May 10, 2017

Terri S. Reeder, PG, CHG, CEG
Senior Engineering Geologist
Coastal Waters Planning Section
SANTA ANA REGIONAL WATER QUALITY CONTROL BOARD
3737 Main Street, Suite 500
Riverside, CA 92501

SUBJECT: REVISED FINAL RESPONSE – MAY 10, 2017
REQUEST FOR PEER REVIEW OF DRAFT BASIN PLAN AMENDMENT TO INCORPORATE TOTAL MAXIMUM DAILY LOADS (TMDLs) FOR SELENIUM IN FRESHWATER, NEWPORT BAY WATERSHED, ORANGE COUNTY, CA

Dear Ms. Reeder,

This letter responds to the attached March 7, 2017 revised request for external scientific peer review for the subject noted above. It revises my original May 1, 2017 response by adding a third and final review.

The review process is described below. All steps were conducted in confidence. Reviewers' identities were not disclosed.

To begin the process for selecting reviewers, I contacted the University of California, Berkeley (University) and requested recommendations for candidates considered qualified to perform the assignment. This service is supported through an Interagency Agreement co-signed by CalEPA and the University. The University was provided with the original November 10, 2016 request letter and attachments, which has been slightly revised as the March 7, 2017 request. No additional material was asked for. The University interviews each promising candidate.

Each candidate who was both qualified and available for the review period was asked to complete a Conflict of Interest (COI) Disclosure form and send it to me for review, with Curriculum Vitae. The cover letter for the COI form describes the context for COI concerns that must be taken into consideration when completing the form. "As noted, staff will use this information to evaluate whether a reasonable member of the public would have a serious concern about [the candidate's] ability to provide a neutral and objective review of the work product."

In subsequent letters to candidates approved as reviewers, I provided the attached January 7, 2009 Supplement to the CalEPA Peer Review Guidelines, which, in part, serves two purposes: a) it provides guidance to ensure confidentiality through the course of the external review, and

b) it notes reviewers are under no objection to discuss their comments with third-parties after reviews have been submitted. We recommend they do not. All outside parties are provided opportunities to address a proposed regulatory action, or potential basis for such, through a well-defined rulemaking process.

Attachment 2 of the March 7 request was highlighted as the focus for the review. Each reviewer was asked to address each conclusion, as expertise allows, in the order given. Thirty days were provided for the review. I also asked reviewers to direct enquiring third-parties to me after they have submitted their reviews.

A third reviewer will be submitting his review in two weeks. I will send you a revised response letter identifying him, and providing his review and curriculum vitae at that time. Two reviewers' names, affiliations, curriculum vitae, initiating letters and reviews are being sent to you now with this letter.

Approved reviewers:

1. Marjorie L. Brooks, Ph.D.
   Associate Professor, Department of Zoology
   Southern Illinois University
   335E, Life Sciences II
   Carbondale, IL 62901

   Telephone: 618-453-4121
   Cell: 307-399-0576
   E-mail: mlbrooks@siu.edu

2. Dirk Wallschläger, Ph.D.
   Professor, School of the Environment
   Director, Water Quality Center; Trent University
   1600 West Bank Drive
   Peterborough, ON K9L 0G2
   Canada

   Telephone: 708-748-1625
   E-mail: dwallsch@trentu.ca

3. Judson Harvey, Ph.D.
   Senior Research Hydrologist
   National Research Program, USGS
   436 National Center
   Reston, VA 20192

   Telephone: 571-420-7616
   E-mail: jwharvey@usgs.gov

If you have any questions, or require clarification from the reviewers, please contact me directly.

Regards,

Gerald W. Bowes

Gerald W. Bowes, Ph.D.
Manager, Cal/EPA Scientific Peer Review Program
Office of Research, Planning and Performance
State Water Resources Control Board
1001 "I" Street, 16th Floor
Sacramento, California 95814

Telephone: (916) 341-5567
FAX: (916) 341-5284
Email: GBowes@waterboards.ca.gov

Attachments:

(1) March 7, 2017 Request by Terri Reeder for Scientific Peer Review
(2) Letters to Reviewers Initiating the Review
    (1) Marjorie L. Brooks, Ph.D.
    (2) Dirk Wallschläger, Ph.D.
    (3) Judson Harvey, Ph.D.
(3) January 7, 2009 Supplement to Cal/EPA Peer Review Guidelines
(4) Curriculum Vitae
    (1) Marjorie L. Brooks, Ph.D.
    (2) Dirk Wallschläger, Ph.D.
    (3) Judson Harvey, Ph.D.
(5) Reviews
    (1) Marjorie L. Brooks, Ph.D.
    (2) Dirk Wallschläger, Ph.D.
    (3) Judson Harvey, Ph.D.

Revised March 7, 2017

TO: Gerald Bowes, Ph.D.
Manager, Cal/EPA Scientific Peer Review Program
Office of Research, Planning and Performance
STATE WATER RESOURCES CONTROL BOARD
Sacramento, CA

FROM: Terri S. Reeder, PG, CHG, CEG
Senior Engineering Geologist
Coastal Waters Planning Section
SANTA ANA REGIONAL WATER QUALITY CONTROL BOARD
Riverside, CA

DATE: November 10, 2016

SUBJECT: REQUEST FOR PEER REVIEW OF DRAFT BASIN PLAN AMENDMENT TO INCORPORATE TOTAL MAXIMUM DAILY LOADS (TMDLs) FOR SELENIUM IN FRESHWATER, NEWPORT BAY WATERSHED, ORANGE COUNTY, CA

Santa Ana Regional Water Quality Control Board (Regional Board) staff hereby request initiation of peer review pursuant to the requirements of Health and Safety Code section 57004 for scientific portions of a proposed Basin Plan Amendment (BPA) to incorporate Total Maximum Daily Loads (TMDLs) for selenium (Se) in three freshwater tributary subwatersheds in the Newport Bay watershed (San Diego Creek, Santa Ana-Delhi Channel, and Big Canyon Wash subwatersheds). These selenium TMDLs do not apply to the saltwater bodies in the Newport Bay watershed (Upper and Lower Newport Bay).

The Regional Board plans to consider the proposed amendment at a regularly scheduled meeting in early 2017. (The Regional Board's 2017 meeting schedule is not yet established, but meetings in early February and mid-March are likely.) Regional Board staff anticipates submittal of the peer review package to CalEPA staff by December 9, 2016.

A succinct summary of the recommended TMDLs and the scientific elements for which review is requested is provided in Attachment 1. Attachment 2 provides a more detailed description of the scientific assumptions, findings and conclusions used in formulating the recommended TMDLs. Briefly, the critical components of the TMDLs needing independent review are: (1) the tissue-based numeric targets, which incorporate two fish tissue targets and one bird egg tissue target for selenium; (2) the impairment assessment portion of the problem statement; (3) the linkage analysis, which uses USGS' biodynamic model[1] to translate the proposed tissue targets into water column concentrations; (4) the allocations section, which then uses those water column translations to develop allocations for waste loads (point sources) and loads (non-point sources); and (5) the minimum monitoring requirements.

[1] The biodynamic model developed by the U.S. Geological Survey has undergone extensive independent peer review as required for their professional publications and by the environmental journals that have published papers on the model's development, identification of underlying fundamental processes, and use in various ecosystems in salt and freshwater. This ecosystem-scale model has been used (or is being used) to develop potential water quality criteria for selenium for the protection of fish and wildlife and/or to predict environmental exposure and risk from selenium to sensitive food webs in California, Colorado, Idaho, Utah, and West Virginia. Attachment 4 includes a list of professional publications that required independent peer review of the model. The USGS does not provide the names of individuals that have provided peer review of their publications.

With these specific needs in mind, we ask that State Water Board staff solicit peer reviewers with expertise in one or more of the following areas, which cover the twelve (12) assumptions, findings and conclusions described in Attachment 2:

- Ecotoxicologist/wildlife biologist with experience in the study and investigation of the fate and effects of selenium in freshwater aquatic ecosystems. Potential reviewers need to have a thorough understanding of selenium exposure routes, speciation, food web transfer and sensitivity, species sensitivity, and biodynamic controls on selenium accumulation and trophic transfer. (Attachment 2: Numeric Targets, Conclusions 1-5; Monitoring, Conclusion 10, TMDL Evaluation Monitoring, Other Considerations, Special Studies; Site-Specific Objectives, Conclusions 11 and12).

- Environmental scientist, ecologist, ecotoxicologist, or other discipline with expertise in ecosystem scale mechanistic modeling, in particular, biodynamic or biokenetic models used to translate selenium concentrations from one medium to another, especially tissue concentrations to water column concentrations, and ecological risk assessment. (Attachment 2: Linkage Analysis, Conclusions 6-8; TMDLs and Allocations, Conclusion 9.)

- A biogeochemist, biochemist or similar background with knowledge of selenium speciation and biogeochemical cycling in freshwater environments, in particular, selenium transfer between aquatic compartments (water, sediment, particulate material, and biota) and the effects of hydrological changes on selenium cycling. (Attachment 2: Linkage Analysis, Conclusions 6 and 7; Monitoring, Conclusion 10, TMDL Evaluation Monitoring, BMP Effectiveness Monitoring, Other Considerations, Special Studies.)

- A hydrologist, hydrogeologist, geologist, or geotechnical/civil engineer familiar with groundwater-surface water dynamics, groundwater and surface water chemistry, and water balance modeling, especially in highly urbanized and hydromodified environments. We recommend that reviewers have knowledge of: geological sources of selenium and selenium geochemistry, treatment and management of selenium and nitrate or similar pollutants in surface and ground waters (including reasonable and feasible Best Management Practices and selenium treatment technologies), and pollutant offset and trading programs. (Attachment 2: TMDLs and Allocations, Conclusion 9; Monitoring Conclusion 10, BMP Effectiveness Monitoring, Offset and Trading Program Monitoring, Source Assessment Monitoring, Special Studies.)

