Technical Support Document for Revision of the Dredged Material Management Program Bioaccumulative Chemicals of Concern List

September, 1998

Prepared for the Agencies of the Dredged Material Management Program

By: Erika Hoffman
US EPA Region 10

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ACRONYMS

BCoC - bioaccumulative contaminant of concern
BT - bioaccumulation trigger levels
BCF - bioconcentration factor
CoC - chemicals of concern
COE - Corps of Engineers
DAIS - Dredged Analysis Information System
DMMP - Dredged Material Management Program
EPA - Environmental Protection Agency
EPWG - Evaluation Procedures Workgroup
ERED – Environmental Residue Effects Database
FW – fresh water
LOED – lowest observed effects dose
Log Kow – log of the octanol/water partitioning coefficient
LUED – lowest unquantified effects does
ML – maximum level
NOED – no observed effects dose
PAH - polycyclic aromatic hydrocarbon
PCB - polychlorinated biphenyl
POC – pollutant of concern
PS – Puget Sound
PSDDA - Puget Sound Dredged Disposal Analysis
PSEP- Puget Sound Estuary Program
SQC - sediment quality criteria
SL – screening level
SW – sea water
WDOE - Washington State Department of Ecology
WSPMP - Washington State Pesticide Monitoring Program

EXECUTIVE SUMMARY

The DMMP Bioaccumulative Contaminant of Concern (BCoC) list, in its current form, is not an accurate reflection of the chemicals that are being used in the State of Washington or detected in sediments and tissue monitoring programs. There are several chemicals on the list that are rarely, if ever, observed in aquatic organisms. Other chemicals are missing from the BCoC list that have the potential to be or are chemicals of concern relative to bioaccumulation in aquatic organisms. This report recommends a list of chemicals to be considered when revising the BCoC list. It also provides chemical-specific information on the use, distribution, and bioaccumulative potential of these chemicals, and suggests important criteria to be used in deciding whether or not to include a chemical on the revised BCoC list.

BACKGROUND

Existing Framework for Bioaccumulation Testing

Washington State's Dredged Material Management Program (DMMP) developed the existing conceptual framework for conducting and interpreting bioaccumulation tests ten years ago (EPTA, 1988). Under this framework, bioaccumulation testing is conducted on dredged material for which there is a "reason to believe" that chemicals of concern may accumulate to unacceptable levels in the tissues of target organisms. The DMMP currently identifies thirty bioaccumulative chemicals of concern (BCoC). If sediment concentrations of any these BCoCs exceed bioaccumulation trigger levels (BT) established by the DMMP (see Table 1), then there is "reason to believe" there is a potential risk to human health and/or that aquatic organisms could accumulate contaminants to levels constituting an unacceptable adverse effect.

Table 1. Current DMMP List of Chemicals of Concern for Bioaccumulation

Metals/Organometals:
Antimony
Arsenic
Mercury
Nickel
Silver
Tributyltin

PAHS:
Benzo(a)pyrene
Fluoranthene

Pesticides:
Aldrin
Chlordane
DDT (total)
Dieldrin
Heptachlor

Volatile Organics:
Ethylbenzene
Trichloroethene
Tetrachloroethene

Phthalates:
Dimethyl phthalate
Di-n-butyl phthalate
Bis(2-ethylhexyl)phthalate

Chlorinated Hydrocarbons:
1,2-Dichlorobenzene
1,3-Dichlorobenzene
1,4-Dichlorobenzene
Hexachlorobenzene

Phenols:
Phenol
Pentachlorophenol

Misc. Extractables:
Hexachloroethane
Hexachlorobutadiene
N-Nitrosodiphenylamine

Other:
PCB (total)
PCDD/PCDF

In such cases, the DMMP agencies require bioaccumulation testing, in addition to toxicity tests, in order determine sediment suitability for unconfined, open-water disposal. This approach to the evaluation of dredged material proposed for unconfined aquatic disposal is consistent with the recently finalized EPA/COE national guidance contained in the *Evaluation of Dredged Material Proposed for Discharge in Waters of the United States*, or "Inland Testing Manual" (COE/EPA, 1998).

The original BCoC list and corresponding BT values were derived in 1988 by the Evaluation Procedures Workgroup (EPWG) of the Puget Sound Dredged Disposal Analysis (PSDDA) program. EPWG evaluated and reached consensus on the BCoC list based on a consideration of the best available monitoring and risk assessment information at the time. This information included both human health risk and ecological risk, as required by the Clean Water Act and implementing regulations. However, because relatively little was known about tissue residues and associated effects in 1988, the guidelines developed and currently implemented relied heavily on human health considerations. To ensure ecological health was addressed, the agencies established safety factors in the form of other guidelines for management of open-water disposal sites (EPTA 1988, MPR 1988). The agencies recognized that issues associated with bioaccumulation would need to be revisited as more tissue-effects data and ecological risk information became available.

Rationale and Context for Revising the DMMP's Bioaccumulative Contaminants of Concern List

Revising the DMMP's current BCoC list is necessary because in many respects this list does not adequately reflect those chemicals that are actually measured and detected in sediments and tissues of aquatic organisms in Washington State. For example, several contaminants currently on the list are rarely detected in sediments or tissues while other frequently detected contaminants that are expected to bioaccumulate do not appear on the list. Furthermore, the scope and availability of residue-effects information is now greatly expanded, facilitating use of ecological risk information in dredged material management decisions.

However, revising the BCoC list is just a first step in a larger process to reevaluate the DMMP's existing framework for assessing bioaccumulation. The proposed process has been outlined in a draft Issue Paper presented at the 1998 Sediment Management Annual Review Meeting (Malek and Gries, 1998). There are several reasons why the DMMP agencies have decided to revise the bioaccumulation framework and guidance. First, some of the human health information on which existing BTs are based needs to be updated (e.g., fish consumption rates). Second, there have been many advances since 1988 in the state of knowledge of bioavailability, bioaccumulation, biomagnification and their implications for human health and ecological risk. Finally, EPA Regions and Corps Districts are expected to jointly develop and issue regional implementation guidance for dredged material testing based on the recently finalized Inland Testing Manual (COE/EPA, 1998).

Information in this report was compiled by EPA staff during the summer and fall of 1997 and presented to the DMMP agencies for review. Following limited internal and external technical review, the report was finalized. The final report was presented for broader peer and public review as an attachment to a draft Status Report at the 1998 Sediment Management Annual Review Meeting. Development of the revised BCoC list will be the responsibility of a workgroup made up of agency staff, technical experts and affected users (e.g., port districts). In addition to revising the DMMP's BCoC list, the charge of the workgroup will be to re-evaluate the conceptual framework for addressing bioaccumulation within the overall context of dredged material management.

PURPOSE

The purpose of this report is to summarize and discuss the extensive body of information characterizing the distribution, bioavailability and risks associated with various contaminants found in sediments and tissues of aquatic organisms in Washington State. Summary information from the general scientific literature is presented in order to characterize the bioavailability of these contaminants and the toxic effects that have been observed when they concentrate in the tissues of aquatic organisms. It is envisioned that the list of chemicals and information presented in this report will be considered in any DMMP process to develop a new BCoC list.

SCOPE

Sixty-five chemicals are proposed here for consideration in revising the DMMP's BCoC list. This list includes all of the 30 chemicals that are on the current list (Table 1), as well as an additional 35 chemicals with documented bioaccumulative properties and that have been detected in Washington State sediment and tissue monitoring programs. Summary information pertaining to potential bioaccumulative risk is presented for each of these chemicals in Tables 2-6. Note that the focus of the presentation is on ecological receptors and endpoints. This information is intended to supplement, rather than replace, the human risk considerations that already form a large part of the DMMP's existing conceptual framework for conducting and interpreting bioaccumulation tests.

Several earlier studies have produced lists of chemicals (primarily pesticides) recommended for monitoring in the tissue of aquatic organisms in Washington State (see below). Although many of the chemicals recommended by these studies are included in Tables 2-6, others were not included because there was little evidence that they occur in State sediments and/or tissues at levels that would pose a risk to ecological or human receptors. Thus, the following chemicals were excluded from further consideration based on a low propensity to bioaccumulate

in tissues (e.g., log Kow< 3.5[1]), a lack of documented use in Washington State, and/or low rates of detection in regional sediment and tissue monitoring programs:

Azinphos-methyl	Endrin
Bromoxynil	Fenvalerate
Biphenyl	Methyl-parathion
Butyl benzyl phthalate	Mirex
Dicamba	Oxadiazon
Dichlorobenzophenone	Pronamide
Diuron	Tetradifon
Ethion	

SOURCES OF INFORMATION USED

Overview

Numerous reports and databases, including data from studies of both fresh and salt-water environments, were reviewed in order to collect the quantitative and qualitative information presented in Tables 2-6. Particular emphasis was placed on summarizing the results of studies documenting the occurrence, bioavailability, or bioaccumulation of contaminants in Washington State. However, it was also important to include more general information on bioavailability and toxicity from the scientific literature in order to more fully characterize the bioaccumulative potential of these chemicals. Sources of information summarized in this report fall into the following general categories:

- Inventories of the types and quantities of pesticides used by government, industry, agriculture and households in Washington State;
- Recommendations for regional sediment and tissue monitoring;
- Chemicals appearing on other BCoC lists;
- Data from WA State tissue monitoring programs;
- Data from WA State sediment monitoring programs;
- Information from the scientific literature on the partitioning, persistence and bioaccumulation potential of chemicals and their degradation products;
- Information on the ecological effects associated with bioaccumulated chemicals.

[1] The octanol-water partition coefficient, Kow, is defined as the ratio of the equilibrium concentrations of a chemical in the two phases of a system consisting of n-octanol and water. The log of Kow is used as an indicator of the tendency for a chemical to partition into the lipid/organic phase of a medium. Chemicals with log Kow values that greater than 3.5 are generally considered likely to partition into organic media such as lipids of organisms and natural organic matter.

Below, a brief description (organized by category) is provided for each of the source documents included in Tables 2-6, including (where appropriate) indication of any particular strengths or weaknesses that could have bearing on its use for the purposes of revising the BCoC list.

State and Regional Pesticide Use

The pesticides included in the current DMMP BCoC list are limited to organochlorine compounds whose use is either highly restricted or banned (e.g., DDT, Chlordane, Aldrin). Thus, it was deemed particularly important to review recent use information in Washington State to determine if other currently used organochlorine pesticides or persistent pesticides from other classes (e.g., organophosphate) would be appropriate to consider for addition to the BCOC list.

- *Tetra Tech (1988). Pesticides of Concern in the Puget Sound Basin: A Review of Contemporary Pesticide Usage, TC 3338-32.*

  Gives estimations of urban (city government, commercial, and private household) and non-urban (military, agriculture, right-of-ways, and forestry) use of pesticides in the Puget Sound Basin based on published county surveys, telephone and letter surveys of users, and extrapolation based on pesticide usage in the San Francisco Bay area. Information is somewhat dated and there is a particularly high degree of uncertainty associated with the extrapolated estimates of urban usage.

