER COLUMBIA RIVER BI-STATE PROGRAM

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Prepared By:

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1.0 INTRODUCTION

The purpose of Task 1 (Initial Data Review and Synthesis) of the Reconnaissance Survey of the lower Columbia River is to compile, summarize, and synthesize existing data on water, sediments, and biota in the river to provide a preliminary characterization of the overall health of the lower river. Evaluation of information on the extent of contamination in various media, measured adverse environmental effects, and potential threats to public health will form the basis for indicating the water quality in the lower Columbia River. This information will also be used to identify potential problem areas and data gaps that need to be considered in the design of the reconnaissance survey

In order to identify and prioritize potential problem areas and data gaps, specific screening criteria are needed to classify impacted areas within the lower river system. This document provides a framework to integrate and evaluate complex scientific information in a form that will result in clear delineation of potential problem areas and data gaps and is based on those developed for urban embayments in Puget Sound (Tetra Tech 1984; 1986; 1988a; 1988b) Whereas the goal of the action-level criteria developed for the Puget Sound Estuary Program (PSEP) Toxic Action Plans was to identify, characterize, and remediate toxic problem areas, the goal of the framework developed for the Bi-State Program is to characterize existing water quality conditions in the river and help select sampling locations for the limited resources available for the reconnaissance survey (Task 6) Therefore, no action-levels will be established in this framework, instead only the ranking, based on the magnitude of difference from reference conditions will be used to identify potential problem areas. Steps in the ranking framework include 1) a review of available data, 2) analyses of spatial and temporal trends of water column quality, microbial contamination, sediment contamination, biological community effects, 3) a ranking of potential problem areas, and 4) identification of data gaps.

The preliminary framework uses a suite of indices to initially identify and prioritize problem areas (Figure 1). The magnitude of a problem is established by comparing contaminant and effects indices with regulatory criteria or reference conditions (in the absence of established regulations) The geographical distribution and number of indices exceeding screening criteria