It is understood that a potential peer review candidate may (is likely to) have expertise in more than one of the above fields; the above descriptions are meant to be qualitative. In the area of selenium fate and transport, the fields of biology, ecology, hydrology, geology, chemistry, and engineering often overlap.

Regional Water Board staff request that the search for potential peer reviewers extend beyond the university system to include potential reviewers from federal or state agencies that have a high degree of expertise with selenium cycling in aquatic environments and selenium effects in fish and wildlife. Expertise in selenium exists within several US federal agencies (e.g., USGS, USFWS, U.S. Department of the Interior [USDOI], and USEPA) and at similar state agencies or organizations in other countries (e.g., Environment Canada). Such other agency reviewers may have the advantage of familiarity with the regulatory process. We therefore request that at least one of the reviewers also have experience in the regulatory environment, including criteria development and implementation. In addition, we ask that one or more of the reviewers be familiar with, or have participated in, the 2009 Pellston Workshop on Selenium in the Aquatic Environment, and the resulting 2010 SETAC publication, Ecological Assessment of Selenium in the Aquatic Environment. We also request that that the peer reviewers who are selected provide comments on the TMDLs staff report and draft BPA within 30 days or less of the receipt of these documents.

This request includes the following enclosures:

Attachment 1 – A summary of the proposed revised TMDLs for selenium in freshwater for the Newport Bay watershed;
Attachment 2 – A list of the scientific assumptions, findings, and conclusions that have been identified by Regional Water Board staff as requiring review. Attachment 2 has been revised to clarify the relationship between several of the conclusions. Revisions are in red font and confined to pages 1 and 2 of the attachment;
Attachment 3a – A list of all participants who have assisted in the development of these proposed selenium TMDLs;
Attachment 3b – A list of all participating members of the Nitrogen and Selenium Management Program (NSMP);
Attachment 4 – A list of references for the draft staff report.

The Basin Plan Amendment package that will be submitted to the selected peer reviewers will include an electronic copy of the proposed draft Basin Plan Amendment, the Newport Bay Watershed Selenium TMDLs draft staff report, and all references and appendices for the draft staff report. We understand that State Board staff has set up a secure File Transfer Protocol (ftp) site for posting documents for the peer reviewers and that we will need to provide staff with a portable electronic device (e.g., CD, DVD, USB drive) that contains copies of all of the necessary documents.

While reviewers are not prevented from commenting on other portions of the referenced documents, we would like to emphasize to potential reviewers the need to provide a concise evaluation of the assumptions, findings, and conclusions in the proposed TMDLs that have been identified by Regional Board staff in Attachment 2. It is particularly important that the scientific rationale underpinning the fish and bird egg tissue numeric targets proposed for the Newport Bay watershed (discussed in detail in Section 4.0 of the draft staff report) receive careful review by qualified individuals.

Should you have any questions, please contact me at Terri.Reeder@waterboards.ca.gov, (951) 906-1899 or (951) 782-4995.

cc: Rik Rasmussen, Manager Water Quality Standards and Assessment Section, SWRCB, rik.rasmussen@waterboards.ca.gov
Janet Hashimoto, USEPA TMDL Lead, Hashimoto.Janet@epa.gov
Daniel Oros, USEPA TMDL Liaison, Oros.Daniel@epa.gov

ATTACHMENT 1

Summary of Proposed Basin Plan Amendment to Adopt Total Maximum Daily Loads for Selenium in Freshwater for the Newport Bay Watershed, Orange County, California

In 2002, the U.S. EPA (EPA) established Total Maximum Daily Loads (TMDLs) for Toxic Pollutants for fresh and salt water bodies in the Newport Bay watershed, including TMDLs for selenium. USEPA's impairment assessment was based on exceedances of the California Toxics Rule (CTR) chronic criterion for selenium in freshwater and exceedances of toxicological and reproductive effect guidelines in freshwater fish tissue.

Regional Board staff proposes the adoption of revised selenium TMDLs for freshwaters in the Newport Bay watershed. The revised impairment assessment conducted to support the recommended TMDLs considered human health risk based on selenium concentrations in fish fillets, ecological risk based on whole body fish tissue and bird egg tissue, and water column concentrations for comparison to the CTR. No impairment for human health, fish or wildlife health due to selenium was found in saltwater for either Upper or Lower Newport Bay. Selenium concentrations in freshwater fish fillets were also below levels of concern for human consumers of fish. However, concentrations of selenium in water, fish and bird egg tissue collected from several of the fresh surface waterbodies in the watershed were found to exceed ecological risk thresholds. Therefore, the proposed selenium TMDLs apply only to the following freshwater tributary subwatersheds in the Newport Bay watershed:

- San Diego Creek Subwatershed
- Santa Ana Delhi Channel Subwatershed
- Big Canyon Wash Subwatershed

The following numeric targets for selenium are being proposed:

1. A whole-body fish tissue target for the protection of fish of 8.1 micrograms selenium per gram dry weight (µg Se/g dw);
2. A whole-body fish tissue target of 5.0 µg Se/g dw as dietary concentration for the protection of birds (5.0 µg Se/g dw);
3. A bird egg tissue target for the protection of aquatic-dependent birds , including federally-listed species of 8.0 µg Se/g dw); and
4. A water column numeric target based on the currently applicable CTR criterion for selenium in freshwater of 5 µg Se/L.

The dietary fish tissue target of 5.0 µg Se/g dw (#2, above) will only apply where bird egg tissue concentrations are exceeding the proposed bird egg tissue numeric target of 8.0 µg Se/g dw even though the proposed primary fish tissue target of 8.1 µg Se/g dw is being met. This is a maximum target; the actual dietary target will be the whole body fish tissue concentration at which the bird egg tissue target is consistently being met (i.e., between 5 and 8.1 µg Se/g dw).

Regional Board staff anticipate presenting these proposed numeric tissue targets as Site-Specific Objectives (SSOs) for adoption in the next two years; therefore, the peer review is expected to serve a dual purpose and we ask that peer reviewers consider the scientific basis of the reports and data presented in the context of the adoption of these tissue targets as water quality objectives. The SSOs are intended to replace the currently applicable CTR chronic criterion of 5 µg/L for selenium in freshwater.

For each subwatershed, water column-based concentrations for selenium were derived from the proposed tissue targets using available site-specific data in the biodynamic model adapted for the Newport Bay watershed by U.S. Geological Survey staff. These concentrations are being proposed as TMDL allocations. However, until the currently applicable CTR criteria for selenium are replaced by revised objectives (e.g., site-specific objectives), allocations based on the CTR chronic criterion for selenium in freshwater are also proposed:

Subwatershed	**Tissue-based Water Column WLA/LA (µg Se/L)**	**CTR-based Water Column WLA/LA (µg Se/L)**
San Diego Creek	10	5
Santa Ana Delhi	11	5
Big Canyon Wash	1	5

In addition, optional conditional mass-based allocations are proposed for those dischargers that qualify to participate in a pilot offset and trading program for selenium.

Recognizing uncertainty in the relationship between the water-column based allocations and achieving the tissue-based numeric targets, the proposed TMDLs specifically provide that where the tissue-based numeric targets are attained, the WLAs/LAs shall also be deemed to be attained.

The implementation plan recommended for these proposed selenium TMDLs requires that a Regional Monitoring Program (RMP) be proposed for each of the three identified subwatersheds and implemented upon Regional Board approval[1]. Each RMP is to address, at a minimum, seven identified elements and several different types of focused monitoring (e.g., TMDL evaluation monitoring, BMP effectiveness monitoring).

These proposed selenium TMDLs are being established and will be implemented as phased TMDLs, consistent with USEPA guidance and based upon the following three-part structure:

- Phase I – Completion <u>as soon as possible, but no later than</u> 6 years from the effective date of the proposed selenium TMDLs[2].
- TMDL Reconsideration – <u>Completion as soon as possible, but no later than 2 years after Phase</u> I. Reconsideration of the proposed selenium TMDLs will be no later than 8 years from the effective date of the proposed selenium TMDLs.
- Phase II – <u>Completion as soon as possible, but no later than 30 years from the effective date of the reconsidered selenium TMDLs</u>.

[1] One RMP can be developed for all three freshwater subwatersheds or separate RMPs can be developed for each subwatershed, requiring the development and submittal of a minimum of one and up to three RMPs by the regulated parties.
[2] Each individual action identified in the implementation plan will be scheduled as a specific number of years/months from the effective date of the proposed selenium TMDLs. The effective date is the date of U.S. EPA approval of the selenium TMDLs.

ATTACHMENT 2

Draft Basin Plan Amendment – Total Maximum Daily Loads for Selenium in Freshwater in the Newport Bay Watershed

Description of Scientific Assumptions, Findings and Conclusions to be Addressed by Peer Reviewers

The statutory mandate for an external scientific peer review (Health and Safety Code Section 57004) states that the reviewer's responsibility is to determine whether the scientific portion of the proposed rule is based upon sound scientific knowledge, methods, and practices. We request that the reviewers make this determination for each of the following assumptions, findings, and conclusions that constitute the scientific portion of the proposed regulatory action. To help with the review, an explanatory statement has been provided for each assumption, finding, and conclusion. Assumptions, findings and conclusions are supported by literature references cited in the staff report (staff report references are included in parentheses).

These selenium TMDLs **only apply** to three freshwater tributary subwatersheds in the Newport Bay watershed (San Diego Creek, Santa Ana-Delhi Channel, and Big Canyon Wash subwatersheds). These selenium TMDLs do not apply to the saltwater bodies in the Newport Bay watershed (Upper and Lower Newport Bay) as there has been no finding of impairment due to selenium in saltwater, marine fish tissue (for human or wildlife consumers of fish), or in eggs collected from birds nesting in the Bay.