- *Washington Agricultural Chemical Usage Summaries (various 1993-1996). Washington Agricultural Statistics Service, US Dept. of Agriculture and WA State Dept. of Agriculture.*

  Tallies annual pesticide use information for a given crop variety (e.g., wheat, carrots, pears). Because annual use information is not consistently available for all crops receiving applications of a particular pesticide, it is not possible to calculate a total annual usage by summing information for all applicable crops in any given year. Instead, the information presented in Table 2 represents the highest annual usage recorded for a single crop during the period 1993-1996. Thus, for most chemicals, total annual usage is likely to be higher than the quantity given in Table 2.

Recommendations for Regional Sediment and Tissue Monitoring

The following studies summarize historical sediment and tissue data from the Puget Sound area and recommend the biological receptors and chemicals of concern on which to focus future monitoring efforts.

- *PSEP (1991a). Toxic Contaminants in Puget Sound Wildlife - Literature Review and Recommendations for Research and Monitoring, Sept. 1991, EPA 910/9-91-023.*

  Reviews historical monitoring data in order to document the range of concentrations of specific contaminants that have been observed in Puget Sound wildlife. The scope of the report was limited to bird and marine mammal species that feed in marine areas of Puget Sound. However, many of these species (e.g., gray whales, raptorial birds, and sea lions) are migratory and/or feed in areas outside of Puget Sound. Tissue residues in these organisms may or may not be reflective of exposures to contamination within Puget Sound. Furthermore, the information reviewed was derived from studies that focused on a subset of highly persistent compounds (e.g., DDT, Dioxins/Furans, PCBs) rather than looking at a broad range of possible contaminants. Recommendations on the contaminants that should be included in fish and wildlife tissue monitoring programs are based on filling data gaps and estimates of the bioaccumulative potential of various chemicals as well as documented evidence of what chemicals actually bioaccumulate.

- *PTI (1991). 1990 Puget Sound Pesticide Reconnaissance Survey, August 1991, EPA 910/9-91-020*

  Analyzed six sediment samples from four streams in the Puget Sound area for a large number of compounds including organophosphate and organochlorine pesticides, chlorinated herbicides, triazine herbicides, and carbamates and urea pesticides. Detected concentrations of all pesticides were below 33 ppb (dry weight). Chemicals were recommended for inclusion in monitoring efforts based on (1) detection at levels exceeding theoretically estimated thresholds for acute toxicological effects; or (2) detection in previous surveys.

- *PSEP (1991b) Pollutants of Concern in Puget Sound. April 1991, EPA 910/9-91-003.*

  Summarizes information on regulatory status, existing numerical criteria, sources, and monitoring data for 64 pollutants identified as contaminants of concern in Puget Sound. Contaminants selected for final pollutants of concern list meet all of the following general criteria: 1) high toxicity as measured in laboratory studies, 2) high persistence in the environment, 3) high bioaccumulation potential and at least one of the following specific criteria relative to Puget Sound: high measured water column or effluent concentrations; existence of known sources; high concentrations relative to sediments from Puget Sound reference areas; widespread distribution in sediments.

- *WA Department of Health. (1995) Tier I Report: Development of SQC for the Protection of Human Health. June 1995.*

  Describes the first tier of a two-tiered process to establish numerical sediment quality criteria for the protection of human health. Over 200 chemicals of concern (CoCs) were identified and divided into the following three groups based on their toxicity, log

Kow, and frequency of detection in the sediment samples from the State's SEDQUAL database. Group 1 chemicals (likely to impact human health) have an EPA toxicity value, log Kow greater than 3.5, and a greater than 5% detection rate in SEDQUAL urban bay sediment stations; Group 2 chemicals (less likely to impact human health) have an EPA toxicity value, and a log Kow less than 3.5 or less than 5% detection rate in SEDQUAL; Group 3 chemicals have no EPA toxicity values but are considered to be of potential human health concern and are reserved for assessment in the future. One limitation of this report is that the CoC list and subsequent groupings are drawn only from those chemicals that appear in the SEDQUAL data base. Furthermore, although results of tissue monitoring are summarized in the report, this information was not used to derive the CoC list or the chemical groups due to the limited size and quality of the tissue database.

Chemicals Appearing On Other Bioaccumulative Chemicals of Concern Lists

Numerous programs have developed lists of target analytes for fish tissue monitoring (see US EPA, 1995). The criteria for selection of target analytes vary depending on the specific program objectives and regional conditions. Many of these programs, however, have taken a conservative approach in assuming that any contaminant that has been measured in sediment or water can potentially bioaccumulate in tissues of aquatic organisms. The resulting lists of target analytes can be huge, sometimes in excess of 200 contaminants. The lists discussed below were developed or have been refined to include only those contaminants that have been clearly demonstrated to be of bioaccumulative concern

- *Target Analytes in Tissues for Dredged Material Testing in US EPA Regions 1, 2, and 9*

  Bioaccumulation testing, a standard requirement of the dredged material testing program, is used to evaluate the suitability of sediments for unconfined disposal in both ocean and inland (404) waters. A list potential target analytes for sediment and tissue testing is presented in both the Green Book (1991) and in the Inland Testing Manual (1998). These lists are intended to serve as a basis for developing regional and site-specific lists. Individual regions are encouraged to modify their lists based on region-specific chemical use patterns and monitoring data. Analyte lists presented in Table 3 are from three EPA Regions, other than Region 10, which regularly require bioaccumulation testing for their dredged material testing programs.

- *Ontario Ministry for the Environment Primary List of Candidate Substances for Bans, Phase-outs or Reductions - Multimedia Revision (October 1993).*

  Chemicals appearing on this list are considered to be persistent, bioaccumulative and toxic by virtue of persisting in water, sediment, soil, or sludge for greater than 50 days, a BCF greater than 500, and demonstrated lethal or sublethal toxicity. As a consequence, these substances are given first consideration as candidates for bans or

phase-outs. The Ontario Ministry's list was reviewed and adopted by WDOE's Bioaccumulative Chemicals of Concern (BCC) Workgroup as a starting point for developing its own list for use in programs agency-wide. Note that chemicals appearing on this list do not necessarily occur in Washington State.

- *Great Lakes Water Quality Initiative Bioaccumulative Chemicals of Concern from FR Vol. 60, no. 56, March 23, 1995.*

  The Great Lakes Bioaccumulative Chemicals of Concern list is limited to any chemical, "…which upon entering the surface waters, by itself or as its toxic transformation product, bioaccumulates in aquatic organisms by a human health bioaccumulation factor greater than 1,000, after considering metabolism and other physicochemical properties that might enhance or inhibit bioaccumulation…" Note that a high bioaccumulation factor criterion was used to limit the list of chemicals for which regulatory criteria would need to be developed.

- *US EPA (1995). Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories: Vol. 1 Fish Sampling and Analysis, 2nd Edition, Sept. 1995. EPA 823-R-95-007.*

  Chemicals were included in the Recommended Target Analyte list based on the frequency of their inclusion in national monitoring programs and the number of States in which they are the basis of a consumption advisory. Source, potential to bioaccumulate, expected human health risk, and feasibility of analysis were also considerations in developing this list.

- *Research Triangle Institute, 1993. National Listing of State Fish and Shellfish Consumption Advisories and Bans, Research Triangle Park, NC.*

  Lists the number of States issuing advisories for various chemicals. Current as of July 22, 1993.

- *EPA (1997) Draft Bioaccumulation Testing and Interpretation for the Purpose of Sediment Quality Assessment: Status and Needs (August 1997)*

  List of potential bioaccumulative chemicals of concern was developed based on input from the Bioaccumulation Analysis Workgroup and review of various agency documents. All chemicals in this list are found in the sediment and in animal tissues at levels associated with toxic effects. Chemicals ranked as highest priority (1) had information readily available, were of immediate concern and known to bioaccumulate, and considered important in one or more EPA programs. Residue and effects information for these chemicals is summarized in the Appendices of the Status and Needs document. Chemicals ranked as secondary priority (2) are known to bioaccumulate and will be researched when more funds are available while those ranked last (3) have the potential to bioaccumulate but will not be researched further.

Tissue Monitoring Data from WA State

The following studies represent the most recent information available (since 1988) documenting concentrations of contaminants of concern in the tissues of various aquatic organisms.

- *Puget Sound Estuary Program (PSEP) (1991c). Chemical Contamination of Harbor Seal Pups in Puget Sound, September 1991, EPA 910/9-91-003.*

  Reports concentrations of various contaminants in the blubber and liver tissue of dead, newborn harbor seal pups from two locations in northern and southern Puget Sound. Major conclusions were that tissue levels of PCBs and p,p'-DDE have declined substantially in Puget Sound. Aside from DDE, most of the other pesticides evaluated in this study were not detected. Note that data for the pesticide toxaphene are ambiguous in that reported concentrations in all samples were below detection but the detection limit (2.4 ppm wet weight) was unusually high for this pesticide.

- *PSEP (1991d) Bioaccumulation of Contaminants in Crab and Clams in Bellingham Bay, September 1991, EPA 910/9-91-042*

  Reports concentrations of various contaminants in field-collected edible crab and clam tissue. The highest detected concentrations of both trace metals and organic compounds were generally low, being comparable to concentrations found in Puget Sound reference areas with presumably low levels of contamination.

- *Washington State Pesticide Monitoring Program (WSPMP) (1994). Reconnaissance Sampling of Fish Tissue and Sediments (1992), December 1994, WDOE Pub. No 94-194.*

  Reconnaissance survey conducted to refine the target analyte list, analytical methods, and field sampling techniques for the biota and sediment sampling portion of the Washington State Pesticide Monitoring Program. Concentrations of pesticides and PCBs were measured in sediments and tissues from field-collected fish from seven freshwater sites in eastern and western Washington. Study concluded that measured tissue concentrations in fish were unlikely to impair reproduction. Note that the target pesticide list used in this study is substantial, covering nearly all of the pesticides that are proposed for consideration in revising the DMMP's BCoC list.

- *WSPMP (1995). 1993 Fish Tissue and Sediment Sampling Report, October 1995, WDOE Pub. No 95-356*

  Reports concentrations of pesticides and PCBs from eighteen fish tissue samples collected from nine freshwater sites scattered throughout the State. Results for DDT and PCBs from several locations exceeded US EPA screening values for human health and/or proposed wildlife criteria. Concentrations of all other pesticides were below

these criteria. Study concluded that some piscivorous wildlife within certain areas of the State may be at risk from consumption of contaminated fish.