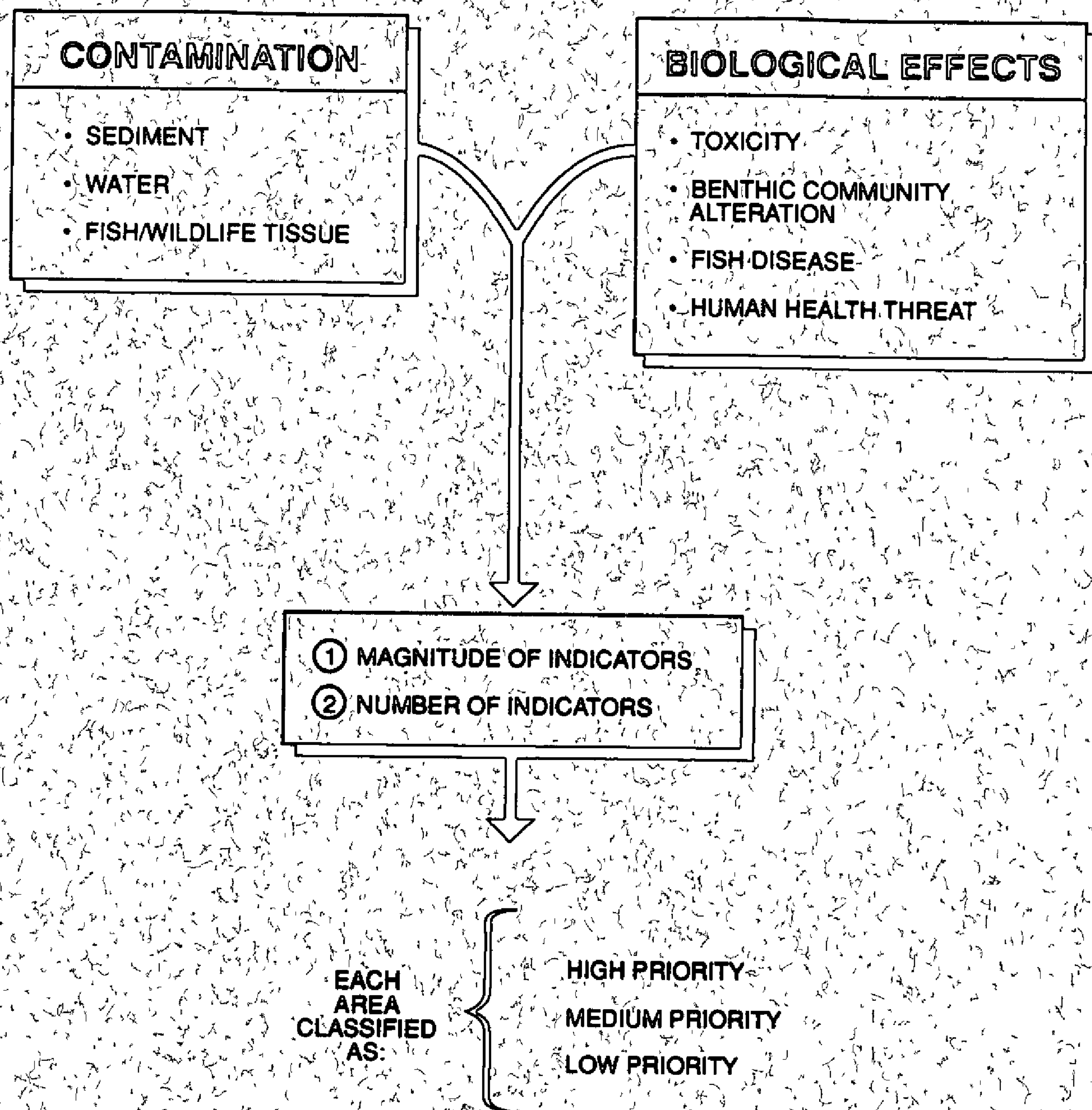

Figure 1. Approach for Evaluating Potential Contamination Problems in the Lower Columbia River

provide additional evidence of impacts to an area of the river. The framework also allows identification of data gaps for each category where little or no data are present.

The framework developed for Task 1 uses existing scientific data for the initial identification of problem areas and data gaps Because the extent and availability of existing data is not yet known, the framework includes evaluation procedures for categories where little or no data exist (e g , microbial concentrations, bioassays) By establishing procedures that address a wide range of data types, these procedures can be applied consistently and appropriately to the data obtained Existing information on the distribution of problem areas or subsequently identified data gaps will be incorporated into the design of the reconnaissance survey sampling plan (Task 6) However, this framework is also intended to 1) provide a preliminary framework for incorporating additional information collected in the reconnaissance survey (Task 6) 2) refine potential problem area identification, and 3) help set priorities for future studies (Task 7).

2.0 PROBLEM AREA AND DATA GAP IDENTIFICATION FRAMEWORK

In order to characterize contaminant distributions in the lower Columbia River and evaluate the ecological and human health significance of those distributions, existing environmental data will be compared to specific screening criteria to define potential water quality problem areas Potential problem areas will be defined, in part, by answering the following questions:

- What are the contaminants of concern?
- What media (sediment, water, biota) are contaminated?
- Is there evidence of adverse ecological impacts?
- Does the magnitude of contamination present a threat to environmental or human health?
- Can proximate contaminant sources be identified?

Answering these questions requires the development of a database with sufficient information to define the spatial distribution of environmental contaminants and biological effects Lack of information will be flagged as a data gap and will be addressed in the design of the reconnaissance survey, where possible.

3.0 SELECTION OF INDICATORS

The primary types of existing information that may be used for problem area identification include both indicators of exposure and indicators of effects:

<u>Indicators of Exposure</u>

- Sediments
  - Contaminant concentrations
  - Geophysical characteristics (e.g., grain size)
  - Conventional sediment chemistry (e.g., TOC)

- Water
  - Contaminant concentrations
  - Conventional chemistry (e.g., DO, pH, etc.)
  - Pathogen abundance (e g., fecal coliform)

- Tissue
  - Contaminant concentrations (e.g., fish, invertebrate, wildlife)
  - Fish liver enzyme activity (i.e., cytochrome P450 and EROD)

<u>Indicators of Effects</u>

- Biota
  - Aquatic community alterations (e.g., reductions in number of individuals or number of taxa)
  - Sediment and effluent toxicity (i.e., bioassays)

Although other variables may be included or only a subset of these variables evaluated as part of Task 1 (based on acceptability or availability of data), those listed form the basis of problem area identification and ranking. The final selection of variables used to identify problem areas will be based on review of the existing data and determination of appropriate and available studies.

Selection of these indicators is based on the following considerations:

- Use of the indicator in past or ongoing studies in the Columbia River
- Documented sensitivity of the response indicator to contaminant effects
- Ability to quantify the indicator within the resource and time constraints of the program

Contaminant levels in sediment, water, and tissue will help establish exposure of aquatic organisms and humans to contaminants. For example, measurement of bioaccumulation in fish provides the following

- A measure of the bioavailability of sediment or water contaminants
- A measure of the potential threat to human health resulting from ingestion of contaminated seafood
- Potential establishment of an important link between bioaccumulation and effects

Response indicators, including benthic macroinvertebrate community structure, fish liver enzyme activity, and sediment toxicity have been selected to characterize several important kinds of potential biological effects. For example, benthic macroinvertebrate community structure has been selected because of its sensitivity to sediment contaminants, importance in local trophic relationships, and ability to establish site-specific response gradients relative to sediment contamination. Although a study of effects on fish populations is beyond the scope of the current project, a study of responses in individual fish may be possible through an assessment of the prevalence of liver enzyme activity. Acute toxicity of sediments may be detected through bioassays and these responses may also be used to establish site-specific response gradients

4.0 DEVELOPMENT OF SCREENING LEVELS

The identification of potential problem areas will be based on the exceedance of a minimum screening level for a contaminant of concern or a biological response variable. The development of screening levels is presented in Figure 2 and involves evaluation of historical data