Note to Reviewers:

The terms "criteria" and "objectives" are a frequent source of confusion. Water quality "criteria" are values recommended by USEPA for adoption by the states. If promulgated by USEPA (e.g., the California Toxics Rule [CTR]), the criteria become enforceable water quality "objectives" in California parlance. Water quality objectives can be either numeric (e.g., CTR criteria) or narrative (e.g. pollutants shall not bioaccumulate in organisms at concentrations that affect human health).

The CTR[1] allows States the discretion to develop site-specific criteria (objectives) when the CTR criteria appear to be either over- or under-protective of designated uses. In these cases, the State may propose site-specific objectives (SSOs) that apply statewide, on a regional or watershed basis, or only to specific, designated water bodies. Under California Law, SSOs must be publically reviewed and approved by the Regional Board, the State Water Resources Control Board (SWRCB), and the State's Office of Administrative Law (OAL). SSOs must be submitted for consideration for adoption as part of a Regional Board Basin Plan Amendment (BPA). This BPA must then be submitted to the USEPA for review and approval under Clean Water Act Section 303. Regional Board staff will be recommending the adoption of the TMDL tissue-based numeric targets as SSOs for selenium for several of the freshwater tributaries in the Newport Bay watershed.

TMDL numeric targets define the measurements that will ensure recovery of the beneficial uses that are impaired so that water quality standards can be attained. Water quality standards

[1] 40 CFR Part 131 (D)(4)

include beneficial uses, water quality objectives (numeric and narrative), and an antidegradation policy. TMDL numeric targets are not themselves criteria or objectives and are therefore not enforceable. For the selenium TMDLs, the tissue-based numeric targets are Regional Board staff's interpretation of the values that must be achieved to meet the narrative water quality objective established in the Region's Basin Plan that toxic substances, including selenium, will not cause or contribute to adverse toxic effects on biota.

In this document, Nos. 1-4, below, address the three proposed tissue-based numeric targets. They provide succinct statements justifying the scientific validity and appropriateness of employing these targets to protect fish and birds that live or forage in freshwater drainages in the Newport Bay watershed from reproductive effects from excessive selenium. No. 11 provides Regional Board staffs' rationale for proposing to adopt these tissue-based numeric targets as SSOs. No. 5 explains why Regional Board staff must, at this time, use the currently legally applicable CTR chronic criterion for selenium in freshwater of 5 micrograms selenium (Se) per liter (µg Se/L) as a final numeric target even though Regional Board staff do not believe that water column criteria for selenium are appropriate or supported by the science. No. 12 explains Regional Board staffs' rationale for this and justification for not proposing to adopt any of the water column-based numeric targets calculated from the tissue targets as SSOs; instead the water column concentrations will be used as translators or surrogates for the tissue-based SSOs to aid in assessing progress towards meeting the SSOs. Therefore, these water column translators will not be directly enforceable as objectives/criteria under State law. Since diet is the primary exposure route for selenium in fish and birds, it is appropriate to adopt objectives that are based on tissue, which is a direct measure of effects, verses water column-based objectives, which are at best only surrogate indicators of likely concentrations in tissue and, thus, of biological effects. If USEPA approves the tissue-based SSOs, they will depromulgate the CTR criterion for selenium in freshwater for the Newport Bay watershed and the tissue-based SSOs will become the legally applicable objectives for selenium in this watershed.

TMDL NUMERIC TARGETS

1. ***Based on draft selenium criteria developed by USEPA, <u>a fish tissue numeric target of 8.1 micrograms selenium per gram dry weight (µg Se/g dw) in whole body fish</u> has been selected as a scientifically supported and appropriate concentration that will protect the species of fish present in the freshwater bodies in the watershed. (Staff Report: Sections 4, 4.1, 4.1.1, 4.4)***

The whole-body fish tissue numeric target protective of fish as a separate endpoint for the freshwater portions of the Newport Bay watershed is based, in part, upon the USEPA's 2014 Draft Selenium Criterion[2].

In May 2014, USEPA released a draft selenium criterion for public comment. The draft criterion reflected the latest scientific information, which indicates that toxicity to aquatic life is driven by dietary exposure. The 2014 draft criterion prioritized fish tissue concentrations over water column concentrations.

[2] The drafting of these TMDLs was substantively completed prior to the release of EPA's revised draft criterion in 2015 and the final criterion in 2016. As noted in the staff report, these TMDLs are phased and structured purposefully to account for the ongoing revisions to selenium objectives.

The 2014 Draft Criterion was based upon chronic toxicity data obtained primarily by searching published literature using USEPA's public ECOTOX database[3]. In addition, USEPA considered studies submitted with comments during the review of the 2004 draft selenium criteria[4], and studies provided in response to an October 2008 Federal Register Notice of Data Availability. All available, relevant, and acceptable chronic toxicity values were used to recalculate the Final Chronic Value (FCV) as outlined in detail in the USEPA guidance for development of water quality criteria (Stephen et al., 1985). The four elements of the 2014 Draft Selenium Criterion, which includes two fish tissue-based and two water column-based elements, are based on this recalculated FCV:

- A fish egg/ovary element of 15.2 µg Se/g dw
- A fish whole-body and/or muscle element of 8.1 µg Se/g dw and 11.8 µg Se/g dw, respectively
- A water-column chronic element for lentic or lotic waterbody types of 1.3 µg Se/L and 4.8 µg Se/L, respectively
- A water-column intermittent element for lentic or lotic waterbody types that is derived from the water-column chronic element to account for potential chronic effects from repeated, short-term exposures (USEPA, 2014a)

Again, the fish tissue elements are prioritized over the water column elements.

After consideration of the 2014 Draft Selenium Criterion and discussions with the stakeholders and USEPA Region IX staff, Regional Board staff selected USEPA's proposed 2014 draft chronic criterion for selenium in whole-body fish of **8.1 µg Se/g dw** as the recommended numeric target for selenium in fish as a separate endpoint. A whole-body fish tissue criterion was selected because of the difficulty of collecting gravid female fish in the freshwater portions of the Newport Bay watershed (only five gestating female fish have been collected over the last four years).

2. ***Based on the recommendation of USFWS staff, a fish tissue numeric target of 5.0 µg Se/g dw in whole body fish as a dietary concentration for the protection of aquatic-dependent birds has been selected as a scientifically supported and appropriate concentration that will protect the birds foraging in the freshwater areas in the Newport Bay watershed. These birds include federally listed species. This dietary concentration would only apply if the fish tissue numeric target for the protection of fish (8.1 µg Se/g dw) is being met, but the numeric bird egg tissue target is not being met in some areas of the watershed (Staff Report: Sections 4. 4.1, 4.1.2, 4.4)***

A whole-body fish tissue selenium concentration target of **5 µg Se/g dw** is proposed for the Newport Bay watershed to protect aquatic-dependent shorebirds. This target is also protective of the fish themselves as it falls below the lower ranges of whole-body selenium concentrations that are associated with minimal effects in fish (ten percent effect concentration [EC_{10}]); see **Appendix I**. As early as 1998, the U.S. Department of the Interior's (USDOI) selenium guidelines identified a toxicity threshold range of 4-6 µg Se/g dw (whole body) for fish (USDOI, 1998); a value of 5 µg Se/g dw lies in the middle of that range (J. Skorupa, USFWS, electronic communication dated October 20, 2008).

[3] (http://cfpub.epa.gov/ecotox/)
[4] In 2004, USEPA released Draft Aquatic Life Criteria for Selenium for public review and comment. This criteria document was not finalized, but has been revised via USEPA 2014.

For birds, ranges in selenium concentrations in dietary items of 3–7 µg Se/g dw (Presser et al. 2004) or 3–8 µg Se/g dw (USDOI, 1998) have been identified to cause potential marginal reproductive effects. As a dietary concentration for aquatic-dependent birds, 5 µg Se/g dw would range from an EC_{10} (Ohlendorf, 2003; logistic model) to an EC_{25} (Beckon et al., 2008; biphasic model) for mallard exposure to selenomethionine with an endpoint of egg hatchability (J. Skorupa, USFWS, electronic communication, October 20, 2008).

Studies indicate that piscivorous birds (e.g., black-crowned night-herons) may be less sensitive to the toxic effects of selenium than mallards (Smith et al., 1988 versus Heinz et al., 1987 and 1989; Goede, 1993; Goede and Wolterbeek, 1993), which have a primarily plant-based diet. However, birds that primarily consume vascular plants and algae have higher caloric requirements (Stewart et al., 2010) resulting in potentially higher exposure rates even though selenium concentrations in plants may be lower than concentrations in aquatic invertebrates or fish. Invertebrate-eating shorebirds (invertivorous birds) appear to be less sensitive to selenium effects than mallards, but more exposed than piscivorous birds.

Though there is some uncertainty regarding the sensitivity of shorebirds to selenium, USFWS staff have supported the 5 µg Se/g dw dietary fish tissue concentration as sufficiently protective of the birds foraging in the freshwater areas in the Newport Bay watershed, including federally listed species: a shorebird—Ridgway's Rail (*Rallus obsoletus levipes;* formerly known as the Light-footed Clapper Rail), and a piscivorous bird—the California Least Tern (*Sterna antillarum brownie*) (J. Skorupa, USFWS, electronic communication, October 20, 2008).

3. ***Based on the recommendation of USFWS staff, <u>a numeric target of 8.0 µg Se/g dw in bird egg tissue has been selected as a scientifically supported and appropriate concentration that will protect the species of aquatic-dependent birds that nest and forage in the watershed</u>. (Staff Report: Sections 4, 4.2, 4.4)***

For birds, a selenium concentration of **8 µg Se/g dw** in egg tissue is proposed as a numeric target for the Newport Bay watershed. Selenium concentrations in eggs are more useful for evaluating potential reproductive impairment than other tissue types (Skorupa and Ohlendorf, 1991; Ohlendorf and Heinz, 2011), as many factors can influence the transfer of selenium from the food eaten by birds through their tissues (e.g., liver, blood) to the eggs, and because effects occur in the developing embryo. Selenium concentrations in livers or blood are useful for assessing exposure at the time of sampling, but they are not as useful as the concentrations in eggs for assessing potential reproductive impairment (Ohlendorf and Heinz, 2011; CH2M Hill, 2009a; CH2M Hill, 2009a also included in **Appendix I**).