- *WSPMP (1996). 1994 Fish Tissue and Sediment Sampling Report, December 1996, WDOE Pub. No 96-352.*

  Reports concentrations of pesticides and PCBs from fourteen fish tissue samples and five sediment samples collected from six (mostly eastern Washington) freshwater sites. Results for DDT and PCBs from several locations exceeded US EPA screening values for human health and/or proposed wildlife criteria. Concentrations of all other pesticides were below these criteria.

- *WSPMP (1998). 1995 Fish Tissue and Sediment Sampling Report, WDOE, Olympia, WA.*

  Reports concentrations of pesticides and PCBs from twenty-four fish tissue samples collected from eight (mostly eastern Washington) freshwater sites. Results for DDT, PCBs, and aldrin/dieldrin from several locations exceeded US EPA screening values for human health and/or proposed wildlife criteria. Concentrations of all other pesticides were below these criteria.

- *WSPMP (1996). Pesticides and PCBs in Marine Mussels - 1995, March 1996, WDOE Pub. No 96-301.*

  Reports concentrations of pesticides and PCBs in field-collected marine mussels from five sites in Puget Sound and one site at the mouth of the Columbia River. All sampling sites were located near agricultural, urban, or industrial sources of contamination. Sampling was timed to coincide with the period when pesticides are most frequently detected in Puget Sound tributary waters. Pesticide concentrations in all samples were less than U.S. EPA human health criteria and were below levels considered a concern for consumption by wildlife.

- *Washington Department of Health (1995). Tier I Report: Development of SQC for the Protection of Human Health, June 1995.*

  Summarizes results of fish and shellfish tissue monitoring from the following studies:

  - PTI (1991). Pollutants of Concern in Puget Sound
  - Landolt et al. (1987). Potential Toxicant Exposure Among Consumers of Recreationally Caught Fish from Urban Embayments of Puget Sound
  - Puget Sound Ambient Monitoring Program data from 1990 and 1991 as summarized in WDOH (1995)
  - U.S. EPA (1985) Commencement Bay Nearshore/Tideflats Remedial Investigation
  - SEDQUAL - Query of 1993 version

- U.S. EPA (1988) Health Risk Assessment of Chemical Contaminants in Puget Sound Seafood

- *USGS (1992) Surface-water Quality Assessment of the Yakima River Basin, Washington: Pesticide and Other Trace-Organic-Compound Data for Water, Sediment, Soil, and Aquatic Biota, 1987-91. USGS Report 92-644.*

  Reports testing results for bed sediment, suspended sediments and fish tissues collected from various parts of the Yakima River basin in south-central Washington during 1987-1991. Bed-sediment samples were collected from 26 stations and fish, mollusks, and crayfish were collected from 32 stations both upstream and down stream from human activities throughout the basin. Aquatic biota samples were analyzed for a suite of organochlorine compounds. Mollusks were also analyzed for PAHs. Bed sediment samples were analyzed for organochlorine and semi-volatile organic compounds only.

- *Munn, M.F., and D.J Gruber (1997) The relationship between land use and organochlorine compounds in streambed sediment and fish in the Central Columbia Plateau, Washington and Idaho, USA, Environmental Toxicology and Chemistry, Vol. 16, No. 9. Pp. 1877-1887.*

  Reports the results of testing streambed sediment and fish from the Central Columbia Plateau for organochlorine pesticides and PCBs. Sampling design was oriented around the objective of examining the relationship between land use and the distribution of these compounds. Sixteen compounds were detected in sediment and fish with tissue samples usually having a greater frequency of pesticide detection. Generally, sediment concentrations were only slightly elevated relative to detection limits, while relatively high concentrations of DDT and its metabolites, Dieldrin, and PCBs were detected in many of the tissue samples. Study concludes that organochlorine are still present in the environment at concentrations that may pose a threat to various trophic levels in the ecosystem and that eroding agricultural soils are a long-term source of many of these compounds to streambed sediments and ultimately into the food web.

Sediment Monitoring Data from WA State

An important indication of the persistence and potential bioavailability of aquatic contaminants is their retention in sediments. The sediment monitoring data provided in Table 5 represents both marine and fresh water sediments from three different types of locations: small streams and sloughs, areas proximal to or influenced by urban/industrial activities, and harbors, marinas, and navigational channels where dredging occurs.

- *Bortleson G.C., and D.A. Davis (June 1997), Pesticides in Selected Small Streams in the Puget Sound Basin, 1987-1995, USGS Fact Sheet 067-97.*

  Summarizes data from several studies that monitored for a broad range of pesticides in small streams and sloughs in the Puget Sound Basin. Generally, data were collected during spring and summer when pesticide concentrations in water and bed sediment would be expected to be highest. The highest pesticide concentrations measured in both media were only slightly above detection limits and there were no exceedances of aquatic life or human health criteria.

- *SEDQUAL*

  Provides frequency of detection and exceedances of the DMMP's 1994 Screening Level (SL) and Maximum Level (ML) values among urban bay stations in the SEDQUAL database (sample basis, n = 2721). Query conducted in November 1997.

- *DAIS (Dredged Analysis Information System)*

  Provides frequency of detection and exceedances of DMMP's 1994 Screening Level (SL) and Maximum Level (ML) values based on a query of all data in the DAIS database (total of 97 surveys) including sediments from dredging projects in Puget Sound, Grays Harbor, and Willipa Bay. Query conducted in November 1997.

Other Information Related to Bioaccumulation Potential

- *Karickhoff and Long (1995). EPA Internal Report on Summary of Measured, Calculated, and Recommended Log Kow values Prepared for Elizabeth Southerland. April 10, 1995.*

  Summarizes measured and modeled log Kow values reported in the literature for numerous organic compounds. For each chemical, a single log Kow value is recommended based on an approach that considers measured, calculated and estimated values from the literature (U.S. EPA, 1996). This approach was applied to an array of non-ionic organic chemicals and released as a draft internal report to EPA's Office of Water. The draft report is now under review by an interagency committee charged with standardizing log Kow values.

  Log Kow values reported in the scientific literature are notoriously variable, particularly for highly hydrophobic compounds (log Kow > 5). Measurement error appears to be the most significant reason for this variability, whereby values for a single chemical can vary by an order of magnitude or more. Log Kow values have been provided in earlier PSDDA documents (e.g., PSDDA, 1996) and in the finalized Inland Testing Manual (EPA/COE, 1998). However, neither of these sources provided log Kow values for all the chemicals being considered nor were the sources

of those values readily apparent. Karickhoff and Long's recommended values, although only available in a draft report, were deemed a preferable source of Log Kows for the purposes of this report since they covered nearly all of the chemicals presented[2] and were derived by applying best professional judgement to all of the available data.

- *Howard, P.H., R.S. Boethling, W.F. Jarvis, W.M. Meylan, and E.M. Michalenko (1991) Handbook of Environmental Degradation Rates. Lewis Publishers, INC.*

  Reviews the existing literature and reports rate constants for individual abiotic and biotic degradation processes for a variety of organic compounds. Established a range of half-lives[3] for both individual degradation processes and specific environmental compartments (soil, surface water, ground water and air). Half-lives for specific environmental media reflect observations of the rate of disappearance of the chemical from that particular compartment, without necessarily identifying the mechanism of loss or accounting for the transport of a chemical between compartments. Thus, overall ranges given are not necessarily representative of a chemical's actual persistence within a particular medium. Ranges of half-lives for soil are used in this report as a relative measure of persistence with which to compare chemicals.

- *Environmental Effects of Dredging Technical Notes: Trophic Transfer and Biomagnification Potential of Contaminants in Aquatic Ecosystems, US Army Corps of Engineers Waterways Experimental Station, Technical Note EEDP-01-33 (January 1995).*

  Examines the potential of various classes of organic and inorganic chemicals to biomagnify[4] in aquatic systems. Information demonstrating trophic transfer (or the lack thereof) of contaminants in laboratory and field experiments was summarized and compared to results from published aquatic food web models. General conclusions were then drawn for various chemicals/classes concerning whether biomagnification is expected to occur within aquatic systems.

- *Aquatic Toxicity Information Retrieval Database (AQUIRE)*

---

[2] Log Kow values for 2,6-dichlorobenzonitrile (dichlobenil) and pentachloroanisol were obtained from the Hazardous Substances data base.

[3] The half-life of a chemical in the environment depends not only on the intrinsic properties of the chemical, but also on the nature of the surrounding environment. Reported half-lives are highly variable, depending on factors such as meteorology, temperature, and the nature of the media and its microbial community. Thus, it is more realistic to characterize a chemical's half-life in a particular medium using a range of values.

[4] Biomagnification is the phenomenon whereby the concentration of a contaminant increases in the tissues of organisms at successively higher tropic levels.

EPA's online database of aquatic toxicity information. Developed in 1981, AQUIRE summarizes various forms of toxicity data from literature published primarily during the period from 1970 to the present. Bioconcentration factors (BCF)[5] are provided for various marine, estuarine and fresh water species based on exposures that were either aqueous, through the diet, or by injection. Results of sediment toxicity testing are not reported in AQUIRE. The AQUIRE database can be accessed on-line by government offices using a variety of methods. There are several commercial vendors who provide access to AQUIRE by the private sector.

- *Verschueren, Karel (1983). Handbook of Environmental Data On Organic Chemicals (Second Edition), Van Nostrand Reinhold Co.*

  Presents a wide variety of physical, chemical, and biological information on various organic chemicals. Fish BCF data are given for 28-day and steady state aqueous exposures. The most commonly tested species for which information is provided are fathead minnow (*Pimephales promelas*) and bluegill sunfish (*Lepomis macrochirus*).

- *Mackay, D., Shiu, W.Y., and K.C. Ma (1995). Illustrated Handbook of Physical - Chemical Properties and Environmental Fate for Organic Chemicals (Vols. 1 - 4), CRC Press.*

  Provides physical, chemical, and biological data for similarly structured groups of chemical substances focusing on those properties that influence the fate of these chemicals in the air, water, soils, sediments and biota. The log BCFs given are derived from various sources.

Information on the Ecological Effects Associated with Bioaccumulated Chemicals

- *Environmental Residue-Effects Database (ERED)*

  The U.S. Army Corps of Engineers/U.S. Environmental Protection Agency Environmental Residue-Effects database is a compilation of data, taken from the literature, where biological effects (e.g., reduced survival, growth, etc.) and tissue contaminant concentrations were simultaneously measured in the same organism. Currently, the database is limited to those instances were biological effects observed in an organism are linked to a specific contaminant within its tissues. Residue-effects information was compiled from studies of freshwater, estuarine, and marine organisms and includes data for numerous organic and inorganic chemicals. ERED is available at

[5] A bioconcentration factor is a unitless value that describes the degree to which a chemical can be concentrated in the tissues of an organism in the aquatic environment where the water is the sole contaminant source. A BCF is the concentration of the chemical in one or more tissues of the aquatic organism divided by the average concentrations of the chemical in the surrounding water.

no cost on the COE Waterways Experiment Station's Web Site (www.wes.army.mil/el/ered). The information provided in Table 6 represents (where available) the lowest tissue concentrations that have been associated with some form of whole organism adverse effects (e.g., reduced survival, growth, or reproduction). Cellular and subcellular response data were not considered. Note that this information does not represent an absolute threshold for effects. Rather, it is intended to serve as an indication of whether and what kind of residue-effects information is available for a particular chemical, and as a low-end benchmark for comparison with the highest measured tissue concentrations from the monitoring data.

