SECTION 3
EFFECTS EVALUATION

3.1 SCREENING OF COPCS FOR SEDIMENT QUALITY BENCHMARKS

A frequent approach to infer the potential for a COPC in sediments to cause risk to ecological receptors is to compare measured concentrations to available sediment quality benchmarks (SQBs). NOAA SQBs for ER-Ls are used to screen concentrations of COPCs in whole sediment samples from Pearl Harbor. ER-Ls are developed as the lower 10th percentile concentration of available sediment toxicity data that have been screened for only samples identified as toxic by original investigators (Long et al. 1995; Buchman 1999).

Comparison of COPC concentrations in sediments from Pearl Harbor to ER-Ls involves dividing sediment COPC concentrations by their respective ER-Ls. Ratios of 1.0 or greater indicate a potential for adverse effects, whereas ratios below 1.0 are considered to have low probabilities for occurrences of adverse effects (Long et al. 1995; Buchman 1999).

Preliminary screening of previous limited sediment chemistry data from Pearl Harbor for ER-Ls was conducted during the project planning process and documented in the final project work plan (USN 1996a; pages 3-33 and 34). The current screening of COPCs is a continuation of this SQB approach with ER-Ls. For the SRA, COPCs with ER-L ratios of 1.0 or greater will be carried forward to Step 3a of a BERA as SQB-COPCs. COPCs with a ratio of less than 1.0 indicate a low probability for occurrences of adverse effects in the context of the ER-L SQBs. An evaluation of the adequacy of detection levels for chemistry measurements in sediments for addressing SQB considerations is presented in Section 6.1. Actual results of the SQB considerations for sediment samples from the harbor are summarized in Section 7.1.

3.2 SCREENING OF COPCS FOR SEDIMENT TOXICITY RELATIONSHIPS

Relationships between concentrations of COPCs in whole sediment and sediment toxicity measured as amphipod survival in whole sediment and echinoderm fertilization in sediment pore water are used to identify sediment toxicity-COPC associations for the SRA. The associations of interest involve statistically significant decreases in amphipod survival or echinoderm fertilization with increasing COPC concentrations. The intent of the evaluations is to identify COPCs that have a greater likelihood to be associated with measured sediment toxicity. The evaluation process applied during the SRA includes a two-phase approach.

In an effort to identify COPCs with the greatest likelihood for showing relationships with sediment toxicity measures in a most efficient and cost-effective manner, a subset of 100 of the 219 sediment samples from the harbor was first identified based on (1) the range of toxicities observed in all 219 sediment samples for both toxicity measures (i.e., no toxicity to most toxic), (2) anticipated pollutant source types, and (3) a range of spatial coverage for measurements throughout the harbor. Figure 3.2-1 illustrates the approach to identify an initial subset of 100 sediment samples for this first phase. In addition to the selected 100 samples, 5 samples were also selected following suggestions from the Informal Regulatory Work Group (IRWG). All COPCs identified in Section 2.1.2 were measured in each of the 105 sediment samples. In addition to individual COPCs, chemistry values were also considered for the following selected composite COPC groupings described in Section 2.1.2: tLMWPAH, tLMWPAH-Long95, tHMWPAH, tHMWPAH-Long95, tPAH, tPAH-Long95, tDDT, tChlordane, total PCB estimated as both tPCB-NOAA18 and tPCB-Aroclor, and tDioxin/Furan. Using the analysis approach described below, statistically significant associations between COPC concentrations (and composite COPC groups) and toxicity values for amphipod survival and echinoderm fertilization were assessed for the subset of 105 sediment samples. Results of evaluations for this initial subset of 105 samples were used to identify a subset of 148 COPCs to be carried forward for chemical measurements in the remaining 114 sediment samples from the harbor. Identification of the 148 COPCs involved assessments for both anticipated COPC-toxicity relationships (i.e., increasing COPC concentration with decreasing