Worldwide, mean background selenium concentrations (no effects level concentrations) in bird eggs are <3 µg Se/g dw (typically 1.5-2.5 µg Se/g dw, with individual eggs <5 µg Se/g dw). Selenium concentrations that are associated with effects have been estimated from field studies of shorebirds and waterfowl and from laboratory studies with mallards, chickens, and Japanese quail (Heinz et al., 1989; CH2M Hill, 2009a; Ohlendorf and Heinz, 2011). Reduced hatching success is considered the most sensitive, reliable endpoint for effects, with effect levels ranging from 6-7 µg Se/g dw to14 µg Se/g dw in black-necked stilt eggs.

In USFWS staffs' opinion (J. Skorupa, USFWS, electronic communication dated July 7, 2009), a range in selenium concentrations of 3-8 µg Se/g dw provides reasonable no effects concentrations (NECs) for egg selenium for sensitive bird species. The range of plausible EC_{10} values overlaps the true NEC for many datasets. The upper end of this range of possible NECs (8 µg Se/g dw) has been judged by USFWS staff to represent sufficient conservatism based on the specific bird species present in the Newport Bay watershed, including the federally listed California least tern and Ridgway's rail (J. Skorupa, USFWS, electronic communication dated October 20, 2008).

4. ***The fish tissue numeric target that applies depends upon the attainment of the bird egg target. (Staff Report: Section 4 and Table 4.3)***
   a. ***<u>Where the bird egg target is attained</u>, the fish tissue target of 8.1 µg Se/g dw applies. This target serves as a protective target for fish as a separate endpoint.***
   b. ***<u>Where the bird egg tissue target is not attained</u>, the fish tissue target of 5 µg Se/g dw, or a site-specific fish tissue concentration at which the bird egg target is met, applies. This target serves as a protective dietary target for aquatic-dependent shorebirds and only applies if the bird egg tissue target is not being attained at a fish tissue concentration of 8.1 µg Se/g dw. (Staff Report: Sections 4, 4.4)***

Selenium concentrations in fish tissue are a good integrator of selenium concentrations in aquatic invertebrates because selenium bioaccumulates in fish relative to the concentration in their diet; the trophic transfer factor for selenium from most [non-bivalve] aquatic invertebrates to fish is 1.1 (**Section 6**). Laboratory-derived trophic transfer factors for a marine piscivorous fish (English seabass – *Dicentrarchus labrax*) support this and fall within the same range as those derived for fish feeding on invertebrates (Stewart et al., 2010), indicating that the trophic transfer factors from invertebrates to fish and fish to fish, are similar. This same relationship has been found between freshwater fish and invertebrates.

Because there is the potential for selenium to bioaccumulate both from fish and from invertebrate food items to aquatic-dependent shorebirds, the recommended fish tissue dietary numeric target of **5 µg Se/g dw** to protect aquatic-dependent shorebirds is lower than that proposed for the protection of fish (8.1 µg Se/g dw**)**. This lower fish tissue target is intended to protect the aquatic-dependent shorebirds that forage in the same aquatic environment, as well as protecting fish. However, the ecosystem may function such that aquatic-dependent birds are protected even when selenium concentrations in fish tissue exceed the lower dietary numeric target. This scenario may be occurring in the Newport Bay watershed, where selenium concentrations in bird eggs appear to be close to the recommended numeric bird egg tissue target of 8 µg Se/g dw, even though fish tissue selenium concentrations exceed the proposed dietary fish tissue target by a greater margin (Section 3.5). Therefore, a separate target, specific to the protection of fish without the dietary linkage to birds, is appropriate for the Newport Bay watershed. As noted however, this target only applies to areas within the watershed where the fish tissue target for the protection of fish is being attained, but the bird egg tissue target is not being met. The secondary dietary fish tissue target of 5 µg Se/g dw is considered to be the lower bound concentration that may be necessary to ensure that the bird egg tissue target is being met. It is acknowledged that the bird egg tissue target may therefore be met at some concentration between 5 and 8.1 µg Se/g dw (Section 4, Table 4.3).

5. ***<u>A water column numeric target of 5.0 µg Se/L is being established for the freshwater tributaries in the watershed</u> in accordance with the currently applicable California Toxics Rule chronic criterion for selenium in freshwater. (Staff Report: Sections 4, 4.3, 4.4)***

The CTR chronic water column concentration for selenium in freshwater is also established as a numeric target for freshwater in these proposed selenium TMDLs. Until tissue-based objectives are approved, the CTR chronic criterion for selenium in freshwater must serve as the final numeric target for selenium for the freshwater areas in the Newport Bay watershed. However, the water column-based target will no longer be in effect once the CTR freshwater criterion has been replaced by revised objectives (e.g., the CTR freshwater selenium criterion has been revised by USEPA and/or selenium SSOs have been approved by USEPA for the freshwater tributaries in the Newport Bay watershed).

Regional Board staff believe that USEPA's draft (2014) and final (2014) recommendations for water column selenium criterion elements for lotic and lentic waterbodies are not appropriate given the wide range in selenium concentrations in water that may, or may not be, directly associated with selenium effects in aquatic life. This holds especially true for the Newport Bay watershed; therefore at this time these selenium TMDLs do not incorporate USEPA's recommended water column elements as a TMDL numeric target. Instead, the TMDLs use site-specific data and modeling to translate the numeric tissue targets into appropriate surrogate water column concentrations for the different waterbodies in watershed (Section 6).

LINKAGE ANALYSIS

6. ***The translation from fish tissue or bird egg tissue to water column concentrations <u>using the biodynamic model developed by USGS staff and adapted to the Newport Bay watershed</u> is supported by scientific data, including site-specific data (Staff Report: Section 6, 6.1, 6.2; Appendices N and O)***

A biodynamic selenium model (herein referred to as the biodynamic model) was developed to conceptualize and quantify the current state of knowledge concerning the dietary transfer of Se through ecosystems (Luoma and Presser, 2009; Presser and Luoma, 2010). The biodynamic model links waterborne concentrations of selenium through food webs, taking into account the partitioning of selenium between water and particulate material and the species-specific transfer factors between trophic levels. The biodynamic model can be used to predict a water-column selenium concentration that would correspond to a specific tissue selenium concentration, such as a guideline or numeric target, or it can take a water-column selenium concentration and use it to predict a selenium concentration in the tissue of a target organism, such as fish or birds.

The biodynamic model was adapted for use in the Newport Bay watershed by developing conceptual food-web models (CH2M Hill 2009b) and compiling data from monitoring in the San Diego Creek watershed and Newport Bay during 1999-2007 (Presser and Luoma, 2009; Appendix N). The model was used to predict water-column selenium concentrations consistent with achieving numeric selenium targets for whole-body fish and bird eggs in Newport Bay (Presser and Luoma, 2009). The TMDL calculations includes all data collected between 1999 and 2007, as reported earlier (Presser and Luoma, 2009) as well as more targeted data collected from in the watershed from 2008 through 2014. These data include all available water, sediment, algae, suspended particulates, fish and bird egg tissue collected from the three subwatersheds to which these selenium TMDLs apply: San Diego Creek, Santa Ana-Delhi Channel, and Big Canyon Wash subwatersheds.

7. ***The modeling simulations, input parameters and assumptions <u>are representative of site-specific conditions for the three freshwater subwatersheds modeled</u>: Santa Ana-Delhi Channel, San Diego Creek, and Big Canyon Wash. (Staff Report: Sections 6, 6.2, 6.2.4; Appendix O)***

The goal of the modeling for the Newport Bay watershed was to characterize the range of concentrations of dissolved selenium that must be maintained in the water column within each subwatershed (Santa Ana-Delhi Channel, San Diego Creek, and Big Canyon Wash) in order to achieve the fish and bird egg tissue concentrations consistent with the applicable numeric targets of the TMDLs. Appendix O of the staff report identifies the assumptions and decisions about coefficients that went into the model calculations that produced the resulting concentration ranges. The documentation also presents the data from which each calculation was made (the metadata, or data behind the final result).

The steps involved in the biodynamic selenium model documentation included:

a) Assembling a data set from each sub-watershed;
b) Calculating a range of watershed-specific partitioning coefficients (Kds) and trophic transfer factors (TTFs) from that data set and specifying the assumptions for each calculation;
c) Testing the validity of the coefficients (or calibrating those coefficients if necessary) by comparing observed tissue concentrations from the subwatersheds with concentrations predicted from the model;
d) Reconsidering the coefficients based upon the validity analysis and calibrating for "better" fits as needed;
e) Modeling water concentrations necessary to achieve the selected targets using the coefficients documented as above (a-d).

The modeling provides several choices for water column concentrations based upon the K_ds that best fit the existing whole body fish tissue and bird egg data in the validation exercise.

8. <u>The range in potential water column concentrations</u> generated by the different model runs for each of the waterbodies modeled and the methods used to calibrate the data are appropriate and supported by scientific data. (Staff Report: Sections 6, 6.2, 6.2.5; Appendix O)

The K_d values used for the different hydrologic compartments in the Newport Bay watershed result in a range of possible water column concentrations for each hydrologic unit (Section 6, **Table 6.2**). Based upon the validation exercise, the numeric targets for fish represent the values with the least uncertainty. The disparity between concentrations in bird eggs and concentrations expected from environmental conditions (as predicted by the biodynamic model) are likely to reflect the larger foraging ranges of birds as compared to fish and differences in feeding preferences among bird species, especially in the areas where the concentration of selenium in birds was much lower than predicted by the model (e.g., Big Canyon Wash).