RECOMMENDATIONS

Chemicals for Consideration

This report identifies sixty-five chemicals that are recommended for consideration in future efforts to revise the DMMP's Bioaccumulative Chemicals of Concern list. Chemicals were included for consideration either because they already appear on the current BCoC list or because they exhibit characteristics indicating that they may be of bioaccumulative concern in the State of Washington. Note, however, that these chemicals do not comprise the final BCoC list. The final list will reflect modifications based on workgroup recommendations and the DMMP review process.

Sources of Information on Bioaccumulation

This report draws upon various sources of information describing the bioaccumulative characteristics of a set of chemicals. The most important sources include regional chemical-use and monitoring data, and information from the scientific literature describing the persistence, partitioning, bioavailability, and residue-effects relationships. This information is recommended as a starting point, to be used in development of the final BCoC list.

The sources used in this report, however, by no means comprise an exhaustive list of the information available for characterizing bioaccumulation. It is recommended that the workgroup also consider consulting the following on-line sources for general information on the bioaccumulative properties of various compounds:

- Toxicity fact sheets - Agency for Toxic Substances and Disease Registry (www.atsdr.cdc.gov)
- Chemical fact sheets - US EPA Office of Pollution Prevention and Toxics (www.epa.gov/opptintr/chemfact/)
- Environment Writer - The National Safety Council (www.nsc.org/ehc/ewtoppg.htm)
- Chemical fact sheets - Spectrum Laboratories Inc. (www.speclab.com/search.html)

- Integrated Risk Information System (IRIS) – US EPA (www.epa.gov/ngispgm3/iris/index.html);
- Pesticide information profiles - Extension Toxicology Network (pmep.cce.cornell.edu/profiles/extoxnet/)

Draft Criteria for Developing a Revised BCoC List

Re-evaluating the DMMP's BCoC list will necessarily involve consideration of a vast array of physical, chemical and biological information. The question remains, however, as to how a workgroup should use this information in deciding the composition of the BCoC list. It is recommended that the workgroup adopt specific criteria relating to occurrence, persistence, bioavailability, and bioaccumulative risk (such as those provided below) to be used as weighting factors in determining the composition of the final BCoC list.

In this section, a set of draft criteria (and their rationale) are presented that are derived from the information sources used in this report. These draft criteria are then applied to the list of sixty-five chemicals proposed for consideration. Table 7 presents the weight of evidence both for (indicated with "+") and against (indicated by "-") including any particular chemical on the revised BCoC list. A blank signifies the criterion does not apply to a given chemical (e.g., log Kow values do not exist for trace metals), the chemical has not been monitored, or no information was available. Note that chemicals used in WA State, but for which monitoring data are lacking, may still be of concern for the purposes of developing a BCoC list.

- Log Kow greater than 3.5

  Chemicals with log Kow values that greater than 3.5 are generally considered likely to partition into organic materials including lipids of organisms.

- Soil half-life greater than 50 days

  Provided as a comparable indicator of persistence. Soil values were used because half-life information was not available for sediments. Fifty days was selected as a threshold based on the scoring system developed by the Ontario Ministry of the Environment (1993)

- Demonstrated biomagnification in the aquatic food web

  Although ability to biomagnify is not a requirement for a chemical to be of concern for bioaccumulation (there are many chemicals which are bioaccumulated at one or more trophic levels but do not biomagnify between trophic levels), it is, nevertheless, an important indication of the persistence of a chemical within the food web.

- Documented use in the State of Washington

  Regional use is a critical consideration, particularly for persistent contaminants that are not currently found on the BCoC list or for which limited monitoring information is available. This is also useful information for interpreting the relevance of BCoC lists from other regions.

- Detection frequency in marine sediments greater than 10%; greater than 50%; Detected in freshwater sediment

  Chemicals that are rarely detected in sediments may be unlikely candidates for the DMMP's revised BCoC list. These threshold detection frequencies are given as examples and have no particular significance except to make the distinction between compounds that are detected "regularly"(>10%) and those that are detected "frequently"(>50%).

- SL exceedance frequency in sediments greater than 40%
- ML exceedence frequency in sediments greater than 10%

  Characterization based on frequency of SL/ML exceedence is an elaboration on the question of how often and at what levels are chemicals observed in sediments. These threshold exceedence frequencies are given as examples and have no particular significance except as an indication of when a chemical "frequently" exceeds an SL or ML value.

- Detection in freshwater and marine tissue monitoring programs

  Detection in tissues of aquatic organisms is a direct indication of a chemical's bioavailability. Unfortunately, WA State tissue monitoring data has not yet been comprehensively compiled in a single data base (as has been done with the sediment data) making it difficult to develop and apply criteria based on frequency of detection.

- Residue-effects data available in literature

  Chemicals for which research has been performed to determine residue-effects concentrations, typically exhibit some degree of bioaccumulation and toxicity. Furthermore, this information would facilitate any future efforts to develop DMMP bioaccumulation guidance.

- Highest measured tissue concentrations equal to or greater than lowest residue-effects concentration.

  A measured tissue concentration of a chemical that is in excess of a reported residue effects concentration is an indication that bioaccumulated levels of that chemical have the potential to cause an adverse ecological effect. Note, however, that the residue effects concentrations used for comparison in this report are not absolute thresholds for effects.

- Included on bioaccumulative chemicals of concern lists from other national/regional monitoring programs.

A chemical that is identified to be of bioaccumulative concern nationally, and regionally, is worth further examination by the workgroup.

REFERENCES

Bortleson G.C., and D.A. Davis, 1997. Pesticides in Selected Small Streams in the Puget Sound Basin, 1987-1995, USGS Fact Sheet 067-97.

Dredged Material Management Program (DMMP), 1998. Revision of Guidelines for Bioaccumulative Chemicals of Concern. Draft Issue Paper prepared for the 1998 Sediment Management Annual Review Meeting.

EPTA, 1988. Evaluation Procedures Technical Appendix. Prepared by the Corps of Engineers in Cooperation with the Environmental Protection Agency, Region 10, and the Washington State Departments of Ecology and Natural Resources.

Great Lakes Water Quality Initiative, 1995. Bioaccumulative Chemicals of Concern, from FR Vol. 60, no. 56, March 23, 1995.

Howard, P.H., R.S. Boethling, W.F. Jarvis, W.M. Meylan, and E.M. Michalenko (1991). Handbook of Environmental Degradation Rates. Lewis Publishers, Inc.

Karickhoff S.W., and J.M. Long, 1995. EPA Internal Report on Summary of Measured, Calculated, and Recommended Log Kow values, Prepared for Elizabeth Southerland. April 10, 1995.

Landolt, M., D. Kalman, A. Nevissi, G. van Belle, K. Van Ness, and F. Hafer, 1987. Potential Toxicant Exposure Among Consumers of Recreationally Caught Fish from Urban Embayments of Puget Sound: Final Report. NOAA Tech. Memo NOS OMA 33.

Mackay, D., Shiu, W.Y., and K.C. Ma, 1995. Illustrated Handbook of Physical - Chemical Properties and Environmental Fate for Organic Chemicals (Vols. 1 - 4), CRC Press.

MPR, 1988. Puget Sound Dredged Disposal Analysis (PSDDA) Management Plan Report. Unconfined Open-Water Disposal of Dredged Material, Phases I (Central Puget Sound). Prepared by the Corps of Engineers in Cooperation with the Environmental Protection Agency, Region 10, and the Washington State Departments of Ecology and Natural Resources.

Munn, M.F., and D.J Gruber, 1997. The relationship between land use and organochlorine compounds in streambed sediment and fish in the Central Columbia Plateau, Washington and Idaho, USA, *Environmental Toxicology and Chemistry, Vol. 16, No. 9. pp. 1877-1887.*

Ontario Ministry for the Environment, 1993. Primary List of Candidate Substances for Bans, Phase-outs or Reductions - Multimedia Revision, October 1993.

PTI, 1991. 1990 Puget Sound Pesticide Reconnaissance Survey, August 1991, EPA 910/9-91-020. Prepared for U.S. EPA Region 10.

PSDDA, 1996. Sediment Bioaccumulation Testing Refinements: Sample Volume Requirements, Simultaneous Co-Testing of Two Species Within a Single Aquarium, and Species Substitution. Clarification paper presented in the 1996 Sediment Management Program Biennial Report (Dredging Years 1994/1995), March 1996.

Puget Sound Estuary Program (PSEP), 1991a. Toxic Contaminants in Puget Sound Wildlife - Literature Review and Recommendations for Research and Monitoring, Sept. 1991, EPA 910/9-91-023. Prepared by PTI for U.S. EPA Region 10.

PSEP, 1991b. Pollutants of Concern in Puget Sound, April 1991, EPA 910/9-91-003. Prepared by PTI for U.S. EPA Region 10.

PSEP, 1991c. Chemical Contamination of Harbor Seal Pups in Puget Sound, September 1991, EPA 910/9-91-003. Prepared by PTI for U.S. EPA Region 10.

PSEP, 1991d. Bioaccumulation of Contaminants in Crab and Clams in Bellingham Bay, September 1991, EPA 910/9-91-042. Prepared by Washington State Department of Ecology.

Research Triangle Institute, 1993. National Listing of State Fish and Shellfish Consumption Advisories and Bans, Research Triangle Park, NC.

Tetra Tech, 1988. Pesticides of Concern in the Puget Sound Basin: A Review of Contemporary Pesticide Usage. Final Report. TC 3338-32. Prepared for U.S. EPA Region 10, Office of Puget Sound, Seattle, WA.

U.S. Army Corps of Engineers (COE), 1995. Environmental Effects of Dredging Technical Notes: Trophic Transfer and Biomagnification Potential of Contaminants in Aquatic Ecosystems, Technical Note EEDP-01-33, US Army Corps of Engineers Waterways Experimental Station, January 1995.

U.S. Environmental Protection Agency (EPA), 1985. Commencement Bay Nearshore/Tideflats Remedial Investigation. Vols. 1,2,3 and 4. Prepared by the Dept. of Ecology, Olympia, WA and EPA Region 10.

U.S. EPA, 1988. Health Risk Assessment of Chemical Contaminants in Puget Sound Seafood. Prepared by Tetra Tech, Inc., Bellevue, WA.

U.S. EPA, 1995. Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories: Vol. 1 Fish Sampling and Analysis, 2nd Edition, EPA 823-R-95-007, September 1995.