amphipod survival or decreasing echinoderm fertilization) and a minimum frequency of detection for chemistry measurements of a COPC in the 105 sediment samples as well as tissue samples collected from the harbor. Specifically, COPCs had to be detected in 3 or more of the 105 sediment samples and 3 or more of the 45 wild-caught tissue samples from the harbor (i.e., 15 composite benthic macroinfauna, 15 epibenthic crabs, and 15 whole-body fish). With informal concurrence of the IRWG (October 1997 meeting), COPCs not meeting the latter detection frequency criteria were removed from consideration for measurement in remaining sediment samples. Finally, chemical measurements for the 148 COPCs were performed in the remaining 114 sediment samples from the harbor.

For both the initial subset of 105 sediment samples and the final full set of 219 sediment samples, assessments for COPC-toxicity relationships involved identification of COPCs exhibiting statistically significant increases in COPC concentrations with decreases in amphipod survival or echinoderm fertilization (Figure 3.2-2). All values for amphipod survival and echinoderm fertilization in field samples are corrected for their associated laboratory negative control values, which is an approach applied in other programs involving sediment toxicity measurements (e.g., Long et al. 1994). A negative control involves exposure of test organisms to a clean test matrix (i.e., native sediment from the area in which amphipods were collected for the amphipod survival tests; clean seawater for echinoderm fertilization tests). Exposure matrices for negative controls are anticipated to be essentially free of contaminants and are intended to provide information for the inferred general health of the test organisms. At the same time, the general health and overall responsiveness of test organisms to stressors (e.g., sediment COPCs) can vary between batches of test organisms. Therefore, corrections of test results for an associated negative control is intended to yield a final data set where batch-to-batch differences in stressor responsiveness for test organism is minimized. As an example of negative control correction, a measured survival/fertilization value of 60% in a field sample would be adjusted to a negative-control-corrected value of 66.7% if the negative control has a survival/fertilization of 90% (i.e., 60% divided by 90% yields 66.7%).

As an additional consideration for negative control corrections, when acceptance criteria for negative controls are not achieved (i.e., negative control values are lower than the method acceptance criterion of 90% for amphipod survival and 70% for echinoderm fertilization), field samples are corrected for the desired acceptance criterion value rather than the actual negative control value. Ideally, tests for field samples are rerun if the survival or fertilization in an associated negative control is below the desired value. However, results for a negative control are not known until the conclusion of the laboratory test (e.g., 10 days from the start of tests for amphipod survival). At the same time, maximum method specified holding times for sediments from time of collection until initiation of a test in the laboratory are not to exceed 14 days (documented in final Quality Assurance Project Plan; USN 1996b). Consequently, reruns for samples in which initial negative controls did not meet desired survival or fertilization acceptance criterion could not be accommodated without exceeding the prescribed 14-day holding time. Therefore, the approach adopted for adjusting toxicity results for samples with negative controls below desired survival or fertilization acceptance criterion values involved correcting field sample values for the acceptance criterion value rather than the actual control value. For example, a measured amphipod survival of 60% in a field sediment sample is corrected to 66.7% rather than 70.6% if the survival in the associated negative control is 85% (i.e., 60% divided by the acceptance criterion of 90% for a corrected value of 66.7% rather than 60% divided by 85% for a corrected value of 70.6%). Use of the criterion-correction approach rather than the preferred negative-control-correction for situations in which negative control criteria are not achieved yields lower survival/fertilization values (i.e., greater toxicity indication), which is appropriate for the highly conservative approach used for the SRA. Application of the criterion-correction approach when appropriate was performed with the informal concurrence of the IRWG. An evaluation of the frequencies of field samples and magnitude of occurrences for negative controls within and below desired levels for amphipod survival and echinoderm fertilization is presented in Section 6.2.