With the exception of Big Canyon Wash[5], the model results using the fish tissue targets and the invertebrate-based food web provides the greatest confidence in predicting the surrogate water column concentrations. The model results for the bird egg tissue target of 8.0 µg Se/g dw over-predict bird egg tissue concentrations when compared to existing data. Since the 5.0 µg Se/g

[5] For Big Canyon Wash, during the model calibration/validation step, the model results using a sediment/detrital link to mosquitofish (which consume detrital materials as well as invertebrates) instead of invertebrates to mosquitofish provided the closest match to the median selenium concentrations measured in mosquitofish collected from the creek. This may be because of the relative abundance of detrital material present in the pond areas as compared to invertebrates. Therefore, for the calculations, the K_d was directly linked to the fish tissue concentration and the invertebrate TTF was not used.

dw fish tissue target is only triggered where bird eggs exceed the bird egg target but the primary fish tissue target of 8.1 µg Se/g dw is being met, the model results for the primary fish tissue target are the most relevant. In general, the 85th percentile K_ds showed the best fit when validating the model for each assessment area using existing water column concentrations to predict fish tissue selenium concentrations. Exceptions to this were the UCI wetlands (best fit was the 75th percentile K_d) and Big Canyon Wash (mean K_d).

The model calculations and validation for the UCI wetlands suggest that reductions in selenium concentrations in the wetlands are currently not needed for resident fish since both the mean and 75th percentile selenium concentrations in fish living in the wetlands are below the primary fish tissue target of 8.1 µg Se/g dw. For the Santa Ana-Delhi Channel, while the model indicated a good correlation between predicted and observed fish tissue selenium concentrations, it over-predicted the water column concentration that would be needed to meet the fish tissue target of 8.1 µg Se/g dw. This is likely a result of the limited dataset available for this subwatershed.

TMDL AND ALLOCATIONS

9. The TMDL and load and wasteload allocations are supported by the scientific information presented in the report. (Staff Report: Section 7)

(Section 7.2) Protection of beneficial uses requires consideration of both the periods of highest selenium exposure (dry weather flows) and the periods of greatest potential harm to the beneficial uses (breeding season and periods of embryonic and/or juvenile development). Dry weather conditions with low flows occur year-round, and therefore, present potential periods of high selenium exposure all year. The period of potential greatest harm due to selenium exposure occurs seasonally (spring and early summer). As a result, consideration of seasonal variations could result in the development of different allocations for different periods of the year or the application of the allocations only during the breeding season. However, to ensure protection of beneficial uses both during the sensitive period and from the higher selenium concentrations that occur during dry weather, a year-round application of the TMDLs and allocations during dry weather conditions is the most protective approach.

Further, to evaluate the influence of seasonality and to provide the most protective assessment of beneficial uses, an averaging period for the wasteload allocations (WLAs) and load allocations (LAs) is appropriate. Averaging periods for the allocations are based on the potential impacts from selenium exposure and variability in observed receiving water data. Since the protection of beneficial uses is linked to chronic not acute selenium conditions, a semi-annual averaging period utilizing an arithmetic mean is appropriate for these TMDLs and allocations. The semi-annual averaging periods are defined as April 1 through September 30 and October 1 through March 31 each year.[6]

---

[6] Note that this averaging period specifically applies to the concentration-based WLAs and LAs. As specifically noted in these proposed selenium TMDLs **(Section 7.3)**, where the tissue-based numeric targets are attained, the WLAs/LAs shall be deemed to be attained. In evaluating the tissue-based numeric targets, an annual averaging period is more appropriate since bird eggs are only available during a very limited time of the year, and fish tissue and other biota should also be collected during the same timeframe that the birds are breeding since they constitute a likely source of selenium input. Because selenium concentrations in fish and bird egg tissue are expected to be much more variable than those in water, a geometric mean statistical approach should be employed for evaluating tissue data.

(Section 7.3) **Tissue-Based Water Column WLAs and LAs**. Ranges of water column concentrations necessary to achieve the tissue-based numeric targets were predicted for the freshwater areas of the watershed using the biodynamic model. These tissue-based water column concentrations, as opposed to the CTR-based water column concentration, provide a direct link to protection of beneficial uses (as they are derived from the tissue-based targets) and are, therefore, established as WLAs and LAs for these proposed selenium TMDLs. A range of loading capacities was derived from the biodynamic model for the three subwatershed areas. The range of results reflects the heterogeneity of the watershed, as well as the complexity in the pathways of selenium accumulation in the local foodwebs. All of the results are deemed equally valid for predictive purposes (i.e., there is not a single “most appropriate” number that results from running the biodynamic model that definitively corresponds with the protection of beneficial uses).

<u>San Diego Creek Subwatershed</u>: Based upon the evaluation of data collected to date in this subwatershed, it appears that fish tissue, not bird egg tissue, is the most sensitive endpoint. Validation modeling for the biodynamic model showed agreement between the predicted and observed selenium concentrations in fish for San Diego Creek, but in almost all cases, the validation modeling over-predicted the bird egg tissue selenium concentrations. Therefore, water column concentrations derived from the fish tissue target as a separate endpoint have been selected as the basis to establish the WLAs and LAs for this subwatershed.

<u>Santa Ana-Delhi Channel</u>: For Santa Ana-Delhi Channel, the predicted concentrations are greater than ambient concentrations. Therefore the allocations are set to existing conditions (ambient concentrations ±95% confidence interval). As the TMDL is implemented, there will be ongoing attempts to collect more tissue data. Such data will be used to re-evaluate the appropriateness of these initial WLAs and Las for this subwatershed.

<u>Big Canyon Wash Subwatershed</u>: In the Big Canyon Wash subwatershed, bird egg tissue is significantly above the numeric targets. With one exception, every sample of pied bill grebe eggs exceeded the target more than threefold (**Appendix O**). Therefore, the predicted water column concentration for the protection of birds has been selected as the basis for WLAs and LAs for this subwatershed.

For each subwatershed, the upper end of the applicable predicted range of probable selenium concentrations has been selected for the establishment of allocations during Phase I of these proposed selenium TMDLs. As noted above, while the model results in a range of possible concentrations, all modeled concentrations are considered equally predictive of what is needed to protect beneficial uses since the range results from various pathways of potential accumulation in various foodwebs. This initial selection is based upon concentrations that are expected to result in protection of beneficial uses, but is not intended to be considered the only concentration that is appropriate (e.g., tissue-based targets may be attained at higher or lower concentrations). This approach also supports the adaptive management component of these proposed selenium TMDLs (**Section 8**) that requires iterative BMP implementation, focused on reductions in selenium concentrations until the tissue-based targets (and CTR water column-based targets, to the extent they remain in effect) are achieved. Further, as these proposed selenium TMDLs will be incorporated into regulatory mechanisms, including NPDES permits, decreasing rather than increasing the WLAs over time, if necessary and appropriate, will comply with the general prohibition on anti-backsliding.

CTR Water Column-Based WLAs and LAs. Until tissue-based objectives are approved, the CTR chronic criterion for selenium in freshwater must serve as the final numeric target for selenium for the freshwater areas in the Newport Bay watershed. As a result, water column-based allocations based on the CTR are also included in these proposed selenium TMDLs. However, the CTR water column-based allocations will no longer be in effect if and when the CTR freshwater criterion has been replaced by revised objectives (e.g., SSOs).

Conditional Mass-Based WLAs. Recognizing the lack of reasonable and feasible BMPs in the watershed, and that allowing certain discharges to be offset rather than prohibited may provide a greater net environmental benefit (**Section 8.5.2**), conditional mass-based WLAs are included as an alternative to the concentration-based WLAs. As a requirement of the offset and trading program, such discharges cannot result in downstream impacts (as defined in **Section 8.5.2.3**). Therefore, these conditional mass-based WLAs will result in attainment of the loading capacity and thereby attainment of the proposed selenium TMDLs.

Attainment of Tissue-Based Numeric Targets. While the tissue-based water column WLAs and LAs are expected to result in attainment of the tissue-based numeric targets, bioaccumulation in the various foodwebs in the watershed may be different than what was modeled with the biodynamic model (**Section 6**). Therefore, where tissue-based numeric targets are attained, the corresponding WLAs/LAs will also be deemed to be attained, regardless of the actual measured water column concentration. This approach emphasizes that the water column concentrations are only surrogate measures, while the tissue-based targets provide for the direct assessment and protection of beneficial uses.

MONITORING

10. A Regional Monitoring Program (RMP) must be developed for each subwatershed area (San Diego Creek, Santa Ana-Delhi Channel, and Big Canyon Wash). The RMP required monitoring elements include minimum monitoring requirements that are scientifically supported, are reasonable and appropriate, and are expected to provide the information needed to meet the intended purpose of each type of monitoring while still allowing flexibility for adaptive management. (Staff Report: Section 8.5.3)

For Regulated Parties implementing a BMP Strategic Plan, a Regional Monitoring Program (RMP) must be developed and submitted to the Executive Officer for approval[7], consistent with the schedule identified in the Implementation Plan (Section 8.13), and implemented upon that approval. A RMP must be developed for each subwatershed area; RMPs can be submitted separately for each subwatershed or two or more can be combined. Integration of the various monitoring requirements for these TMDLs and coordination with other existing monitoring efforts (e.g., other TMDLs, the MS4 permit, other regional monitoring programs, etc.), is encouraged.

To be considered for approval by the Executive Officer, each RMP must include the following elements:

- TMDL Evaluation Monitoring *(Section 8.5.3.1)*
- BMP Effectiveness Monitoring *(Section 8.5.3.2)*

[7] It is expected that prior to Executive Officer approval, input and recommendations from the U.S. Fish and Wildlife Service (USFWS) and the CDFW will be solicited concerning the proposed monitoring, particularly biological monitoring conducted as part of Assessment Area monitoring (see below).