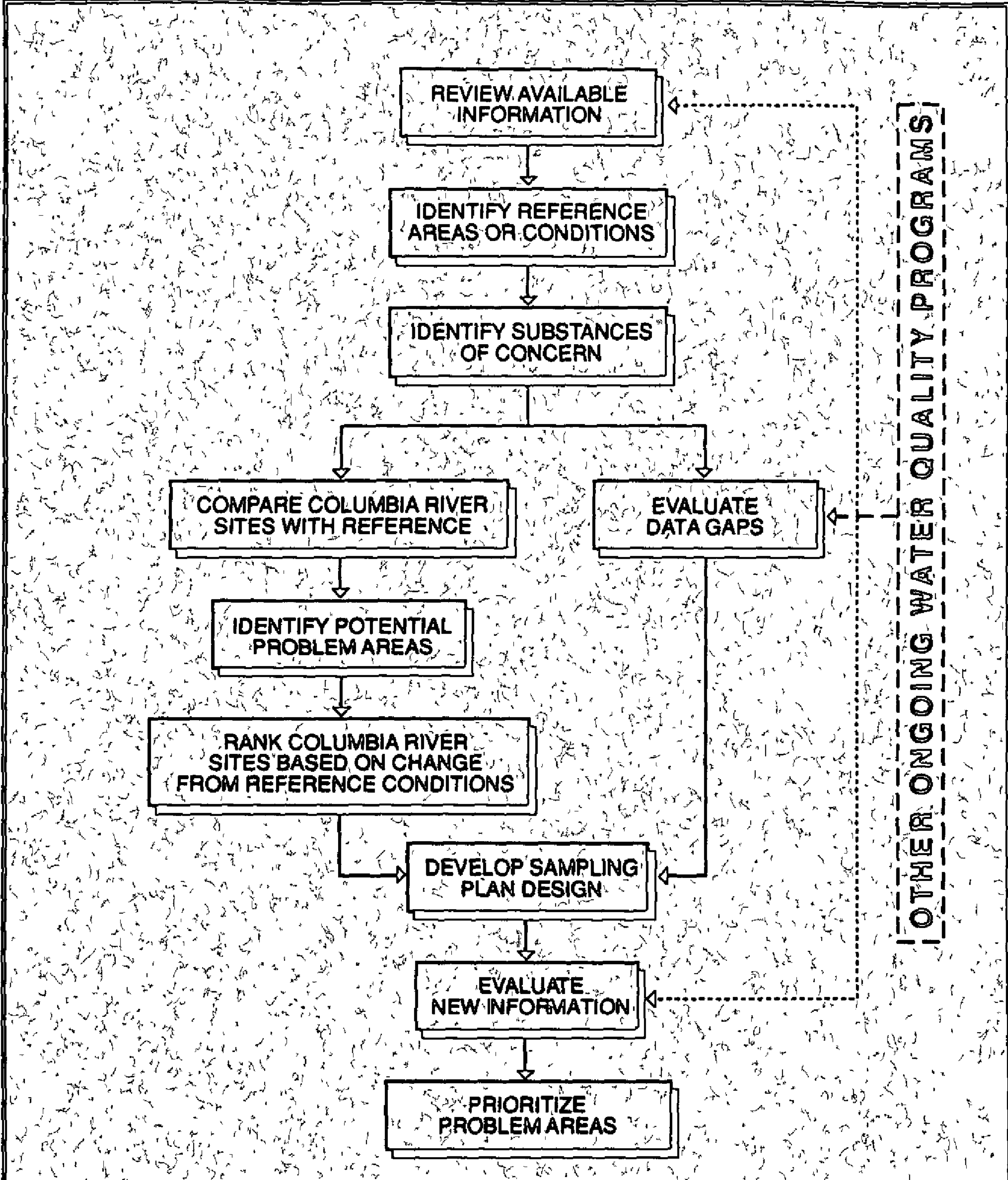

Figure 2. Development of Problem Areas and Data Gap Identification Ranking Framework and Reconnaissance Survey Sampling Plan Design

(1980 to 1990), identification of contaminants of concern, characterization of reference conditions using contaminant and effects indices, and comparison of site contamination levels with regulatory criteria or reference contaminant levels. As discussed above, the preliminary screening levels developed here will be refined in Task 7 by incorporating data collected during the proposed reconnaissance survey as well as other on-going monitoring programs (as the information becomes available).

4.1 Contaminants of Concern

All recent contaminant data from accepted studies will be summarized and contaminants of concern will be selected based on the following criteria:

- Widespread distribution
- Locally elevated concentration
- High hazard to either biota or human health

A preliminary list of chemical contaminants of concern for the lower Columbia River studies is given in Table 1. The preliminary list is composed of the U.S. EPA priority pollutants, plus other chemicals considered to have local significance in the lower Columbia River (e.g., dioxins, furans and radionuclides). Several conventional water and sediment quality variables have also been included to facilitate comparison between areas with different bulk chemical or physical properties. Selection of contaminants of concern for the purpose of initial problem area identification will be based on available historical data.