Assessments for COPC-toxicity associations for the SRA consider COPC concentrations in two forms: (1) detected values only and (2) total values consisting of detected values when a COPC is detected and half the nondetect value reported by the laboratory when

the COPC is not detected in a sediment sample (Figure 3.2-2). A greater degree of certainty can be assigned to the relationships when COPC data are based on detected values. As noted in the figure, an operational requirement for assessing associations involves only evaluating associations when a COPC is detected in at least 3 sediment samples. If a COPC data set includes at least three detected values but all samples are not represented by detected values, the COPC-toxicity associations are evaluated for both (1) the reduced data set of detect only values and (2) the full data set of detect values plus half nondetect values.

COPC-toxicity associations are assessed by Spearman Rank Correlation analyses. Spearman Rank is a nonparametric procedure that provides a measure of association between rank orders for a data set. The procedure does not require data points to be linearly related with a normal distribution about a regression line with constant variance. Assumptions of normality and homogeneity of variance, which are required for parametric procedures (e.g., Pearson correlation), are not required for nonparametric procedures such as Spearman Rank. Information generated in the Spearman Rank procedure includes the Spearman's rho (or r) correlation coefficient and a significance (or P) value for the association of the ranked data points. The rho quantifies the strength of the association for the ranked values, and can vary from -1 to +1 (i.e., a perfect increasing-to-decreasing relationship gives a rho of -1, a perfect increasing-to-increasing relationship gives a rho of +1). COPC-toxicity relationships in evaluations for the SRA anticipate increasing COPC concentrations with decreasing amphipod survival or echinoderm fertilization (i.e., rho values tending toward -1). The P value for an association is the probability of being wrong in concluding that an association exists (i.e., the probability of falsely rejecting the null hypothesis of no association, or committing a Type I error). One-tailed probabilities are applied for all evaluations because the relationship of interest anticipates decreasing amphipod survival or echinoderm fertilization with increasing COPC concentrations in sediments. A statistically significant association of interest occurs when a one-tailed P value for a Spearman Rank Correlation is 0.05 or less and the rho value is between 0 and -1.

COPCs exhibiting the desired statistically significant relationship for the Spearman Rank procedure are classified as toxicity-COPCs to be carried forward from the SRA to a subsequent BERA. Results of all Spearman Rank analyses for the harborwide data set of sediments for both amphipod survival and echinoderm fertilization are presented in Section 7.2.

3.3 NO-OBSERVED-ADVERSE-EFFECT-LEVEL TOXICITY REFERENCE VALUES FOR BIOACCUMULATION

For assessing potential bioaccumulation risk to target ecological receptors for the SRA, exposure point values (EPVs) for a receptor are compared to appropriate toxicity reference values (TRVs) for a COPC for the receptor. TRVs are developed from toxicological endpoint values (TEVs) from the scientific literature. USEPA (1997; p. 1-9) notes "Screening ecotoxicity values should represent a no-observed-adverse-effect-level (NOAEL) for long-term (chronic) exposures to a contaminant." Use of NOAEL values is recommended because the "screening-level risk calculation is a conservative estimate to ensure that potential ecological threats are not overlooked" (USEPA 1997; p. 2-4).

Therefore, NOAELs are the preferred measurement endpoint for the SRA. In identifying the most appropriate NOAEL for a particular COPC and receptor, TEVs considered from the scientific literature include measurement endpoints of:

- no-observed-adverse-effect-levels (NOAELs);
- lowest-observed-adverse-effect-levels (LOAELs); and
- median lethal concentrations or doses (LC50s/LD50s).

If an appropriate NOAEL is available and it is below the lowest available LOAELs or LC50s or LD50s, then the NOAEL is used as the TRV for the SRA.