U.S. EPA, 1996. Draft Protocol for Setting Kow Values, NERL Athens, September 5, 1996.

U.S. EPA, 1997. Bioaccumulation Testing and Interpretation for the Purpose of Sediment Quality Assessment: Status and Needs (Draft - August 1997).

U.S. EPA-U.S. COE, 1991. Evaluation of Dredged Material Proposed for Ocean Disposal (Testing Manual). EPA-68-C8-0105. U.S. EPA, Office of Marine and Estuarine Protection, Washington, D.C.

U.S. EPA-U.S. COE, 1998. Evaluation of Dredged Material Proposed for Discharge in Inland and Waters of the U.S. (Testing Manual). EPA-823-B-98.

U.S. Geological Survey (USGS), 1992. Surface-water Quality Assessment of the Yakima River Basin, Washington: Pesticide and Other Trace-Organic-Compound Data for Water, Sediment, Soil, and Aquatic Biota, 1987-91. USGS Report 92-644.

Verschueren, Karel, 1983. Handbook of Environmental Data On Organic Chemicals (Second Edition), Van Nostrand Reinhold Co.

Washington State Department of Health, 1995. Tier I Report: Development of SQC for the Protection of Human Health. June 1995. Office of Toxic Substances.

Washington State Pesticide Monitoring Program (WSPMP), 1994. Reconnaissance Sampling of Fish Tissue and Sediments (1992), WDOE Pub. No 94-194, December 1994.

WSPMP, 1995. 1993 Fish Tissue and Sediment Sampling Report, October 1995, WDOE Pub. No 95-356

WSPMP, 1996. 1994 Fish Tissue and Sediment Sampling Report, WDOE Pub. No 96-352. December 1996.

WSPMP, 1996. Pesticides and PCBs in Marine Mussels - 1995, WDOE Pub. No 96-301, March 1996.

WSPMP, 1998. 1995 Fish Tissue and Sediment Sampling Report, WDOE, Olympia, WA.

Table 2. Washington State Pesticide Use and Recommendations for Monitoring

Chemical	PS Basin use tons/yr (1)	WA Ag. use tons/yr (2)	PSEP Wildlife (3)	PTI Pest. Recon. (4)	PSEP POC (5)	WDOH COC group (6)
1,2-Diclorobenzene					-	2
1,3-Diclorobenzene					+	3
1,4-Diclorobenzene					+	1
2,6-dichlorobenzonitrile (dichlobenil)	3.5			+		
Aldrin					+	1
Anthracene					+	1
Antimony					+	1
Arsenic					+	1
Benzo(a)anthracene					+	1
Benzo(a)pyrene					+	1
Benzo(g,h,i)perylene					+	1
Benzofluoranthenes					+	1
Biphenyl						1
Bis(2-ethylhexyl) phthalate					+	1
Butyl benzyl phthalate					-	1
Cadmium					+	1
Chlordane	25*		+		-	2
Chlorpyrifos	20	134		+		
Chromium					+	1
Chrysene					+	1
Copper					+	1
DCPA (dacthal)		22.8				
DDT (total)			+	+	+	1
Diazinon	41.5	5.9		+		
Dibenzo(a,h)anthracene					+	3
Dicofol (kelthane)	0.43	0.15				
Dieldrin			+		+	2
Dimethyl phthalate					-	2
Di-n-butyl phthalate					-	1
Di-n-octyl phthalate					-	1
Endosulfan I/II	7	48.1		+		2
Endosulfan sulfate						
Endrin					-	2
Ethylbenzene					+	2

Table 2. Washington State Pesticide Use and Recommendations for Monitoring

Chemical	PS Basin use tons/yr (1)	WA Ag. use tons/yr (2)	PSEP Wildlife (3)	PTI Pest. Recon. (4)	PSEP POC (5)	WDOH COC group (6)
Fluoranthene					+	1
A-BHC					-	2
G-BHC (lindane)	1.5		+	+	+	2
Heptachlor	5.5*				-	2
Heptachlor epoxide						2
Hexachlorobenzene (HCB)					+	1
Hexachlorobutadiene					+	1
Hexachloroethane					-	2
Indeno(1,2,3-c,d)pyrene					+	3
Lead					+	3
Mercury			+		+	1
Methoxychlor		32.1				
Nickel					+	1
N-nitrosodiphenylamine					+	1
Parathion	6.5			+		
PCB (total)			+		+	1
PCDD			+		+	1
PCDF			+		+	1
Pentachloroanisol						
Pentachlorophenol	360		+	+	+	1
Phenanthrene					+	3
Phenol					+	2
Pyrene					+	1
Selenium			+			1
Silver					+	1
Tetrachloroethene (PCE)					+	2
Toxaphene						
Trichloroethene (TCE)					+	3
Trifluralin	2.7	8.6				
Zinc					+	1

FOOTNOTES TO TABLES 2-7

All tissue data are given in ppb wet weight units except where noted otherwise.
All sediment data are given in ppb dry weight units.
NA = not applicable; ND = not detected; NDA = no data available;

(1) Estimated non-urban and urban usage (tons/year) of pesticides in the Puget Sound (PS) Basin from Tetra Tech (1988) *Pesticides of concern in the Puget Sound Basin: A review of contemporary pesticide usage.* (*) Indicates that compound has been canceled or has restricted use.

(2) Highest yearly agricultural usage (tons/year) on a single crop between 1993-1996. From *Washington Agricultural Chemical Usage Summaries (1993-1996)*.

(3) Listed as a recommended contaminant of concern for fish and wildlife monitoring in PSEP (1991a) *Toxic Contaminants in Puget Sound Wildlife - Literature Review and Recommendations for Research and Monitoring.*

(4) Recommended for sediment monitoring based on sediment data collected from four streams and presented in PTI (1991) *1990 Puget Sound Pesticide Reconnaissance Survey.*

(5) Appears (+) on pollutants of concern (POC) list in PSEP (1991b) *Pollutants of Concern in Puget Sound*. (-) Indicates that compound appeared on list of contaminants of potential concern but was not included on the final POC list.

(6) Ranking as a chemical of concern in Washington from WDOH (1995) *Tier I Report: Development of SQC for the Protection of Human Health*. Rankings made according to the following groupings: (1) Group 1 chemicals have an EPA toxicity value, Log Kow >3.5, and detection frequency > 5% in SEDQUAL urban bay sediment data; (2) Group 2 chemicals have an EPA toxicity value, and Log Kow < 3.5 or detection frequency< 5% in SEDQUAL; (3) Group 3 chemicals have no EPA toxicity values.

(7) Required analytes in tissue testing for determining dredged material suitability in US EPA Region 1 (New England).

(8) Required analytes in tissue testing for determining dredged material suitability in US EPA Region 2 (New York/New Jersey).

(9) Required analytes in tissue testing for determining dredged material suitability in US EPA Region 9 (California/Hawai'i).

(10) The Ontario Ministry for the Environment Primary List of Candidate Substances for Bans, Phase-outs or Reductions (1993). Chemicals on list persist in the environment for greater than 50 days, have BCF values greater than 500, and are toxic to aquatic organisms.

(11) Great Lakes Water Quality Initiative Bioaccumulative Chemicals of Concern from Federal Register Volume 60, no. 56, March 23, 1995.

(12) Recommended Target Analytes from U.S. EPA (1995) *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories: Volume 1* (second edition). (*) Indicates chemicals that are under evaluation for possible future inclusion as recommended target analytes in State fish and shellfish contaminant monitoring programs.

(13) Number of states issuing advisories for contaminants. From Research Triangle Institute 1993. *National Listing of State Fish and Shellfish Consumption Advisories and Bans* (as of July 22, 1993). (*) Indicates that three states have advisories based on fish contaminated with PAHs but no information is available on which (if any) particular PAH compounds are the cause of the advisories.

(14) Ranking as a potential bioaccumulative chemical of concern from U.S. EPA (1997) *Draft Bioaccumulation Testing and Interpretation for the Purpose of Sediment Quality Assessment: Status and Needs*. Rankings indicate: (1) = highest priority, (2) = will be researched when new funds available; (3) = on list but no plans to researched further for this effort.

(15) Maximum concentrations of contaminants detected in the blubber and/or liver tissue of seal pups. From PSEP (1991c) *Chemical Contamination of Harbor Seal Pups in Puget Sound.* (*) Indicates data quality questionable due to unusually high detection limit.

(16) Maximum concentrations of contaminants detected in crab and clam tissue from the PSEP (1991d) *Bioaccumulation of Contaminants in Crab and Clams in Bellingham Bay*.

(17) Maximum concentrations of pesticides and PCBs detected in fish tissue from the WSPMP (1994) *Reconnaissance Sampling of Fish Tissue and Sediments* (*1992)*.

(18) Maximum concentrations of pesticides and PCBs detected in fish tissue from the WSPMP (1995) *1993 Fish Tissue Sampling Report.*

(19) Maximum concentrations of pesticides and PCBs detected in fish tissue from the WSPMP (1996) *1994 Fish Tissue and Sediment Sampling Report.*

(20) Maximum concentrations of pesticides and PCBs detected in fish tissue from the WSPMP (1998) *1995 Fish Tissue and Sediment Sampling Report.*

(21) Maximum concentrations of pesticides and PCBs detected in marine mussels from the WSPMP (1996).

(22) Maximum fish and shellfish residues reported in various studies as summarized in WDOH (1995) *Tier I Report: Development of SQC for the Protection of Human Health*.

(23) Frequency of detection and exceedances of 1994 Screening Level (SL) and Maximum Level (ML) values among urban bay stations in the SEDQUAL database (sample basis, n = 2721).

(24) Frequency of detection and exceedances of 1994 Screening Level and Maximum Level values among all surveys in the DAIS database (n = 97 surveys).

(25) DMMP Screening Level (SL) and Maximum Level (ML) values from *Sediment Management Program Biennial Report - Dredging Years 1994/1995, Appendix B.*

(26) Highest concentrations of pesticides detected in fresh water bed sediment as summarized in G.C. Bortleson and D.A. Davis (1997) *Pesticides in Selected Small Streams in the Puget Sound Basin, 1987-1995*.

(27) Highest concentrations measured in fish (F) and/or sediment (S) as reported in USGS (1992) *Surface-Water Quality Assessment of the Yakima River Basin, WA 1987-91*.

(28) Highest concentrations of pesticides detected in fresh water sediment and fish from the Central Columbia Plateau as reported in Munn and Gruber (1997) *The relationship between land use and organochlorine compounds in streambed sediment and fish in the Central Columbia Plateau, Washington and Idaho, USA.*

(29) Recommended log Kow values from Karickhoff and Long (1995) *EPA Internal Report on Summary of Measured, Calculated, and Recommended Log Kow values.* (*) Log Kow values for 2,6-dichlorobenzonitrile (dichlobenil) and pentachloroanisol were obtained from the Hazardous Substances Data Bank compiled by the National Library of Medicine.

