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Aquatic Ecosystem-Scale Selenium Modeling for Invertebrates, Fish, and Birds

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Ecosystem-scale selenium modeling is a linked approach that conceptualizes and then quantifies the variables that determine how selenium is processed from water through diet to predators. The result is a biologically-based protocol for site-specific evaluations and predictions of risk from selenium. This approach uses geochemical and physiological factors from either laboratory or field studies and independently considers selenium loading, dissolved concentrations, transformation to particulate material, bioaccumulation, and trophic transfer. Watershed considerations can be predator-driven to assess the protection of fish and birds vulnerable to selenium and/or those threatened or endangered. The model derives forecasts of dissolved selenium concentrations from bioaccumulated selenium in chosen predator species (e.g. a tissue criteria value or a tissue Predicted No-Effect Concentration). Key inputs are: (1) trophic transfer from invertebrates to fish or birds; (2) bioaccumulation from particulates into invertebrate prey; and (3) partitioning constants between sediment and water (i.e., Kd). Protocols were developed to estimate Kd when data are not available. Invertebrate bioaccumulation is derived from particulate material through biodynamic modeling using ingestion rate, assimilation efficiency, and uptake and efflux rates. Bioaccumulated concentrations in fish and birds are derived from the relationship of concentrations in diet to concentrations in egg, liver, or muscle that serve as endpoints for determination of toxicity. Model forecasts were independently validated from existing data; and can be site-specifically validated by collection of carefully

designed matched datasets across ecosystem media. Although sufficient data are presently available to use the model for estimating outcomes of specific decisions about regulatory criteria for selenium, uncertainties about predictions are increasingly narrowed as site-specific data on selenium are developed. Uncertainties could be further narrowed by more knowledge of (a) factors that control accumulation of selenium in site-specific food webs; (b) factors that control selenium transformation and transport; and (c) toxicity testing that links diet to effects in birds and fish.