At the same time, appropriate NOAELs may not be available or available LOAELs or LC50s or LD50s may be below the lowest available NOAELs. USEPA (1997; p. 1-10)

notes "…NOAELs currently are not available for many groups of organisms and many chemicals." In such a situation, USEPA (1997; p. 1-10) notes "…When a LOAEL value, but not a NOAEL value, is available from the literature, a standard practice is to multiply the LOAEL by 0.1 and to use the product as the screening ecotoxicity value. Support for this practice comes from a data review indicating that 96 percent of chemicals included in the review had LOAEL/NOAEL ratios of five or less, and that all were ten or less (Dourson and Stara, 1983)." Additionally, literature-derived TEVs based on LC50 or LD50 values have been divided by factors of approximately 10 to estimate LOAEL-equivalent values or 100 to estimate NOAEL-equivalent values as noted in Wentsel et al. (1997; p. 51) and Calabrese and Baldwin (1993). In the absence of an available NOAEL or if an appropriate LOAEL or LC50 or LD50 occurs below a lowest available NOAEL, literature-derived LOAELs and LC50s or LD50s are adjusted to estimated NOAEL-equivalent TRVs for the SRA with the following equations.

Available LOAEL TEV: NOAEL-equivalent TRV = LOAEL/10.
Available LC50 or LD50 TEV: NOAEL-equivalent TRV = LC50/100 or LD50/100.
Available LC50 or LD50 TEV: LOAEL-equivalent TRV = LC50/10 or LD50/10.

In selecting appropriate TEVs, USEPA (1997; p. 1-9) notes "Ecological effects of most concern are those that can impact populations (or higher levels of biological organization). Those include adverse effects on development, reproduction, and survivorship." Therefore, TEVs for the SRA are focused on measurement endpoints relating to growth or development, reproduction, and survival for appropriate test organisms.

Finally, TEVs for development of NOAEL TRVs are focused on the following phylogenetic groupings that encompass receptor groups of interest for the SRA.

- Aquatic invertebrates – target aquatic invertebrate receptors include epibenthic crabs and composite benthic macroinfauna (the latter comprised primarily of crustacea including snapping and ghost shrimp with additional presence of polychaete worms based on samples from Pearl Harbor).

- Fish – target fish receptors include epibenthic fish (i.e., represented by tilapia and the bandtail goatfish).

- Birds – target bird receptors include waterbirds (i.e., represented by the Hawaiian stilt, Hawaiian coot, Hawaiian duck, Hawaiian moorhen, and black-crowned night heron), shorebirds (i.e., represented by the wandering tattler), and piscivorous seabirds (i.e., represented by the sooty tern).

Available literature-derived TEVs (i.e., NOAELs, LOAELs, and LC50s or LD50s) for COPCs for endpoints of growth or development, reproduction, and survival are compiled for phylogenetic groups of (1) birds, (2) fish, and (3) aquatic crustacea for the SRA. If the lowest NOAEL for a COPC in a particular group is below all LOAELs and LC50s or LD50s, then this lowest NOAEL is selected as the NOAEL TRV for the entire phylogenetic group. If no NOAEL is available, or if a LOAEL or LC50 or LD50 is below the lowest NOAEL, then a lowest NOAEL-adjusted TRV (see above adjustment algorithms) is selected as the NOAEL-equivalent TRV for the phylogenetic group.

To account for TRV differences between species, uncertainty factors (UFs) are often applied to adjust for anticipated species differences. For example, USEPA (1996; p. xi and xii) notes "Extrapolating toxicological effect levels between species is often required in wildlife risk assessments and criteria calculations because of limitations in the quantity and quality of toxicity data available for the target species of interest. Such interspecies toxicity extrapolations often constitute a significant source of uncertainty in risk assessments and may be controversial, particularly under 'data poor' situations that typify the availability of chronic toxicity data for wildlife." Additionally, "…actual selection of an interspecies UF in a given circumstance requires the use of professional judgment and is best performed on a case-by-case basis. In selecting an interspecies UF, judgment is required in assessing the degree of uncertainty that exists in extrapolating between the test and target species. Aspects to consider in assessing the magnitude of the interspecies UF include information relating to toxicokinetic and toxicodynamic differences that may exist between the test and target species, the quantity and quality of toxicity data

available, physiological and taxonomic similarities between species, the physicochemical and toxicological properties of the chemical of concern, and the intended level of protection of the risk assessment." Because of the preceding complexities for identifying and justifying a particular interspecies UF for adjusting TRVs between species, the lowest available NOAEL or, if appropriate, NOAEL-equivalent TRV for a COPC for all available values for particular phylogenetic group (i.e., crustacea, fish, or birds) is used to assess potential screening-level risk for target receptors for the SRA.