- Offset and Trading Program Monitoring[8] *(Section 8.5.3.3)*
- Source Assessment Monitoring *(Section 8.5.3.4)*
- Other Considerations *(Section 8.5.3.5)*
- Special Studies *(Section 8.5.3.6)*
- Quality Assurance and Quality Control Measures *(Section 8.5.3.7)*

The above monitoring elements reflect the various aspects of these proposed selenium TMDLs that are supported, informed and/or evaluated by monitoring in the watershed. In order to ensure integration of these elements and the various components of these proposed selenium TMDLs within each subwatershed, the monitoring requirements are contained within one unified document, the RMP.

TMDL Evaluation Monitoring** (Section 8.5.3.1**)

The purpose of the TMDL evaluation monitoring is to assess progress toward the attainment of the WLAs, LAs and the tissue-based numeric targets[9], consistent with California Water Code Section 13242.

The TMDL evaluation monitoring is divided into two categories:

- **Assessment Point Monitoring** – Assessment Point Monitoring will be used to assess, through water column monitoring, whether the WLAs and LAs are being attained. An assessment point within each of the subwatershed/channel areas has been identified at the downstream end for each of the three subwatersheds. The monitoring parameters for the Assessment Point Monitoring must consist of the following:

    - Water column: selenium (total and dissolved)[10]
    - Flow

  The frequency of sample collection must be sufficient to evaluate the WLAs and LAs (including the seasonal evaluation) and must be specified in the RMP.

- **Assessment Area Monitoring** – Assessment area monitoring will be used to assess, through bird egg and fish tissue samples, attainment of the tissue-based numeric targets. Tissue samples must be collected throughout the subwatershed area. For instances where sufficient tissue samples cannot be collected from an assessment area, a surrogate parameter (e.g., macroinvertebrates, reptiles, amphibians) may be used. The surrogate parameter must be proposed in the Regional Monitoring Program and, therefore, is subject to approval by the Executive Officer. The purpose of the surrogate parameter is to allow for an alternative assessment, as appropriate, of the tissue-based numeric targets to avoid a default presumption of attainment or lack of attainment due to an insufficient number of tissue samples. Given that numeric targets have not been established for these surrogate parameters, they would be used for informative purposes

[8] Only required where the Regulated Parties opt to implement the Offset and Trading Program.
[9] The monitoring program's purpose is not to determine permit compliance. Permit compliance will be determined as described in **Sections 7 and 8.11** of the staff report.
[10] Selenium species in addition to total and dissolved selenium (collected at same time as assessment area monitoring is being conducted) should be considered under Other Considerations, but are not required for all monitoring events or locations.

(e.g., to observe trends over time) rather than compliance determinations. Two to three assessment areas have been designated for each subwatershed based on the presence of habitat suitable to support aquatic organisms and provide foraging and/or nesting habitat for aquatic-dependent birds.

At a minimum, the monitoring parameters for the Assessment Area Monitoring must consist of the following:

- **Bird Egg Tissue (individual eggs, contents only)**: total selenium and percent solids; aquatic-dependent birds, especially shorebirds.
- **Fish Tissue (composite, whole-body tissue analyses)**: total selenium and percent solids; targeted species include juvenile and adult fish of the *Centrarchidae* family (e.g., bluegill, largemouth bass) and smaller fish such as red shiners or mosquito fish where centrarchids are not available.
- **Surrogate Parameters: L**ocations with limited habitat may not reliably provide fish or bird eggs for collection (e.g., Santa Ana-Delhi Channel). Therefore, the RMP must identify appropriate surrogate parameters (e.g., larger macroinvertebrates, such as crayfish, reptiles such as non-native turtles, or amphibians such as non-native frogs) for sampling.

The frequency of sample collection must be sufficient to evaluate the tissue-based numeric targets, provided sufficient samples can be collected during target sample collection times, and must be specified in the RMP.[11] At a minimum, an attempt to collect samples must be conducted annually in each assessment area, unless and until the Executive Officer determines that sufficient tissue data has been obtained to adequately characterize conditions and a lower sample collection frequency is warranted. Bird egg collection should be conducted during the nesting season (generally March through August). Fish collection should be at the same time of year to capture the potential effects of fish as bird dietary items and for effects to spring fish reproduction (common timing for most of the target species).

BMP Effectiveness Monitoring *(Section 8.5.3.2****)***

The purpose of the BMP effectiveness monitoring is to assess the effectiveness of the BMPs that have been implemented pursuant to the BMP Strategic Plan(s).

Changes in selenium concentrations in receiving waters, fish tissue, and bird eggs as a result of BMPs can be evaluated on either a project-specific or regional basis (e.g., the assessment area), depending upon the location and scale of the BMP. In addition, depending upon the type of BMP implemented, additional parameters or factors may be warranted (e.g., selenium speciation; bacteriological monitoring). Therefore, the monitoring that is appropriate to assess BMP effectiveness will be project-specific. However, to ensure integration of the goals and purposes of the BMP Strategic Plan and the RMP, a project-specific monitoring plan must be developed for each project. Each project-specific monitoring plan must be appended to the overall RMP and address the following:

---

[11] It is expected that prior to Executive Officer approval, input and recommendations from the U.S. Fish and Wildlife Service and the California Department of Fish and Wildlife will be solicited concerning the proposed monitoring, particularly biological monitoring conducted as part of Assessment Area monitoring.

- Baseline conditions prior to the project;
- Monitoring locations and rationale for the monitoring locations;
- Monitoring parameters, which at a minimum must include selenium in water (total and dissolved);
- Frequency with which each selenium reduction BMP will be monitored once the BMP is constructed and fully functioning. Monitoring must be sufficient to determine performance and selenium reduction effectiveness; and
- Duration of the BMP effectiveness monitoring.

Offset and Trading Program Monitoring *(Section 8.5.3.3)*

The purpose of the offset and trading program monitoring component is to provide the data that verify the generation of credits, and to conduct assessments on the effects of the offsets and/or trades on receiving water conditions to prevent localized impacts. This monitoring element only applies to Regulated Parties that opt to participate in the Offset and Trading Program.

For Regulated Parties who are generating credits via a BMP, at a minimum, monitoring must include the following:

- Influent water to the BMP (prior to treatment):
    - Water Column: selenium (total and dissolved)
    - Flow
- Effluent water (post-treatment) from the BMP (diversion projects are excluded from this requirement)
    - Water Column: selenium (total and dissolved)
    - Flow

For Regulated Parties who seek to use credits, at a minimum, monitoring must include the following:

- At the point of discharge:
    - Water Column: selenium (total and dissolved)
    - Flow
- Downstream of the point of discharge:
    - Water Column: selenium (total and dissolved). Water column monitoring conducted under the TMDL Evaluation Monitoring may be sufficient to satisfy this requirement.
    - Bird Egg Tissue: consistent with the requirements specified in TMDL Evaluation Monitoring; tissue monitoring conducted under Assessment Area monitoring may be sufficient to satisfy this requirement.
    - Fish Tissue: consistent with the requirements specified in TMDL Evaluation Monitoring; tissue monitoring conducted under Assessment Area monitoring may be sufficient to satisfy this requirement.

Source Assessment Monitoring *(Section 8.5.3.4)*

As BMPs needed to achieve these proposed selenium TMDLs are implemented, and as conditions in the subwatershed areas change over time, the collection of selenium source data in each of the subwatershed areas may be necessary to identify and assess significant remaining inputs that do not have BMPs. The need for and selection of additional sample collection locations will be based on the results of Assessment Point and Assessment Area monitoring. Each subwatershed RMP must provide for this monitoring element.

Other Considerations *(Section 8.5.3.5)*

In addition to the required monitoring elements of the RMP (TMDL evaluation monitoring, BMP effectiveness monitoring, offset and trading program monitoring, and source assessment monitoring), other elements, such as those listed below, may be considered for inclusion in the RMP. These elements are not required components of the RMP, but may be considered as the program develops or added based on consultation with Regional Board staff, and may change over time:

- **Selenium Speciation Analysis** – The chemical speciation of selenium is a critical consideration in assessing the potential impacts of selenium because the bioavailability and toxicity of selenium are greatly affected by its chemical forms. Monitoring aimed at collecting data on the chemical speciation of selenium in the water column should be considered where appropriate.
- **Additional Monitoring Sites** – Additional sites that provide meaningful data to support refinement of the TMDLs and/or BMP implementation may be considered. These sites would not be used for TMDL evaluation purposes but to support future decision-making.
- **Additional Monitoring Triggers** – As part of the overall adaptive management aspect of these proposed selenium TMDLs, the RMP may consider triggers where additional monitoring is warranted (e.g., tissue concentrations that are orders of magnitude higher than other samples).

Special Studies *(Section 8.5.3.6)*

Special studies are supplemental to the core, routine components of the RMP. These studies are intended to answer discrete questions and are not intended to be part of the routine monitoring conducted through the RMP. These studies can inform and fill data gaps that support refinement and/or modification to these proposed selenium TMDLs. Special studies can be recommended by the Regulated Parties or proposed by Regional Board staff. Any special study conducted during Phase I must be completed prior to the TMDL Reconsideration in order for that information to be included in that process.

Quality Assurance and Quality Control Measures *(Section 8.5.3.7)*

The Regional Monitoring Program must identify the quality assurance and quality control measures (QA/QC) that will be implemented including consideration of California's Surface Water Ambient Monitoring Program (SWAMP).