4.2 Selection of Reference Conditions

All historical data used to characterize the lower Columbia River will be evaluated for use in representing reference area conditions and developing screening levels for both exposure and effects indicators. Candidate reference sites will include those that have been 1) identified as such in existing studies, 2) have few contaminants of concern detected in water, sediment, or tissue collected from that area, and 3) have little indication of biological effects. If adequate data are available, reference conditions will be characterized for each medium (water, sediment, and tissue) and each response index (e.g., macroinvertebrate abundance and diversity, sediment or effluent toxicity). In addition, contaminant level will be stratified by river segment (as defined in Task 3), grain size and total organic carbon content (sediments), and lipid content (tissues).

As a first step, the distribution of contaminant concentrations in each medium will be examined for all accepted studies, and stratified as described above. Data representing the least contaminated sites (i.e., the lowest 20 percent) will be used to establish the reference

TABLE 1. PRELIMINARY LIST OF PRIORITY POLLUTANTS, OTHER SELECTED CONTAMINANTS, AND CONVENTIONAL VARIABLES FOR PROBLEM IDENTIFICATION (page 1 of 2)

Metals

Silver	**Arsenic**
Beryllium	**Cadmium**
Chromium	**Copper**
Mercury	**Nickel**
Lead	**Antimony**
Sellenium	**Thallium**
Zinc	

Volatiles

Chloromethane	**Bromomethane**
Vinyl Chloride	**Chloroethane**
Methylene Chloride	**1,1-Dichloroethylene**
1,1-Dichloroethane	**trans-1,2-Dichloroethylene**
Chloroform	**1,2-Dichloroethane**
1,1,1-Trichloroethane	**Carbon Tetrachloride**
Bromodichloromethane	**1,2-Dichloropropane**
trans-1,3-Dichloropropene	**Trichloroethylene**
Chlorodibromomethane	**1,1,2-Trichloroethane**
Benzene	**cis-1,3-Dichloropropene**
Bromoform	**1,1,2,2-Tetrachloroethane**
Tetrachloroethylene	**Toluene**
Chlorobenzene	**Ethylbenzene**
total Xylenes	

Acid Extractable Organics (Semivolatiles)

Phenol	**2-Chlorophenol**
2-Nitrophenol	**2,4-Dimethylphenol**
2,4-Dichlorophenol	**4-Chloro-3-methylphenol**
2,4,6-Trichlorophenol	**2,4-Dinitrophenol**
4-Nitrophenol	**4,6-Dinitro-2-methylphenol**
Pentachlorophenol	

Base/Neutrals (semivolatiles)

bis(2-Chloroethyl)Ether	**1,3-Dichlorobenzene**
1,4-Dichlorobenzene	**1,2-Dichlorobenzene**
bis(2-Chloroisopropyl)Ether	**N-Nitroso-di-n-propylamine**
Hexachloroethane	**Nitrobenzene**
Isophorone	**bis(2-Chloroethoxyl Methane**
1,2,4-Trichlorobenzene	**Naphthalene**
Hexachlorobutadiene	**Hexachlorocyclopentadiene**
2-Chloronaphthalene	**Dimethylphthalate**
Acenaphthylene	**Acenaphthene**
2,4-Dinitrotoluene	**2,6-Dinitrotoluene**

TABLE 1. PRELIMINARY LIST OF PRIORITY POLLUTANTS, OTHER SELECTED CONTAMINANTS, AND CONVENTIONAL VARIABLES FOR PROBLEM IDENTIFICATION (page 2 of 2)

Base/Neutrals (semivolatiles) - (continued)

Diethylphthalate	4-Chlorophenyl-phenylether
Fluorene	N-Nitrosodiphenylamine
4-Bromophenyl-phenylether	Hexachlorobenzene
Phenanthrene	Anthracene
Di-n-butylphthalate	Fluoranthene
Pyrene	Butylbenzylphthalate
3,3'-Dichlorobenzidine	Benzo(a)Anthracene
bis(2-Ethylhexyl)phthalate	Chrysene
Di-n-octylphthalate	Benzo(b)Fluoranthene
Benzo(k)Fluoranthene	Benzo(a)Pyrene
Indeno(1,2,3-cd)Pyrene	Dibenzo(a,h)Anthracene
Benzo(g,h,i)Perylene	

Pesticides

Aldrin	BHC
Chlordane	4,4'DDD
4,4'DDE	4,4'DDT
Dieldrin	Endosulfan
Endrin	Endrin aldehyde
Heptachlor	Toxaphene

Other Contaminants

Dioxins	Furans
Radionuclides	

Conventionals

Bacteria	Dissolved Oxygen
Temperature	Nitrates
Ammonium	Phosphate
Suspended Solids	TOC
Sediment Grain Size	

range of chemical concentrations As a second step, biological effects data for sites representing the lowest chemistry values will be examined to see if they corroborate the chemistry data. However, it is likely that reference values for biological effects will be developed independently of contaminant data because of the lack of synoptic data for a given site In this case, a similar approach as described for sediment data will be used for biological data The frequency distribution of each effects index will be tabulated. Those areas with biological effects values indicating the least impact (e g , greatest diversity and abundance values) will be used to represent reference conditions Given sufficient data, reference values will be developed by habitat type

4.3 Calculation of Screening Levels

Existing regulatory criteria will be used as screening levels for the lower Columbia River Reconnaissance Survey for the purpose of problem area identification and ranking. State and federal water quality criteria will be used as the screening levels for contaminants measured in the water column. Where water quality criteria between states or between state and federal criteria disagree, the more conservative (i.e., lower value) will be used (Table 2).