Greater details for development of lowest NOAEL or NOAEL-equivalent TRVs for the SRA for both aquatic and bird receptors are provided in the following sections.

3.3.1 Critical Body Residues for Aquatic Receptors

Whole body tissue residues for COPCs in samples of wild-caught aquatic organisms from Pearl Harbor are used to estimate potential risk to aquatic receptors (i.e., represented by composite benthic macroinfauna, epibenthic crabs, tilapia, and bandtail goatfish). The concept is patterned after a "critical body residue" approach (e.g., McCarty and Mackay 1993; Jarvinen and Ankley 1999; Jarvinen et al. 1998; Field 1998). As described in USEPA (1998; p. 69), "Biomarkers and tissue residues are particularly useful when exposures across many pathways must be integrated and when site-specific factors influence bioavailability."

Several comprehensive compilations of information were initially consulted as a first step for identifying tissue-based residue effects levels for lowest NOAEL or NOAEL-adjusted TRVs for the SRA. For example, the Environmental Residue-Effects Database (ERED) developed by the U.S. Army Corps of Engineers and USEPA summarizes information from studies where measured tissue concentrations for chemicals are linked with biological responses or effects in aquatic organisms. The ERED database is currently available on the World Wide Web (www.wes.army.mil/el/ered). USEPA/Duluth has also developed and recently published a separate comprehensive summary for effects levels of tissue residues for a wide range of inorganic and organic chemicals in aquatic organisms (Jarvinen and Ankley 1999). Other sources of tissue-based residue effects levels

considered for the SRA include publications by Beyer et al. (1996) and the series of Contaminant Hazard Reviews from the U.S. Fish and Wildlife Service (Eisler 1985 through 1998).

In addition to TEVs for specific COPCs, TEVs for PCB and dioxin/furan congeners in fish are estimated from TEVs for 2,3,7,8-TCDD and application of 2,3,7,8-TCDD TEFs for fish from a publication supported by the World Health Organization (Van den Berg et al. 1998). The latter publication includes congener-specific TEFs for PCBs and dioxins and furans in fish, but notes that comparable TEFs cannot be developed for aquatic invertebrates because of insufficient information for invertebrate receptors.

Overall, a 4-level screening approach is applied to identify and develop lowest NOAEL or NOAEL-equivalent TRVs for aquatic receptor groups of crustacea and fish (Figure 3.3.1-1). The first screening level involves identification of tissue-based TEVs in which exposure routes to test organisms include aqueous media, contaminated sediments, or contaminated diets. An example of an exposure route not considered is injection of COPCs into test organisms. The second screening level refines level 1 TEVs to those with effects related to growth or development, reproduction, and/or survival. Effects not considered include measurements relating to physiological or biochemical parameters whose overall ecological significance can be unclear or controversial. The third screening level refines level 2 TEVs to measurements for whole body residues. Restriction of TEVs to whole body values is based on the existing measurements for whole body residues in samples of wild-caught organisms from the harbor, which are based in part on the intended ecological relevance for exposures to higher trophic level consumers such as birds (e.g., bird receptors generally consume whole prey items). Following conversion of level 3 TEVs to their dry weight equivalents if necessary (wet weight to dry weight conversions are based on a value of 20% for aquatic receptors following the approach applied for TEVs in Jarvinen and Ankley 1999 based on Stephen et al. 1985), a final level 4 screen identifies either the lowest NOAEL or, if appropriate, lowest NOAEL-adjusted TRV. COPC measurements in whole-body samples of epibenthic crabs and composite benthic macroinfauna are compared to the lowest NOAEL or NOAEL-equivalent TRVs in the crustacea TRV data set; COPC

measurements in whole-body samples of tilapia and bandtail goatfish are compared to the lowest NOAEL or NOAEL-equivalent TRVs in the fish TRV data set.