SITE-SPECIFIC OBJECTIVES FOR SELENIUM

11. The proposed tissue-based numeric targets for selenium in fish and bird egg tissue are expected to be proposed in the future as site-specific objectives for the Newport Bay watershed. These tissue-based selenium concentrations are protective of the fish and aquatic-dependent bird species present in the watershed including federally-listed species. <u>Therefore the proposed numeric tissue targets</u>

***of 8.1 µg Se/g dw in whole body fish for the protection of fish, 8.0 µg Se/g dw in bird eggs for the protection of aquatic-dependent birds, and 5 µg Se/g dw as a dietary target for the protection of birds[12] are reasonable and appropriate as proposed site-specific objectives** for the Newport Bay watershed. (Staff Report: Section 4, Appendix K.)*

Site-specific Objective for the Protection of Fish
A fish tissue concentration for the protection of fish as its own endpoint in whole body fish of **8.1 µg Se/g dw** is expected to be proposed (as a separate regulatory action in the future) as a site-specific objective for freshwater fish in the Newport Bay watershed. This tissue concentration is based on USEPA's 2014 Draft Criterion for Selenium in freshwater (Appendix C). This number was selected by Regional Board staff as it falls in the middle between the estimated final chronic values (FCVs) recommended by GEI (9.1, 10.8, and 22.31 µg Se/g dw; Appendix J) and calculated by Regional Board staff (7.2 and 7.4 µg Se/g dw; Appendix K). While subsequent revisions after independent and internal peer review resulted in a slight increase in USEPA's 2016 final criterion for selenium in whole body fish (from 8.1 to 8.5 µg Se/g dw), the increase is not statistically relevant for these TMDLs. Several test model runs using the biodynamic model were made using USEPA's final recommended aquatic life criterion for selenium in whole body fish for comparison to the proposed TMDL numeric target. Calculated water column concentrations for selenium did not show a significant difference between the two criteria, especially for water bodies with the highest K_ds, and only resulted in a change in water column concentrations generated by the biodynamic model of 0.1-1.2 µg Se/L.

Though this proposed criterion may be re-evaluated as work to develop recommended selenium site-specific objectives for the watershed proceeds, it is not expected to change significantly. As this concentration is considered to be protective of the fish present in the Newport Bay watershed, it is reasonable and appropriate to adopt the whole body fish tissue concentration of 8.1 µg Se/g dw as a site-specific objective.

Site-specific Objective for Fish as a Dietary Concentration for the Protection of Birds
A whole-body fish tissue selenium concentration of **5 µg Se/g dw** is expected to be proposed in the future as a site-specific objective for the Newport Bay watershed as a dietary concentration for the protection of aquatic-dependent birds. Ranges in dietary selenium concentrations of 3–7 µg Se/g dw (Presser et al. 2004) or 3–8 µg Se/g dw (USDOI, 1998) have been identified to cause potential marginal reproductive effects in birds. As a dietary concentration for aquatic-dependent birds, 5 µg Se/g dw would range from an EC_{10} (Ohlendorf, 2003; logistic model) to an EC_{25} (Beckon et al., 2008; biphasic model) for mallard exposure to selenomethionine with an endpoint of egg hatchability (J. Skorupa, USFWS, electronic communication, October 20, 2008).

USFWS staff have supported the 5 µg Se/g dw dietary fish tissue concentration as sufficiently protective of the birds foraging in the freshwater areas in the Newport Bay watershed, including federally listed species: a shorebird—Ridgway's Rail (*Rallus obsoletus levipes;* formerly known as the Light-footed Clapper Rail), and a piscivorous bird—the California Least Tern (*Sterna*

[12] As described in the numeric targets section of this document, the applicable fish tissue numeric target depends upon the attainment of the bird egg target. The *5 µg Se/g dw* target serves as a protective dietary target for aquatic-dependent shorebirds and only applies if the bird egg tissue target is not being attained at a fish tissue concentration of 8.1 µg Se/g dw.

antillarum brownie) (J. Skorupa, USFWS, electronic communication, October 20, 2008). It is therefore reasonable and appropriate to also adopt this whole body fish tissue concentration of 5.0 µg Se/g dw as a dietary site-specific objective for selenium for the protection of birds. This fish tissue concentration would only apply to areas where the bird egg concentration of 8.0 µg Se/g dw is not being attained even though the fish tissue concentration of 8.1 µg Se/g dw is being attained. As a site-specific criterion, the same rule would apply.

Site-specific Objective for the Protection of Birds
For birds, a selenium concentration of **8 µg Se/g dw** in egg tissue is expected to be proposed as a site-specific objective for the Newport Bay watershed in the future. Selenium concentrations in eggs are more useful for evaluating potential reproductive impairment than other tissue types (Skorupa and Ohlendorf, 1991; Ohlendorf and Heinz, 2011). Worldwide, mean background selenium concentrations (no effects level concentrations) in bird eggs are <3 µg Se/g dw (typically 1.5-2.5 µg Se/g dw, with individual eggs <5 µg Se/g dw). Selenium concentrations that are associated with effects have been estimated from field studies of shorebirds and waterfowl and from laboratory studies with mallards, chickens, and Japanese quail (Heinz et al., 1989; CH2M Hill, 2009a; Ohlendorf and Heinz, 2011). Reduced hatching success is considered the most sensitive, reliable endpoint for effects, with effect levels ranging from 6-7 µg Se/g dw to14 µg Se/g dw in black-necked stilt eggs.

In USFWS staffs' opinion (J. Skorupa, USFWS, electronic communication dated July 7, 2009), a range in selenium concentrations of 3-8 µg Se/g dw provides reasonable no effect concentrations (NECs) for egg selenium for sensitive bird species. The upper end of this range of possible NECs (8 µg Se/g dw) has been judged by USFWS staff to represent sufficient conservatism based on the specific bird species present in the Newport Bay watershed, including the federally listed California least tern and Ridgway's rail[13] (J. Skorupa, USFWS, electronic communication dated October 20, 2008). Therefore, it is reasonable and appropriate to adopt the bird egg tissue concentration of 8.0 µg Se/g dw as a site-specific objective for the protection of birds.

12. The water column concentrations generated by the biodynamic model will not be proposed as site-specific objectives. (Staff Report: Section 4, Appendix K.)

In their 2014 Draft selenium criterion (Appendix C), USEPA translated their primary egg/ovary fish tissue selenium criterion into two water column concentration elements, one for lentic and one for lotic waterbodies. However, in the data sets used by USEPA to develop their water column elements, there were a significant percentage of sites where the selenium water column criterion elements would be either under- or over-protective, especially for lotic systems. For the lotic systems included in the dataset, in 30% of the samples the selenium water concentrations exceeded the proposed lotic criterion element yet the fish tissue selenium concentrations were below the proposed fish egg/ovary criterion. In California, this has been observed in several areas where paired data for selenium water column concentrations and whole body fish tissue are available (e.g., Calleguas Creek, Muddy Slough in the Central Valley). For lentic systems, there was a slightly better correlation between tissue and water concentrations; however, more than 30% of the time, the binary relationship between water and tissue concentrations was either over or under their respective criteria. Therefore, Regional Board staff believes that because of the very site-specific nature of selenium speciation, bioaccumulation, cycling, and trophic transfer, it is more appropriate to generate water column concentrations using the

[13] Formerly called the California Light-footed Clapper Rail.

biodynamic model on a site-specific basis, instead of relying on the water column elements developed by USEPA (this also applies to USEPA's 2016 final water column elements).

This holds especially true for the Newport Bay watershed. As an example, while median ambient water column concentrations in the San Diego Creek and Big Canyon watersheds are similar (13-14 µg Se/L and 14-15 µg Se/L, respectively), median ambient tissue concentrations in fish and bird eggs differ significantly. Western mosquitofish are found in both subwatersheds (only fathead minnows and mosquitofish have been found in Big Canyon Wash to date). Data from 2002-2013 show a median concentration of 16 µg Se/g dw in mosquitofish collected from lower San Diego Creek and a median concentration of 57 µg Se/g dw in mosquitofish collected from lower Big Canyon Wash. A similar disparity in bird egg tissue concentrations is also evident (5.3 µg Se/g dw in bird eggs collected from the San Diego Creek subwatershed and 33 µg Se/g dw in those collected from the Big Canyon Wash subwatershed). This is because of the large differences between the partitioning coefficients (K_ds) between the two subwatersheds: 272 for San Diego Creek and 3308 for Big Canyon Wash.

<u>Regional Board staff will recommend adoption of only of tissue-based site-specific objectives</u> for selenium for the reasons given above and because while the biodynamic model provides a good approximation of potential water column concentrations that would result in attainment of the proposed tissue concentrations in fish and bird egg tissue, it does not provide an exact value but a range in potential values, primarily due to uncertainties in the calculated K_ds and trophic transfer factors (TTFs). As selenium is accumulated in aquatic and aquatic-dependent organisms through their diet and not water, tissue concentrations provide a direct link to effects in sensitive fish and wildlife. <u>Therefore, it is reasonable and appropriate to ***not*** adopt site-specific objectives for selenium in water for the Newport Bay watershed</u>.

THE BIG PICTURE

Reviewers are not limited to addressing only the specific topics presented above, and are asked to contemplate the following questions:

a) In reading the staff report and the proposed Basin Plan amendment, are there any additional scientific issues not described above, which are part of the scientific basis of the proposed TMDLs? If so, please comment with respect to the statutory language above.

b) Taken as a whole, is the scientific portion of the proposed rule based upon sound scientific knowledge, methods, and practices?

The Board has a legal obligation to consider and respond to all feedback on the scientific portions of the proposed rule. Because of this obligation, reviewers are encouraged to focus the feedback on the scientific issues that are relevant to the central regulatory elements being proposed. Some proposed actions might rely significantly on professional judgment where available scientific data are not as extensive as needed to support the statutory requirement for scientific rigor. In these situations, the proposed course of action is to be favored over no action.