In the absence of numeric criteria, screening values will be derived from the subset of data selected to represent reference conditions. A single representative reference value for each contaminant of concern in each medium will be calculated. The same process will be applied to biological effects indices for each habitat type represented in the historical data. Calculations of average values may not provide an accurate representation of reference values because environmental data often have statistical distributions that deviate from normal or Gaussian distributions Representative values for a given exposure or response index will be developed by performing an analysis of the frequency distribution of data from selected reference areas. Use of the 50th percentile reference value is proposed as the screening level for each indicator, except in the cases where regulatory criteria exist (e.g., water quality criteria).

If no reference data are available for specific contaminants or media (as may be the case for some of the variables evaluated in Task 1), alternative screening levels are proposed. For the case of sediment contaminants, the Washington State Sediment Standards may be used as screening levels. Bioaccumulation data may be compared to Food and Drug Administration (FDA) limits for human consumption to evaluate the relative threat to human health Sediment or effluent toxicity data may be compared to U.S. Environmental Protection Agency (U S EPA) reference toxicant data, in the absence of reference values.

TABLE 2 SUMMARY OF PROPOSED SCREENING LEVEL MARINE WATER QUALITY CRITERIA FOR THE LOWER COLUMBIA RIVER

Pollutant	Concentrations (ug/L) Marine Acute	Marine Chronic	Freshwater Acute	Freshwater Chronic
Acenaphthene	970[a]	710[a]	1,700[a]	520[a]
Acrolein	55[a]	b	68[a]	21[a]
Acrylonitrile	b	b	7,550[a]	2,600[a]
Aldrin	0 71[d]	0 0019[g]	2 5[d]	0 00192[g]
Ammonia (unionized NH_3)	0 233[e]	0 035[f]	--[h,i]	--[h,i]
Antimony	e	b	9,000[a]	1,600[a]
Arsenic	b	b	--	--
Pentavalent	2,319[a]	b	850[a]	48[a]
Trivalent	69[e]	36[f]	360	190
Asbestos	b	b	--	--
Benzene	5,100[a]	700[a]	5,300[a]	--
Benzidine	b	b	2,500[a]	--
Beryllium	b	b	130[a]	5 3[a]
Cadmium	43[e]	9 3[f]	3.9[h]	1 1[h]
Carbon tetrachloride	50,000[a]	b	35,200[a]	--
Chlordane	0 09[d]	0 004[g]	2.4[d]	0 0043[g]
Chlorinated benzenes	160[a]	129[a]	250[a]	50[a]
Hexachlorobenzene	160[a]	129[a]	--	--
Chlorinated ethanes				
Dichloroethane 1,2	113,000[a]	b	118,000[a]	20,000[a]
Hexachloroethane	940[a]	b	980[a]	540[a]
Pentachloroethane	390[a]	281[a]	7,240[a]	1,100[a]
Tetrachloroethane 1,1,2,2	9,020[a]	b	--	2,400[a]
Trichloroethane 1,1,1	31,200[a]	b	--	--
Trichloroethane 1,1,2	b	b	--	9,400[a]
Chlorinated ethylenes				
Dichloroethylenes	224,000[a]	224,000[a]	11,600[a]	--
Tetrachloroethylene	10,200[e]	450[a]	5,280[a]	840[a]
Trichloroethylene	2,000[a]	b	45,000[a]	21,900[a]
Chlorinated naphthalene	7 5[a]	b	1,600[a]	--
Chlorinated phenols				
Chlorophenol 2	b	b	4,300[a]	2,000[a]
Chlorophenol 4	29,700[a]	b	--	--
Dichlorophenol 2,4	b	b	2,020	365
Pentachlorophenol (penta)	13[e]	7 9[f]	20[i]	13[i]
Tetrachlorophenol 2,3,5,6	440[a]	b	--	--
Trichlorophenol 2,4,6	b	b	--	970
Chloride	--	--	860 0h[e]	230 0h[f]
Chlorine	13[e]	7 5[f]	19.0	11 0
Chloroalkyl ethers	b	b	238,000[a]	--
Chloroethyl ether (bis-2)	b	b	--	--
Chloroform	b	b	28,900[a]	1,240[a]

TABLE 2 (Continued)