(30) Ranges of half-lives in soil as summarized in *Howard et al., (1991) Handbook of Environmental Degradation Rates*. (*) Indicates that range of soil half-life values for 2,6-dichlorobenzonitrile (dichlobenil) obtained from the Hazardous Substances Data Bank compiled by the National Library of Medicine.

(31) Biomagnification potential based on information from Table 1 in COE (1995) *Environmental Effects of Dredging Technical Notes: Trophic Transfer and Biomagnification Potential of Contaminants in Aquatic Ecosystems*.

(32) Lowest tissue concentrations at which adverse effects have been observed for aquatic organisms from the COE/EPA Environmental Residue Effect Database (ERED). For each chemical, it is indicated whether ERED includes residue-effects data for freshwater (FW) and/or marine/estuarine (SW) organisms. When available, quantified endpoints are preferentially reported (e.g., LD50 - Lethal dose with 50% mortality, ED50 - sublethal dose with 50% effect). Use of a "less than" symbol (<) indicates that more than one data point of a given type is reported in ERED. When quantified effects data are unavailable, the lowest LUED (Lowest unquantified effects dose) value is reported. When no effects data are available NOED (no observed effects dose) concentrations are provided. Cellular and subcellular effects data were not considered in this summary. **Note that this information is not intended to represent an absolute threshold for effects**. It is provided here as an indication of whether and what kind of residue-effects information is available for a particular chemical, and as a low-end benchmark for comparison with the highest measured tissue concentrations presented in Tables 4 and 5. All data given in wet weight units. (*) ERED information given for total DDT is based on an LD50 for p,p' DDT.

(33) Range of bioconcentration factors (BCF) are provided as an indication of a chemical's propensity to bioaccumulate in tissues following exposure to the soluble form of the compound. BCFs for fresh water and marine organisms are from one of the following three sources: (a) Mackay et al., *Illustrated Handbook of Physical - Chemical Properties and Environmental Fate for Organic Chemicals*, (b) Hazardous Substances Data Bank compiled by the National Library of Medicine, (c) Verschueren (1983). *Handbook of Environmental Data on Organic Chemicals*, and (d) EPA's AQUIRE database.

Table 3. Chemicals Appearing On Other Bioaccumulative Chemicals Of Concern Lists

Chemical	Region 1 (7)	Region 2 (8)	Region 9 (9)	Ontario (10)	GLWQI (11)	USEPA (12)	# States with Advisories (13)	EPA Status ranking (14)
1,2-Diclorobenzene								3
1,3-Diclorobenzene								3
1,4-Diclorobenzene		+		+				3
2,6-dichlorobenzonitrile (dichlobenil)								
Aldrin	+	+	+	+	+			1
Anthracene	+	+	+	+		*		3
Antimony								
Arsenic	+	+	+			*	1	1
Benzo(a)anthracene	+	+	+	+		*	*	1
Benzo(a)pyrene	+	+	+	+		*	*	1
Benzo(g,h,i)perylene	+	+	+	+		*	*	1
Benzofluoranthenes	+	+	+			*	*	1
Biphenyl								
Bis(2-ethylhexyl) phthalate								
Butyl benzyl phthalate								
Cadmium	+	+	+	+		+	2	1
Chlordane	+	+	+	+	+	+	24	1
Chlorpyrifos						+		1
Chromium	+	+	+				1	1
Chrysene	+	+	+			*	*	
Copper	+	+	+				1	1
DCPA (dacthal)								3
DDT (total)	+	+	+	+	+	+	9	1
Diazinon						+		1
Dibenzo(a,h)anthracene	+	+	+			*	*	3
Dicofol (kelthane)						+		1
Dieldrin	+	+	+	+	+	+	3	1
Dimethyl phthalate								
Di-n-butyl phthalate								
Di-n-octyl phthalate								
Endosulfan I/II	+	+	+	+		+		3
Endosulfan sulfate	+	+	+	+				
Endrin	+		+	+		+		3
Ethylbenzene								

Table 3. Chemicals Appearing On Other Bioaccumulative Chemicals Of Concern Lists

Chemical	Region 1 (7)	Region 2 (8)	Region 9 (9)	Ontario (10)	GLWQI (11)	USEPA (12)	# States with Advisories (13)	EPA Status ranking (14)
Fluoranthene	+	+	+			*	*	1
A-BHC			+	+	+			3
G-BHC (lindane)	+		+	+	+	+		3
Heptachlor	+	+	+	+				1
Heptachlor epoxide	+	+	+			+	1	3
Hexachlorobenzene (HCB)	+			+	+	+	2	2
Hexachlorobutadiene					+		1	3
Hexachloroethane								3
Indeno(1,2,3-c,d)pyrene	+	+	+			*	*	3
Lead	+	+	+			*	4	1
Mercury	+	+	+	+	+	+	27	1
Methoxychlor			+					3
Nickel	+	+	+					1
N-nitrosodiphenylamine								
Parathion								
PCB (total)	+		+	+	+	+	31	1
PCDD	+	+	+	+	+	+	22	1
PCDF	+	+	+	+		+	22	1
Pentachloroanisol								3
Pentachlorophenol				+			1	1
Phenanthrene			+	+		*	*	1
Phenol								
Pyrene	+	+	+			*	*	1
Selenium			+			+	5	1
Silver		+	+					1
TBT			+	+			1	1
Tetrachloroethene (PCE)								
Toxaphene	+		+	+	+	+	2	1
Trichloroethene (TCE)								
Trifluralin				+				3
Zinc	+	+	+				1	1

Table 4. Tissue Monitoring Data from WA State

Chemical	PSEP Seals (15)	Belli Bay Crab/Clam (16)	WSPMP 1994 (17)	WSPMP 1995 (18)	WSPMP 1996 (19)	WSPMP 1998 (20)	WSPMP Mussels (21)	WDOH Tier I sum. data (22)
1,2-Diclorobenzene	ND							
1,3-Diclorobenzene	ND							< 530
1,4-Diclorobenzene	ND							ND
2,6-dichlorobenzonitrile (dichlobenil)								
Aldrin	ND	ND	ND	ND	ND	ND	ND	ND
Anthracene	ND	ND						< 130
Antimony								< 14,400
Arsenic	< 132	< 5600						< 32,000
Benzo(a)anthracene	ND	ND						<310
Benzo(a)pyrene	ND	ND						<240
Benzo(g,h,i)perylene	ND	ND						<21
Benzofluoranthenes	ND	ND						<330
Biphenyl								
Bis(2-ethylhexyl) phthalate	ND							< 9100
Butyl benzyl phthalate	ND							
Cadmium	<6.1	< 230						< 1610
Chlordane	ND	ND	< 97	< 36	< 33	< 36	< 1.2	
Chlorpyrifos	ND	ND	ND	ND	ND	< 28	ND	
Chromium								< 2330
Chrysene	ND	ND						< 360
Copper	< 26,800							<204 ppm
DCPA (dacthal)				< 5	< 25	< 150	< 0.33	
DDT (total)	< 74	ND	<1700	< 707	< 2800	< 3728	<17	< 410
Diazinon			ND	ND	ND	ND	ND	
Dibenzo(a,h)anthracene	ND	ND						< 58
Dicofol (kelthane)			< 50	ND	ND	ND	ND	
Dieldrin	ND	ND	< 42	< 10	< 13	< 44	< 0.7	ND
Dimethyl phthalate	ND							< 260
Di-n-butyl phthalate	ND							< 67
Di-n-octyl phthalate	ND							< 1700
Endosulfan I/II	ND	ND	ND	ND	ND	ND	< 36	< 3
Endosulfan sulfate	ND	ND	ND	< 8	ND	< 11	< 7.9	
Endrin	ND	ND		ND	ND	ND	ND	
Ethylbenzene								< 48

Table 4. Tissue Monitoring Data from WA State

Chemical	PSEP Seals (15)	Belli Bay Crab/Clam (16)	WSPMP 1994 (17)	WSPMP 1995 (18)	WSPMP 1996 (19)	WSPMP 1998 (20)	WSPMP Mussels (21)	WDOH Tier I sum. data (22)
Fluoranthene	ND	ND						< 970
A-BHC	<180	ND	ND	ND	< 0.38	ND	ND	< 6
G-BHC (lindane)	ND	ND	< 8	< 1	< 0.44	ND	ND	< 0.66
Heptachlor	ND	ND	ND	< 0.5	ND	ND	ND	ND
Heptachlor epoxide	ND	ND	< 8.3	< 8.2	< 14	ND	ND	
Hexachlorobenzene (HCB)	ND		ND	< 20	< 10	< 5.7	< 0.45	< 29
Hexachlorobutadiene	ND							< 70
Hexachloroethane	ND							
Indeno(1,2,3-c,d)pyrene	ND	ND						< 23
Lead	< 48.2	< 290						< 11.2 ppm
Mercury	<2200	< 160						< 1500
Methoxychlor	ND	ND	ND	ND	< 1.2	ND	ND	
Nickel	< 78.4							< 6500
N-nitrosodiphenylamine	ND							ND
Parathion			ND	ND	ND	ND	ND	
PCBs (total)	< 23,000	ND	< 379	< 1230	< 99	< 314	< 46	< 2100
PCDD								< 0.064
PCDF								< 0.019
Pentachloroanisol				ND	ND	ND	ND	
Pentachlorophenol	ND	ND			ND	ND		< 480
Phenanthrene	ND	ND						< 740
Phenol	ND							ND
Pyrene	ND	ND						< 920
Selenium	< 1050							< 8500
Silver	< 203							< 340
TBT								
Tetrachloroethene (PCE)								< 230
Toxaphene	ND*	ND	ND		ND	< 240	ND	
Trichloroethene (TCE)								ND
Trifluralin						< 14		
Zinc	ND							< 130 ppm