The lowest NOAEL or NOAEL-equivalent TRVs for crustacea and fish are summarized in Tables 3.3.1-1 and 3.3.1-2, respectively. The tables include information for the total number of TEVs considered in an entire data set, the numbers of TEVs by effect (i.e., growth or development, reproduction, and/or survival) and measurement endpoint (i.e., NOAEL, LOAEL, or LC50), and available details relevant to the specific TEV measurement. The latter details include the following.

- The test organism (both common and scientific names).
- The exposure form for the COPC.
- The exposure medium.
- The TEV measurement endpoint.
- The TEV effect.
- The TEV and its concentration units.
- The conversion factor applied to adjust a TEV to its NOAEL-equivalent value, if necessary.
- The estimated percent dry of wet weight for converting a wet-weight TEV to its dry-weight equivalent (i.e., 20%; in accordance with the approach applied in Jarvinen and Ankley 1999 based on Stephan et al. 1985).
- The final lowest NOAEL or NOAEL-equivalent TRV (in units of milligram [mg] of COPC per kilogram [kg] dry weight of whole-body tissue).
- The tissue type for a TEV measurement (always whole body).
- The exposure route for the TEV measurement.
- The lifestage of the test organism.
- Information relating to the test site and conditions.
- The testing duration for the TEV measurement.
- Any additional relevant comments.
- The compilation source and specific reference for the TEV study.

The lowest NOAEL or NOAEL-equivalent TRV for a COPC is indicated in a shaded column in the tables.

A number of COPCs in Tables 3.3.1-1 and 3.3.1-2 have no available, appropriate NOAEL or NOAEL-equivalent TRV. When appropriate, these COPCs are represented by TRVs for surrogate COPCs. Selection of an appropriate surrogate COPC is based on similarities in structural and toxicological properties between chemicals. For example, 2-methylnaphthalene and naphthalene are selected as the surrogate COPCs for all naphthalene-related LMWPAHs for crustacea and fish, respectively. In instances where an appropriate surrogate COPC is not apparent, a data gap is identified that precludes estimates of potential risk for the COPC for the SRA. Examples of the latter include missing TEVs/TRVs for metals such as aluminum, antimony, iron, manganese, molybdenum, and silver for crustacea and cobalt, iron, manganese, molybdenum, and nickel for fish.

An overall evaluation of the adequacy of detection levels for chemistry measurements in tissue samples for addressing lowest NOAEL TRVs for aquatic receptors is presented in Section 6.3.

3.3.2 Ingestion Doses for Birds

Toxicity related to ingestion doses for COPCs in birds (i.e., mg of COPC per kg of body weight for a bird per day) is used to estimate potential risk to bird receptors for the SRA. NOAEL or NOAEL-equivalent TRVs as ingestion doses are developed from available TEVs from the scientific literature. Initial considerations for TEVs include values as both doses (i.e., mg of COPC per kg of body weight per day) and food concentrations (i.e., mg of COPC per kg of food consumed by a bird). If a TEV is reported as a food concentration, the value is converted to a dose-equivalent value using the following allometric equation for "all birds" from USEPA's Wildlife Exposure Factors Handbook (USEPA 1993a; p. 3-4).

$$TEV_{bird} = (EC_{food} \times FI_{food})/W_{bird} = (EC_{food} \times [0.0582 \times W_{bird}^{0.651}])/W_{bird}$$

where:

TEV_{bird} = toxicological endpoint value for a COPC to a test bird as an ingestion dose (units of mg of COPC per kg of bird weight per day);

EC_{food} = concentration of the COPC in the food item (units of mg of COPC per kg of food item);

FI_{food} = food ingestion or dietary intake rate or ration for the test bird (kg of food per day); and

W_{bird} = body weight of the test bird (kg).