Pollutant	Concentrations (ug/L) Marine Acute	Marine Chronic	Freshwater Acute	Freshwater Chronic
Chloroisopropyl ether (bis-2)	b	b	--	--
Chloromethyl ether (bis)	b	b	--	--
Chlorpyrifos	0.011[e]	0.0056[f]	0.083	0.041
Chromium				
Hexavalent	1,100[e]	50[f]	16	11
Trivalent	10,300[a]	b	1,700[h]	210[h]
Copper	2.9[e]	2.9[f]	18[h]	12[h]
Cyanide	1.0[e]	1.0[f]	22	5.2
DDT	0.13[d]	0.001[g]	1.1	0.001
DDT Metabolites				
DDD	3.6[a]	b	0.06[a]	--
DDE	14[a]	b	1,050[a]	--
Demeton	b	0.1	--	0.1
Dichlorobenzenes	1,970[a]	b	1,120[a]	763[a]
Dichlorobenzidines	b	b	--	--
Dichloropropanes	10,300[a]	3,040[a]	23,000[a]	5,700[a]
Dichloropropenes	790[a]	b	6,060[a]	244[a]
Dieldrin	0.71[d]	0.0019[g]	2.5	0.0019
Dimethylphenol 2,4	b	b	2,120[a]	--
Dinitrotoluenes	590[a]	370[a]	330[a]	230[a]
Dinitrotoluene 2,4	590[a]	370[a]	--	--
Dioxin (2,3,7,8-TCDD)	b	b	0.01[a]	0.0001[a]
Diphenylhydrazine 1,2	b	b	270[a]	--
Dissolved oxygen	>6 mg/L		>8 mg/L	
Endosulfan	0.034[d]	0.0087[g]	0.22[a]	0.056[a]
Endrin	0.037[d]	0.0023[g]	0.18	0.0023
Ethylbenzene	430[a]	a	32,000[a]	--
Fecal coliform	100/100 mL		14/100 mL	
Fluoranthene	40[a]	16[a]	3,980[a]	--
Guthion	b	0.01	--	0.01
Haloethers	b	b	360[a]	122[a]
Halomethanes	12,000[a]	6,400[a]	11,000[a]	--
Heptachlor	0.053[d]	0.0036[g]	0.52	0.0038
Hexachlorobutadiene	32[a]	b	90[a]	9.3[a]
Hexachlorocyclohexane (HCH)				
HCH-alpha	b	b	--	--
HCH-beta	b	b	--	--
Lindane (HCH-gamma)	0.16[d]	b	2.0	0.08
HCH (mixture of isomers)	0.34[a]	b	--	--

TABLE 2 (Continued)

Pollutant	Concentrations (µg/L) Marine Acute	Marine Chronic	Freshwater Acute	Freshwater Chronic
Hexachlorocyclopentadiene	7.0[a]	b	7.0[a]	5.2[a]
Isophorone	12,900[a]	b	117,000[a]	--
Lead	140[e]	5.6[f]	82[h]	3.2[h]
Malathion	b	0.1	--	0.1
Manganese	b	b	--	--
Mercury	2.1[e]	0.025[f]	2.4	0.12
Methoxychlor	b	0.03	--	0.03
Mirex	b	0.001	--	0.001
Naphthalene	2,350[a]	b	2,300[a]	620[a]
Nickel	75[d]	8.3[g]	1,400[h]	160[h]
Nitrobenzene	6,680[a]	b	27,000[a]	--
Nitrophenols	4,850[a]	b	230[a]	150[a]
Dinitrophenols	4,850[a]	b	--	--
Dinitro-o-cresol 2,4	4,850[a]	b	--	--
Nitrosamines	3,300,000[a]	b	--	--
Nitrosodibutylamine	3,300,000[a]	b	5,850[a]	--
Nitrosodiethylamine	3,300,000[a]	b	--	--
Nitrosodimethylamine	3,300,000[a]	b	--	--
Nitrosodiphenylamine	3,300,000[a]	b	--	--
Nitrosopyrrolidine	3,300,000[a]	b	--	--
Parathion	b	b	0.065	0.013
pH	6.5-8.5		7.0-8.5	
Phenol	5,800[a]	b	10,200[a]	2,560[a]
Phosphorous (elemental)	b	0.1	--	--
Phthalate esters	2,944[a]	3.4[a]	940[a]	3[a]
Dibutylphthalate	b	b	--	--
Diethylphthalate	b	b	--	--
Dimethylphthalate	b	b	--	--
Di-2-ethylhexylphthalate	b	b	--	--
Polychlorinated biphenyls	10[a]	0.03[g]	2.0	0.014
Polynuclear aromatic hydrocarbons	300[a]	b	--	--
Selenium (inorganic selenite)	410[d]	54[g]	260	35
Silver	2.3[d]	b	4.1[h]	0.12
Sulfur (hydrogen sulfide, H_2S)	b	2[g]	--	2.0
Temperature °C	≤18° C		≤16° C	
Thallium	2,130[a]	b	1,400[a]	--
Toluene	6,300[a]	5,000[a]	17,500[a]	--
Toxaphene	0.21[e]	0.0002[f]	0.73	0.0002
Turbidity	≤5 NTU above background			