Table 5. Sediment and Tissue Monitoring Data from WA State

Chemical	SEDQUAL (23)			DAIS (24)			PSDDA 1994 (25)		USGS/WDOE	USGS Yakima	USGS
	% detected	% > SL	% > ML	% detected	% > SL	% > ML	SL	ML	(26)	(27)	East WA (28)
1,2-Diclorobenzene	3.5	46.5	1.4	0.7	20	0	19	350		ND (S)	
1,3-Diclorobenzene	4.2	4.6	NA	0.1	0	NA	170	NA		ND (S)	
1,4-Diclorobenzene	9.2	56.6	6.3	1.7	15.4	7.7	26	260		ND (S)	
2,6-dichlorobenzonitrile (dichlobenil)	NA	NA	NA	NA	NA	NA	NA	NA	< 40		
Aldrin	3.3	15.8	NA	22.7	17.8	NA	10	NA		< 40 (F) ND (S)	ND (F) (S)
Anthracene	65.4	50.8	11.1	45	14	1.8	130	1300		ND (F) < 99 (S)	
Antimony	68.9	17.0	1.7	69.1	1.4	0.2	20	200			
Arsenic	92.5	10.9	2.6	90.5	0.5	0	57	700			
Benzo(a)anthracene	81.3	41.8	6.5	65	14	0.21	450	4500		< 130 (S)	
Benzo(a)pyrene	78.1	33.5	3.1	62.3	6	0	680	6800		< 10 (F) < 160 (S)	
Benzo(g,h,i)perylene	62.1	26.5	2.0	48.1	3.7	0	540	5400		ND (F) < 160 (S)	
Benzofluoranthenes	80.0	47.3	8.6	63.6	15.4	0	800	8000		ND (F) < 340 (S)	
Biphenyl	86.50	NA	NA	NA	NA	NA	NA	NA			
Bis(2-ethylhexyl) phthalate	57.7	7.3	NA	66.1	2.3	NA	3100	NA			
Butyl benzyl phthalate	28.1	12.2	NA	13.2	1	NA	470	NA		< 360 (S)	
Cadmium	80.5	41.4	1.9	87.2	24.3	0	0.96	9.6			
Chlordane	0.6	25.0	NA	7.5	30.8	NA	10	NA	< 25	< 30 (F) < 15 (S)	< 53 (F) < 8 (S)
Chlorpyrifos	NA	NA	NA	NA	NA	NA	NA	NA			
Chromium	97.5	NA	NA	NA	NA	NA	NA	NA			
Chrysene	84.4	41.6	6.1	70.5	11.3	0	670	6700		ND (F) < 160 (S)	
Copper	99.1	36.0	NA	98.2	14.3	0.14	81	810			
DCPA (dacthal)	NA	NA	NA	NA	NA	NA	NA	NA			< 67 (F) < 58.5 (S)
DDT (total)	NDA	NDA	NDA	36.4	46.6	9.2	6.9	69	< 40	< 3400 (F) < 1700 (S)	< 3000 (F) < 77 (S)
Diazinon	NA	NA	NA	NA	NA	NA	NA	NA	< 10		
Dibenzo(a,h)anthracene	44.5	40.5	4.9	20.4	81.8	0	120	1200		ND (S)	
Dicofol (kelthane)	NA	NA	NA	NA	NA	NA	NA	NA		< 300 (F)	
Dieldrin	2.8	14.6	NA	20.3	32.9	NA	10	NA		<170 (F) <47 (S)	< 260 (F) < 10 (S)
Dimethyl phthalate	16.0	16.7	NA	3.9	7.1	NA	160	NA		ND (S)	
Di-n-butyl phthalate	24.2	7.8	NA	13.8	1	NA	1400	NA		< 160 (S)	
Di-n-octyl phthalate	15.8	5.2	NA	8.54	0	NA	6200	NA		< 190 (S)	
Endosulfan I/II	0.0	NA	NA	NA	NA	NA	NA	NA	< 20	<70 (S)	ND (F) (S)
Endosulfan sulfate	0.0	NA	NA	NA	NA	NA	NA	NA			
Endrin	0.5	NA	NA	NA	NA	NA	NA	NA		ND (F) < 17 (S)	< 10 (F) ND (S)
Ethylbenzene	4.3	57.7	19.2	2.1	42.9	21.4	10	50			

Table 5. Sediment and Tissue Monitoring Data from WA State

Chemical	SEDQUAL (23)			DAIS (24)			PSDDA 1994 (25)		USGS/WDOE	USGS Yakima	USGS
	% detected	% > SL	% > ML	% detected	% > SL	% > ML	SL	ML	(26)	(27)	East WA (28)
Fluoranthene	88.1	49.7	9.3	76.3	18.6	1.62	63	6300		< 50 (F) < 120 (S)	
A-BHC	0.0	NA	NA	NA	NA	NA	NA	NA		ND (F)	ND (F) (S)
G-BHC (lindane)	0.8	58.3	NA	12.9	1.1	NA	10.0	NA		ND (F) ND (S)	ND (F) < 5 (S)
Heptachlor	2.4	17.5	NA	3.9	18.5	NA	10.0	NA		ND (F) ND (S)	ND (F) (S)
Heptachlor epoxide	0.7	NA	NA	NA	NA	NA	NA	NA		< 20 (F) < 2 (S)	< 23 (F) < 4.5 (S)
Hexachlorobenzene (HCB)	11.3	32.8	8.7	4.4	3.1	0.0	23.0	230.0		ND (F) ND (S)	< 33 (F) < 6 (S)
Hexachlorobutadiene	9.3	36.8	11.9	0.1	100	0	29	290		ND (S)	
Hexachloroethane	3.4	9.8	0.0	0	0	0	1400	14000		ND (S)	
Indeno(1,2,3-c,d)pyrene	65.4	74.2	1.8	48.5	52.8	0	69	5200		ND (S)	
Lead	95.6	35.9	4.4	93.5	16.9	0	66	660			
Mercury	80.5	48.9	3.1	82.3	26.8	0.66	0.21	2.1			
Methoxychlor	0.0	NA	NA	NA	NA	NA	NA	NA		< 10 (S)	ND (F) (S)
Nickel	98.1	1.1	NA	97.8	1	NA	140	NA			
N-nitrosodiphenylamine	4.6	63.4	15.9	0.6	0	0	28	220		ND (S)	
Parathion	0.0	NA	NA	NA	NA	NA	NA	NA			
PCB (total)	62.7	51.5	3.7	44.8	46.8	4.7	130	2500			< 820 (F) ND (S)
PCDD	94.7	NA	NA	NA	NA	NA	NA	NA			
PCDF	84.2	NA	NA	NA	NA	NA	NA	NA		< 900 (F) < 700 (S)	
Pentachloroanisol	NA	NA	NA	NA	NA	NA	NA	NA			ND (F) (S)
Pentachlorophenol	7.6	31.1	6.7	1.4	40	0	100	690	< 40	< 1200 (S)	
Phenanthrene	77.4	43.9	8.6	67.3	13.5	1.2	320	3200		< 90 (F) K6< 140 (S)	
Phenol	29.9	49.0	5.9	21.8	19.4	0	120	1200		< 870 (S)	
Pyrene	88.2	59.2	8.4	79.5	31	1.04	430	7300		ND (F) < 190 (S)	
Selenium	36.2	NA	NA	NA	NA	NA	NA	NA			
Silver	69.6	18.3	2.6	65.6	6.6	0.62	1.2	6.1			
TBT	90.4	NA	NA	NA	NA	NA	NA	NA			
Tetrachloroethene (PCE)	5.9	50.0	13.3	0.1	0	0	14	210			
Toxaphene	0.0	NA	NA	NA	NA	NA	NA	NA		< 1200 (F) ND (S)	ND (F) (S)
Trichloroethene (TCE)	4.4	16.3	12.2	0	0	0	160	1600			
Trifluralin	NA	NA	NA	NA	NA	NA	NA	NA			
Zinc	97.3	23.0	3.1	98.5	13.7	0	160	1600			

Table 6. Other Information Related to Bioaccumulation Potential and Information on the Ecological Effects Associated with Bioaccumulated Chemicals

Chemical	Log kow (29)	Soil 1/2 life days (30)	Biomag. Pot. (31)	ERED residue-effect concs. (32)	BCF (33)
1,2-Diclorobenzene	3.43	28 - 180	NO	FW LD100 >138 ppm	40-28,000 (a)
1,3-Diclorobenzene	3.53	28 - 180	NO	FW ED50 1440 ppm	66-10,000 (a)
1,4-Diclorobenzene	3.42	28 - 180	NO	FW ED100 > 47 ppm	60-400,000 (a)
2,6-dichlorobenzonitrile (dichlobenil)	2.74 *	133-196 *		FW NOED 2 ppm	15-53 (b)
Aldrin	6.5	21 - 592	NO	FW LD/ED50 0.8 ppm	350-4500 (c)
Anthracene	4.55	50 - 460	NO	FW NOED 45.5 ppm	7-16,600 (a)
Antimony	NA	NA		NDA	0.1-14 (d)
Arsenic	NA	NA	YES	FW LD50 > 8.1 ppm	NDA
Benzo(a)anthracene	5.7	102 - 680	NO	FW NOED 17.5 ppm	347-100,000 (a)
Benzo(a)pyrene	6.11	57 - 530	YES	FW&SW ED50 > 2.1 ppm	13-9 mil. (a)
Benzo(g,h,i)perylene	6.7	590 - 650	NO	NDA	28,000-350,000 (a)
Benzofluoranthenes	6.2	360 - 2140	NO	NDA	2-140,000 (a)
Biphenyl	4.84	1.5 - 7		FW&SW ED50 15.6 ppm	436 (c)
Bis(2-ethylhexyl) phthalate	7.3	5 - 23	NO	NDA	20-107,700 (d)
Butyl benzyl phthalate	4.84	1 - 7	NO	NDA	663 (c)
Cadmium	NA	NA	NO	FW&SW ED100 > 0.83 ppm	1-5000 (d)
Chlordane	6.32	238 -1386	NO	NDA	108-7300 (c)
Chlorpyrifos	5.26	17 - 119		FW&SW ED38 0.4 ppm	42-28,300 (d)
Chromium	NA	NA	NO	FW LD50 55ppm	20-40 (CrVI) (d)
Chrysene	5.7	371 - 1000	NO	FW NOED 2.6 ppm	6-52,000 (a)
Copper	NA	NA	NO	FW&SW ED100 > 1.6 ppm	37-51,500 (d)
DCPA (dacthal)	4.4	18 - 92		NDA	NDA
DDT (total)	6.1-6.7	730 - 6250	YES	FW&SW LC50 95 ppm *	700-70,000 (a)
Diazinon	3.81	14 - 87		SW ED50 > 0.3 ppm	2-2800 (d)
Dibenzo(a,h)anthracene	6.69	361 - 940	NO	FW NOED 0.5 ppm	10-70,000 (a)
Dicofol (kelthane)	6.06	NA		NDA	1600-18,900 (d)
Dieldrin	5.37	175 - 1080	YES	FW&SW LD50 1.1	700-5500 (c)
Dimethyl phthalate	1.57	1 - 7	NO	NDA	57 (d)
Di-n-butyl phthalate	4.61	2 - 23	NO	FW LUED 32 ppm	500-6700(d)
Di-n-octyl phthalate	8.06	7 - 28	NO	NDA	2600-13,600 (d)
Endosulfan I/II	4.1	0.02 - 9	NO	NDA	9000-10,000 (d)
Endosulfan sulfate	3.66	77 - 140		NDA	NDA
Endrin	5.06	NA	YES	FW&SW ED50 > 0.2 ppm	500-13,000 (c)
Ethylbenzene	3.14	3 - 10		NDA	5-204 (a)