Values for W_{bird} are the minimum or smallest value for a particular species from Dunning (1993).

Several comprehensive compilations of TEV information were initially consulted as a first step for identifying ingestion-based effects levels for lowest NOAEL or NOAEL-adjusted TRVs for the SRA. TEVs considered include both ingestion doses and food concentrations. Sources for TEVs include the U.S. Navy (EFA West 1998), the series of Contaminant Hazard Reviews from the U.S. Fish and Wildlife Service (Eisler 1985 through 1998), Oak Ridge National Laboratory (Sample et al. 1996), the USEPA TERRETOX database, and publications for pesticides by Kamrin (1997) and Milne (1995). TEVs for birds for PCB and dioxin/furan congeners are also estimated from TEVs for 2,3,7,8-TCDD and application of 2,3,7,8-TCDD TEFs for birds from the publication supported by the World Health Organization (Van den Berg et al. 1998).

Overall, a 4-level screening approach is applied to identify and develop lowest NOAEL or NOAEL-equivalent TRVs for birds (Figure 3.3.2-1). The first screening level involves identification of TEVs based on the exposure route. Exposures through diet are preferred. In the absence of values for dietary exposures, values for gavage exposures (i.e., force feeding as through a stomach tube) are considered. Exposure routes not considered include injection and topical/dermal applications. The second screening level refines level 1 TEVs to effects related to growth or development, reproduction, and/or

survival. Effects not considered include measurements for physiological or biochemical parameters whose overall ecological significance can be unclear or controversial. The third screening step converts level 2 TEVs for food concentrations to dose-equivalent values. A final level 4 screen identifies either the lowest NOAEL or, if appropriate, lowest NOAEL-adjusted TRV. COPC values determined as ingestion doses to selected bird receptors for the SRA from consumption of either aquatic forage items (i.e., composite benthic macroinfauna, epibenthic crabs, tilapia, or bandtail goatfish) or incidental sediment are compared to the lowest NOAEL or NOAEL-equivalent TRVs in the bird TRV data set.

Lowest NOAEL or NOAEL-equivalent TRVs for birds are summarized in Table 3.3.2-1. The table includes information for the total number of TEVs considered, the numbers of TEVs by effect (i.e., growth or development, reproduction, and/or survival) and measurement endpoint (i.e., NOAEL, LOAEL, or LD50), and available details relevant to the specific TEV measurement. The latter details include the following.

- The bird test organism (both common and scientific names).
- The exposure form for a COPC.
- The TEV measurement endpoint.
- The TEV effect.
- The TEV and its concentration units.
- The conversion factor applied to adjust a TEV to its NOAEL-equivalent value, if necessary.
- The body weight for the test bird if the TEV is a food concentration (from Dunning 1993).
- The final lowest NOAEL or NOAEL-equivalent TRV (in units of mg of COPC per kg of body weight).
- The exposure route and technique for developing the TEV.
- The lifestage of the test bird.
- The exposure period or duration for the TEV measurement.
- Any additional relevant comments.
- The compilation source and specific reference for the TEV study.

The lowest NOAEL or NOAEL-equivalent TRV for a COPC is indicated in the shaded column in the table.

A number of COPCs in the table have no available, appropriate NOAEL or NOAEL-equivalent TRV. When appropriate, these COPCs are represented by TRVs for surrogate COPCs. Selection of an appropriate surrogate COPC is based on similarities in structural and toxicological properties between chemicals. For example, naphthalene is selected as an appropriate surrogate compound for TRVs for all naphthalene-related LMWPAHs. In instances where an appropriate surrogate chemical is not apparent, a data gap is identified that precludes estimates of potential risk for the COPC for the SRA. Examples of the latter include absent TEVs/TRVs for metals such as antimony, cobalt, iron, and tin.

An overall evaluation of the adequacy of detection levels for chemistry measurements in samples of wild-caught aquatic organisms and sediments for addressing lowest NOAEL TRVs for birds is presented in Section 6.3.

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