TABLE 2. (Continued)

	Concentrations (ug/L)			
	Marine		Freshwater	
Pollutant	Acute	Chronic	Acute	Chronic
Vinyl chloride	b	b	--	--
Zinc	95[e]	86[f]	120[h]	110[h]

D = Detected in effluent

ND = Not detected in effluent

NR = Not reported

[a] Data insufficient to derive criteria Value presented is the lowest observed effect level (LOEL) These concentrations represent apparent threshold levels for acute and/or chronic toxic affects, and are intended to convey information about the degree of toxicity of a pollutant in the absence of established criteria

[b] Criterion has not been established for marine water quality

[c] Human health criteria for carcinogens at the 10^{-6} risk level, assuming lifetime consumption of 6 5 g/day average of contaminated fish and/or shellfish for a 70 kg male person.

[d] Not to be exceeded at any time

[e] Maximum 1-h average Not to be exceeded more than once every 3 yr.

[f] Maximum 96-h (4 day) average Not to be exceeded more than once every 3 yr

[g] Maximum 24-h average Not to be exceeded more than once every 3 yr.

[h] Hardness dependent criteria (100 mg/L used)

[i] pH dependent criteria (7 8 pH used)

References. Goldbook=U S. EPA 1986, Update No 2=U S. EPA 1987

5.0 COMPARISON WITH SCREENING LEVELS

Once the screening levels for each chemical or biological indicator have been identified, values observed at specific sites will be compared with these screening values to establish an index reflecting the degree of contamination. This index is termed Elevation Above Reference (EAR) and is calculated as the ratio of a given variable to a reference value for that variable. These indices are used to reduce large data sets into interpretable numbers that reflect the magnitude of the different indicators among areas. As presented above, the 50th percentile reference value will be used for each index because of the difficulty in representing "average" or reference conditions.

The index for water column contamination (WI_i) is expressed as:

$$WI_i = C_{si} / C_{ci}$$

where

C_{si}	=	Contaminant concentration i at a study area
C_{ci}	=	State or federal water quality criteria concentration for contaminant i

The index for pathogen abundance (BAC_i) is expressed as:

$$BAC_i = A_{si} / A_{ci}$$

where

A_{si}	=	Bacterial abundance at study area i
A_{ci}	=	State water quality criteria concentration

The index for sediment contamination (SI_i) is expressed as:

$$SI_i = C_{si} / C_{r50}$$

where

C_{si}	=	Contaminant concentration i at a study area
C_{r50}	=	Contaminant concentration (50th percentile) at a reference area

The index for sediment or effluent toxicity (TI_i) is expressed as:

$$TI_i = M_{si} / M_{r50}$$

where.

M_{si} = Survival or abnormality rate i at a study area
M_{r50} = Survival or abnormality rate (50th percentile) at the reference area(s)

The index for bioaccumulation (BI_i) is expressed as:

$$BI_i = C_{si} / C_{r50}$$

where

C_{si} = Tissue concentration of contaminant or contaminant group i at a study area
C_{r50} = Tissue concentration of contaminant or contaminant group (50th percentile) at the reference area(s)

Benthic community structure cannot be measured by a single indicator, but by several community indicators that can reflect deleterious community alterations (e.g., abundance, species richness, and species dominance). Most of the multiple benthic community structure indices (BCI) are calculated as the inverse ratio of the value for these selected community indicators at study sites relative to reference areas:

$$BCI_i = BC_{r50} / BC_{si}$$

where.

BC_{r50} = The value of a selected benthic community structure indicator i (50th percentile) at the reference area
BC_{si} = The value of the same benthic community structure indicator i at the study area

An inverse ratio is used for most benthic community structure indicators because values for affected study sites would be lower than those at reference sites. For example, contaminated sites will probably have reduced numbers of species or reduced numbers of amphipods relative to reference sites. An increase in the index would therefore reflect a decrease in absolute value of the variable but an increase in adverse effect relative to reference conditions.

6.0 PRIORITIZATION OF AREAS

Prioritizing areas of the river for further study in the reconnaissance survey will be based on a ranking of each indicator variable calculated for each medium (e.g., sediment, water, tissue). These calculations will be made for each station with adequate data, or stations grouped by river segment or other appropriate area. Areas with contaminants or effects exceeding screening levels will then be ranked for each medium. Data gaps will be identified for each indicator variable and for each river segment. Areas with few stations or studies with only a limited number of variables will be identified as data gaps. Areas with no information will be ranked higher than areas where some data exists. Those areas with the highest potential problem area ranks or most data gaps will be summarized for each medium. Areas with many sample sites and substantial amounts of data may be avoided as part of the reconnaissance survey, whereas areas with few sample points and little data will be targeted for further sampling.