Table 6. Other Information Related to Bioaccumulation Potential and Information on the Ecological Effects Associated with Bioaccumulated Chemicals

Chemical	Log kow (29)	Soil 1/2 life days (30)	Biomag. Pot. (31)	ERED residue-effect concs. (32)	BCF (33)
Fluoranthene	5.12	140 - 440	NO	FW&SW ED50 > 1.9 ppm	5-80,000 (a)
A-BHC	3.8	14 - 135	NO	NDA	60-500 (c)
G-BHC (lindane)	3.73	14 - 240	NO	FW&SW LUED > 0.13 ppm	10-15,000 (d)
Heptachlor	6.26	1 - 5	NO	SW LD39 10.4 ppm	200-21,000 (a)
Heptachlor epoxide	5	33 - 552		SW LD39 8 ppm	200-14,400 (d)
Hexachlorobenzene (HCB)	5.89	969 - 2089	NO	NDA	1230-290,000 (a)
Hexachlorobutadiene	4.81	28 - 180		NDA	NDA
Hexachloroethane	4	28 - 180		FW NOED > 0.86 ppm	139 (d)
Indeno(1,2,3-c,d)pyrene	6.65	600 - 730	NO	NDA	NDA
Lead	NA	NA	NO	FW ED50 > 70 ppm	1-12 (d)
Mercury	NA	NA	YES	FW&SW ED35 > 1.6 ppm	47-27,000 (d)
Methoxychlor	5.08	180 - 365		NDA	1-8574 (d)
Nickel	NA	NA	NO	FW&SW LD50 223 ppm	5000-10,000 (d)
N-nitrosodiphenylamine	3.16	10 - 34		FW NOED 2 ppm	217 (d)
Parathion	3.83	10 - 168		FW&SW LD50 > 0.3 ppm	60-747 (d)
PCBs (total)	vary	vary	YES	FW&SW LD33 1.1 ppm	NDA
PCDD	vary	vary	NO	FW LD50 > 6.5E-5 ppm	NDA
PCDF	vary	vary		FW NOED 9E-5 ppm	NDA
Pentachloroanisol	5.45 *	NA		NDA	9100-20,000 (b)
Pentachlorophenol	5.09	23 - 178	NO	FW&SW LD100 >13.8 ppm	40-5600 (a)
Phenanthrene	4.55	16 - 200	NO	FW&SW ED50 > 30.7 ppm	6-25,000 (a)
Phenol	1.48	1 - 10		NDA	17-123,000 (a)
Pyrene	5.11	210 - 1900	NO	FW&SW ED50 189 ppm	5-44,600 (a)
Selenium	NA	NA	YES	FW LD35 1.6 ppm	0.3-322 (d)
Silver	NA	NA	NO	SW LUED > 1650 ppm	16-16,000 (d)
TBT	NA	NA		FW&SW LD50 > 0.57 ppm	NDA
Tetrachloroethene (PCE)	2.67	180 - 360		FW NOED 0.17 ppm	40-115 (a)
Toxaphene	5.5	NA	YES	FW&SW LD90 36 ppm	400-152,000 (d)
Trichloroethene (TCE)	2.71	180 - 360		FW NOED > 0.14 ppm	17-40 (a)
Trifluralin	5.34	21 - 190		NDA	1030-6000 (c)
Zinc	NA	NA	YES	FW&SW ED100 130 ppm	3-8800 (d)

Table 7. Recommended Criteria for Developing a BCoC List

Chemical	Log Kow > 3.5 (29)	Soil 1/2 life > 50 days (30)	Biomagnifies (31)	Pesticides Used in Puget Sound Basin (1)	Pesticides Used in Eastern Washington (2)	Marine Sediment Detection Frequency > 10% (23,24)	Marine Sediment Detection Frequency > 50% (23,24)	SL Exceedences > 40% (23,24)	ML Exceedences > 10% (23,24)	Detected in Fresh water Sediment (26,27,28)	Detected in Marine Tissue Monitoring (15,16,21,22)	Detected in Fresh Water Tissue Monitoring (16-20,27,28)	Residue-Effects Data in Literature	Highest Tissue Concs. > tissue LOEDs from ERED (32)	Included on COC Lists From Other National/Regional Tissue Monitoring Programs
1,2-Diclorobenzene	-	+				-	-	+	-	-	-		+	-	-
1,3-Diclorobenzene	+	+				-	-	-	-	-	+		+	-	-
1,4-Diclorobenzene	-	+				-	-	+	-	-	-		+	-	+
2,6-dichlorobenzonitrile (dichlobenil)	-	+		+	-	-	-	-	-	+			+	-	-
Aldrin	+	+		-	-	+	-	-	-	-	-	-	+	-	+
Anthracene	+	+				+	+	+	+	+	+	-	+	-	+
Antimony						+	+	-	-		+		-		-
Arsenic			+			+	+	-	-		+		+	+	+
Benzo(a)anthracene	+	+				+	+	+	-	+	+		+	-	+
Benzo(a)pyrene	+	+	+			+	+	-	-	+	+	+	+	-	+
Benzo(g,h,i)perylene	+	+				+	+	-	-	+	+	-	-		+
Benzofluoranthenes	+	+				+	+	+	-	+	+	-	-		+
Biphenyl	+	-				+	+						+	-	-
Bis(2-ethylhexyl) phthalate	+	-				+	+	-			+		-		-
Butyl benzyl phthalate	+	-				+	-	-		+	-		-		-
Cadmium						+	+	+	-		+		+	+	+
Chlordane	+	+		-	-	-	-	-		+	+	+	-		+
Chlorpyrifos	+	+		+	+		-				-	+	+	-	+
Chromium						+	+				+		+	-	+
Chrysene	+	+				+	+	+	-	+	+	-	+	-	+
Copper						+	+	-			+		+	+	+
DCPA (dacthal)	+	+		-	+					+	+	+	-		-

Table 7. Recommended Criteria for Developing a BCoC List

Chemical	Log Kow > 3.5 (29)	Soil 1/2 life > 50 days (30)	Biomagnifies (31)	Pesticides Used in Puget Sound Basin (1)	Pesticides Used in Eastern Washington (2)	Marine Sediment Detection Frequency > 10% (23,24)	Marine Sediment Detection Frequency > 50% (23,24)	SL Exceedences > 40% (23,24)	ML Exceedences > 10% (23,24)	Detected in Fresh water Sediment (26,27,28)	Detected in Marine Tissue Monitoring (15,16,21,22)	Detected in Fresh Water Tissue Monitoring (16-20,27,28)	Residue-Effects Data in Literature	Highest Tissue Concs. > tissue LOEDs from ERED (32)	Included on COC Lists From Other National/Regional Tissue Monitoring Programs
DDT (total)	+	+	+	-	-	+	-	+	-	+	+	+	+	-	+
Diazinon	+	+		+	+					+	-		+	-	+
Dibenzo(a,h)anthracene	+	+				+	-	+	-	-	+		+	-	+
Dicofol (kelthane)	+			+	+						-	+	-		+
Dieldrin	+	+	+	-	-	+	-	-		+	+	+	+	-	+
Dimethyl phthalate	-	-				+	-	-		-	+		-		-
Di-n-butyl phthalate	+	-				+	-	-		+	+		+	-	-
Di-n-octyl phthalate	+	-				+	-	-		+	+		-		-
Endosulfan I/II	+	-		+	+	-	-			+	+	-	-		+
Endosulfan sulfate	+	+				-	-				+	+	-		+
Endrin	+		+	-	-	-	-			+	-	+	+	-	+
Ethylbenzene	-	+				-	-	+	+		+		-		-
Fluoranthene	+	+				+	+	+	-	+	+	+	+	-	+
A-BHC	+	+				-	-			-	+	+	-		+
G-BHC (lindane)	+	+		+	-	+	-	+		-	+	+	+	-	+
Heptachlor	+	-		-	-	-	-	-		-	-	+	+	-	+
Heptachlor epoxide	+	+				-	-			+	-	+	+	-	+
Hexachlorobenzene (HCB)	+	+				+	-	-	-	-	+	+	-		+
Hexachlorobutadiene	+	+				-	-	+	+	-	+		-		+
Hexachloroethane	+	+				-	-	-	-	-	-		+	-	-
Indeno(1,2,3-c,d)pyrene	+	+				+	+	+	-	-	+		-		+
Lead						+	+	-	-		+		+	-	+

Table 7. Recommended Criteria for Developing a BCoC List

Chemical	Log Kow > 3.5 (29)	Soil 1/2 life > 50 days (30)	Biomagnifies (31)	Pesticides Used in Puget Sound Basin (1)	Pesticides Used in Eastern Washington (2)	Marine Sediment Detection Frequency > 10% (23,24)	Marine Sediment Detection Frequency > 50% (23,24)	SL Exceedences > 40% (23,24)	ML Exceedences > 10% (23,24)	Detected in Fresh water Sediment (26,27,28)	Detected in Marine Tissue Monitoring (15,16,21,22)	Detected in Fresh Water Tissue Monitoring (16-20,27,28)	Residue-Effects Data in Literature	Highest Tissue Concs. > tissue LOEDs from ERED (32)	Included on COC Lists From Other National/Regional Tissue Monitoring Programs
Mercury			+			+	+	+	-		+		+	+	+
Methoxychlor	+	+		-	+	-	-			+	-	+	-		+
Nickel						+	+	-	-		+		+	-	+
N-nitrosodiphenylamine	-	-				-	-	+	+	-	-		+	-	-
Parathion	+	+		+	-	-	-				-	-	+	-	-
PCB (total)	+	+	+			+	+	+	-		+	+	+	+	+
PCDD	+	+				+	+				+		+	+	+
PCDF	+	+				+	+			+	+	+	+	+	+
Pentachloroanisol	+									-	-		-		-
Pentachlorophenol	+	+		+	-	-	-	+	-	+	+	-	+	-	+
Phenanthrene	+	+				+	+	+	-	+	+	+	+	-	+
Phenol	-	-				+	-	+	-	+	-		-		-
Pyrene	+	+				+	+	+	-	+	+	-	+	-	+
Selenium			+			+	-				+		+	+	+
Silver						+	+	-	-		+		+	-	+
Tributyl tin						+	+						+	-	+
Tetrachloroethene (PCE)	-	+				-	-	+	+		+		+	-	-
Toxaphene	+		+	-	-	-	-			-	-	+	+	-	+
Trichloroethene (TCE)	-	+				-	-	-	+		-		+	-	-
Trifluralin	+	+		+	+							+	-		+
Zinc			+			+	+	-	-		+		+	+	+

ADDITIONAL FOOTNOTES TO TABLE 7

(+) Meets criteria
(-) Does not meet criteria.
Blank signifies that the criterion does not apply to a given chemical, the chemical has not been monitored, or that no information was available.
LOED - Lowest Observed Effect Dose
COC - Contaminants of Concern