As indicated in the above sections, the ranking framework is largely based on development of indices for contamination and biological effects relative to a reference site or reference condition. Ideally, the various contaminant and biological effects indices would be compiled into an assessment matrix where the number and magnitude of the various indices relative to reference conditions could be used to score and rank potential problem areas. However, for the lower Columbia River, the development of an assessment matrix and a systematic scoring procedure may not be feasible because such an approach is based on the availability of synoptic data for a number of complementary variables (e.g., sediment chemistry, toxicity, biological communities) as measured at a large number of sites. The data available from the lower Columbia River are derived from a wide number of studies conducted at various times during the past 5-10 yr, and which varied considerably in study objectives, study design, sampling locations, sampling variables, and analytical methods. Consequently, problem area definition for the lower Columbia River will be based on a more general categorization of the contaminant and biological effects indices.

Three priority levels (i.e., highest priority, secondary priority, low priority) will be established based on the magnitude of the various indices for each type of medium. An example of this approach is shown in Table 3. Theoretical data rather than actual study area data were used in this table to illustrate how information from multiple indicators can be integrated for an

TABLE 3. THEORETICAL EXAMPLE OF CRITERIA FOR PRIORITIZING PROBLEM AREAS[a]

Data Category	Highest Priority	Secondary Priority	Low Priority
Eutrophication	Minimum dissolved oxygen <3.0 mg/L	Minimum dissolved oxygen 3.0–5.0[b] mg/L	Minimum dissolved oxygen >5.0[b] mg/L
Toxic contamination			
Sediment chemistry	Metals: EAR >50 Organics: EAR >100	Metals: EAR 10–50 Organics: EAR 10–100	Metals: EAR <10 Organics: EAR <10
Water column chemistry[c]	Metals: EAR[d] >50 Organics: EAR >100	Metals: EAR 10–50 Organics: EAR 10–100	Metals: EAR <10 Organics: EAR ≤10
Bioassay	Amphipod >50% mortality Oyster >50% mortality	Amphipod 25–50% mortality Oyster 25–50% mortality	Amphipod <25% mortality Oyster <25% mortality
Microbial contamination	Fecal coliform bacteria EAR >10	Fecal coliform bacteria EAR 1[d]–10	Fecal coliform bacteria EAR <1[d]

[a] See text for explanation of criteria.

[b] Class B water quality standard for marine waters.

[c] Water column EARs based on appropriate water quality standard.

[d] Fecal coliform bacteria EAR value of 1 corresponds to the appropriate water quality standard for Class A or Class B marine waters.

overall evaluation and prioritization of different areas. For this example, only general indices such as "sediment contamination" or "eutrophication" are presented. In the actual application, multiple indices of different types of sediment contamination will be evaluated, including separate measures for groups of organic compounds and metals. Similarly, the benthic macroinvertebrate category will include specific measures of benthic community structure However, the selected indices will only be those that are common among studies Evaluation of information in this format enables decision-makers to answer several questions

- Is there an increase in sediment contamination, sediment toxicity, or biological effects at any study area?

- What combination of indicators is elevated?

- What are the relative magnitudes of the elevated indices (e.g., which pose the greatest relative threats)?

In the theoretical example shown in Table 3, specific criteria are developed for each index In this way, each study area on the lower Columbia (e g , River Segments 1-4) can be prioritized in terms of potential problems by summing the number of indices that are found in each of the three priority levels for each area For example, if in river segment 1B, all the indices fell into the highest priority level, then this area would receive a higher priority for further study in the reconnaissance survey than an area where most of the indices fell into the low priority level The sum of the number of indices in each priority level will be compiled and then an overall site ranking will occur which will lead to setting of priorities for potential problem areas for each area.

The presence or lack of data (data gaps) will be factored into the reconnaissance survey more informally than the scheme described for problem areas, to help in identifying areas for further study. For example, areas with no data or ongoing studies will be identified as a high priority data gap, whereas areas with some existing data or a single sampling point, will receive a moderate data gap priority

Using this assessment approach, contamination and effects may be analyzed at several levels of spatial resolution (e.g., the entire project area, smaller study areas within the project area, or individual stations). Detailed examination of each study area may be necessary because spatial heterogeneity of contamination can be relatively high. For example, past studies may have identified apparent "hot spots" near contaminant sources In such situations, it is important to determine if broad-scale sediment toxicity, or biological effects detected in the area result only from localized contamination. Alternatively, examination of a larger study area (e.g., river segments) may provide an overview of the conditions throughout the river segment or identify large data gaps for that area.

Because of their mobility, fishes used in the bioaccumulation and enzyme assessments may not be appropriate for studying localized effects (although this is dependent on the individual species), but can be used to characterize generalized areas. Quantitative relationships among sediment contaminant levels, benthic infauna, and water column contaminants may be used to evaluate small-scale response gradients. Such relationships may be used to predict the occurrence of biological problems in an area where chemistry data are available but biological data are not.

The results of the ranking and evaluation of the spatial distribution of problem areas will provide a basis for the design of the reconnaissance survey. Project resources will be directed towards the areas having the highest priority based on either problem area ranking or lack of information.

7.0 REFERENCES

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