Contact	Agency/Company	Area of Expertise/Classification	Role/Affliation with Se TMDLs
AbuSaba, Khalil	AMEC Environment and Infrastructure	Senior Associate Scientist - Water Resources, Se Speciation	former NSMP Consultant
Arenal, Christine	CH2MHill	Project Scientist - Marine & Wildlife Biology, Wildlife Toxicology	Data compliation for NSMP, Luoma-Presser model, and Se TMDLs/SSOs
Byron, Earl	CH2MHill (retired)	Biologist - fish specialist	STRC/ TMDL Contract - Bioaccumulation studies/ current NSMP consultant
Edens, Ava	CH2MHill	Biologist - fish specialist	STRC/ TMDL Contract - Bioaccumulation studies/ current NSMP consultant
Frank, Paul	CH2MHill (former employee)	Project Technologist/Civil Engineer - Watershed Management, WQ	Development of Nitrogen/Se BMP model for evaluating implementation scenarios
Ohlendorf, Harry	CH2MHill	Biologist - Avian specialist, Se effects	STRC/ TMDL Contract - Bioaccumulation studies/ current NSMP consultant
Santolo, Gary	CH2MHill	Biologist - Avian specialist, Se effects	STRC/ TMDL Contract - Bioaccumulation studies/ current NSMP consultant
Pohl, Dave	City of Newport Beach, CA	Engineer, Big Canyon Nature Park Restoration Project	NSMP consultant
Beardsley, Jeff	Big Canyon Golf Course	Superintendent	Big Canyon Restoration Project consultant
Lee, Iris	City of Newport Beach, CA		NSMP working group TMDL subgroup member
Vukojevic, Mark	City of Newport Beach, CA	Engineer, Water Quality Manager	NSMP consultant
Stein, Robert	City of Newport Beach, CA	Engineer, Big Canyon Nature Park Restoration Project	NSMP working group TMDL subgroup member
Estrada, Gene	City of Orange, CA	Senior Civil Engineer, Public Works Department	NSMP working group TMDL subgroup member
Bonigut,Thomas	City of San Clemente, CA	Engineering/storm water	former NSMP Consultant
Carr, Amanda	County of Orange, OC Public Works, OC Watersheds Prgm	Deputy Director - OC Public Works/OC Environmental Resources Service Area	Former NSMP chair.
Crompton, Christopher	County of Orange, OC Public Works, OC Watersheds Prgm	Manager, Environmental Resources	NSMP co-chair
Goong, Stuart	County of Orange, OC Public Works, OC Watersheds Prgm	Environmental Resources Specialist	former assistant coordinator to NSMP chair
Peng, Jian	County of Orange, OC Public Works, OC Watersheds Prgm	Chief - Water Quality Planning	assistant coordinator to NSMP chair
Shao, Stella	County of Orange, OC Public Works, OC Watersheds Prgm	Environmental Resources Specialist	field studies/data management
Skorpanich, Mary Anne	County of Orange, OC Public Works, OC Watersheds Prgm (retired)	Division Manager, OC Watersheds Program	
Abbott, David	Daniel B. Stephens & Associates	Senior Scientist - Hydrogeologic Characterization Lead	Water balance studies: Swamp of the Frogs area, San Diego Creek subwatershed and Big Canyon subwatershed
Cullen, Stephen J.	Daniel B. Stephens & Associates	Project Principal Hydrogeologist - Project Oversight	Water balance studies: Swamp of the Frogs area, San Diego Creek subwatershed and Big Canyon subwatershed
Dodge, John J.	Daniel B. Stephens & Associates	Professional Geologist - Project Manager	Water balance studies: Swamp of the Frogs area, San Diego Creek subwatershed and Big Canyon subwatershed
Schnaar, Gregory	Daniel B. Stephens & Associates	Senior Scientist - Task Manager	Water balance studies: Swamp of the Frogs area, San Diego Creek subwatershed and Big Canyon subwatershed
Stephens, Daniel B.	Daniel B. Stephens & Associates	Technical Advisor	Water balance studies: Swamp of the Frogs area, San Diego Creek subwatershed and Big Canyon subwatershed
Umstot, Todd	Daniel B. Stephens & Associates	Senior Scientist - Watershed Modeling Lead	Water balance studies: Swamp of the Frogs area, San Diego Creek subwatershed and Big Canyon subwatershed
Wolf, Chris	Daniel B. Stephens & Associates	Senior Scientist - Lead Geochemist	Water balance studies: Swamp of the Frogs area, San Diego Creek subwatershed and Big Canyon subwatershed
Paulsen, Susan	Exponent (former employee of Flow Science, Inc.)	Principal Scientist	NSMP representative and consultant for The Irvine Company; NSMP working group TMDL subgroup member
Canton, Steve	GEI Consultants, Inc.	Senior Aquatic Toxicologist and VP - Environmental Division	Review of fish tissue numeric targets
Skigen, Sarah	GEI Consultants, Inc.	Ecology Division Manager - Environmental Division	Review of fish tissue numeric targets
Bernstein, Brock B.	Independent Consultant	Environmental Scientist/ facilitator	NSMP Work Plan and Independent Advisory Panel
Cowan, Karen H.	Independent Consultant (former employee of Larry Walker Ass	Environmental Scientist/ facilitator	Former NSMP chair; current NSMP consultant, TMDLs
Alvarado, Bryant	Larry Walker Associates	Project Engineer II-A	NSMP Consultant, TMDLs
Ashby, Karen	Larry Walker Associates	Vice President	NSMP Consultant, Project Manager
Cooper Desai, Ashli	Larry Walker Associates	Vice President	NSMP Consultant, TMDLs
Corneillie, Kristine	Larry Walker Associates	Senior Engineer	NSMP Consultant, Se SSOs
Coyne, Kevin	(former employee of Larry Walker Associates)	unknown	NSMP Consultant, TMDLs, CEQA
Krueger, Tracy	(former employee of Larry Walker Associates)	unknown	Former NSMP Consultant, Load Allocations
Martinez, David	(former employee of Larry Walker Associates)	Attorney	Former NSMP Consultant, CEQA
Mike Casterline	Picarro (former employee of Larry Walker Associates)	Senior Project Developet/Director of Sales	Former NSMP Consultant
McCord, Stephen	McCord Environmental, Inc. (former employee of Larry Walker	President	Former NSMP Consultant, Sources and Loads
Coffee, Mary Lynn	Nossaman, Gunther, Knox, & Elliot, LLP	Attorney	NSMP representative for Great Park Corporation and Tustin Legacy Community Partners;NSMP working group TMDL subgroup member
Brodberg, Robert	Office of Environmental Health Hazard Asessment (OEHHA)	Human Health Fish Advisories, Water Quality	Se TMDLs - Human health impairment assessment SV
Linville, Regina	Office of Environmental Health Hazard Asessment (OEHHA)	Ecotoxicology, Site-Specific Risk Assessment, Cyanobacteria	former SWRCB representative, NSMP & Se SSO
Apt, Daniel	Olaunu, Michael Baker International, formerly RBF Consulting	Vice President/Engineer - Se TMDLs: BMP implementation, economic and CEQA analyses	NSMP Consultant
Taylor, Scott	Michael Baker International, RBF Consulting	Se BMPs/TMDLs	NSMP Consultant
Lantin, Anna	Michael Baker International, RBF Consulting	Se BMPs/TMDLs	NSMP Consultant
Dutargi, Shilpa	Michael Baker International, RBF Consulting	Se BMPs	NSMP Consultant
Candaele, Remi	Michael Baker International, RBF Consulting	Se BMPs	NSMP Consultant
Hohnbaum, Jeremy	Michael Baker International, RBF Consulting	Se BMPs	NSMP Consultant
Villarreal, Gian	Michael Baker International, RBF Consulting	TMDLs	NSMP Consultant
Lajoie, Glenn	Michael Baker International, RBF Consulting	CEQA	NSMP Consultant
Johnson, Tiffany	Michael Baker International, RBF Consulting	CEQA	NSMP Consultant
McKenney, Larry	SAWPA	Executive Counsel	Former Division Manager, County of Orange, Public Works; Current consultant for Lennar Homes on NSMP

Contact	Agency/Company	Area of Expertise/Classification	Role/Affliation with Se TMDLs
Mehran, Mohsen	Rubicon Engineering, Inc.	Hydrologist	NSMP Independent Advisory Panel
Allen, James M.	Southern California Coastal Water Research Project	Biologist/Icthiologist	STRC/ TMDL Contract - Bioaccumulation studies
Bay, Steve	Southern California Coastal Water Research Project	Sediment chemistry	TMDL Contract - Bioaccumulation studies
Sutula, Martha	Southern California Coastal Water Research Project	Wetlands specialist	TMDL Contract - Sediment chemistry studies
Edwards, Dave	USGS, formerly State Water Resources Control Board	Environmental Scientist	NSMP Se SSO Resource Agency Participant
Kimball, Tom	CalEPA, formerly State Water Resources Control Board	Environmental Scientist	NSMP Se SSO Resource Agency Participant
Ogg, Brian	State Water Resources Control Board	Environmental Scientist	NSMP Se SSO Resource Agency Participant
Rasmussen, Rik	State Water Resources Control Board	Environmental Scientist	NSMP Se SSO Resource Agency Participant
Combs, Gerald	U.S. Department of Agriculture	Nutritional biochemistry	NSMP Independent Advisory Panel
Rice, David	State Water Resources Control Board	Attorney, Office of the Chief Counsel	RWQCB-8 counsel on Se TMDLs
Bromley, Eugene	U.S. Environmental Protection Agency	NPDES permitting	CTR Se Revision coordinator/facilitator
Delos, Charles	U.S. Environmental Protection Agency (retired)	Environmental Scientist, Aquatic Life Criteria Program	Revision of Selenium CTR criteria
Fleck, Diane	U.S. Environmental Protection Agency	Engineer/attorney	Se SSO - NPDES permitting liason
Hashimoto, Janet	U.S. Environmental Protection Agency	Monitoring, 305(b) Integrated Report Coordinator, Water Quality Assessment Chief	Se TMDLs and SSOs
Henry, Tala	U.S. Environmental Protection Agency (retired)	Toxicologist - Special Assistant & ChAMP Coordinator, Risk Assessment Division, Office of Pollution Prevention	Revision of Selenium CTR criteria
Keydel, Susan	U.S. Environmental Protection Agency	NPS Pollution Program, California	Provided input on NPS components and allocations for the TMDLs
Kozelka, Peter	U.S. Environmental Protection Agency	NPDES permitting	Former EPA TMDL liason to RWQCB
Lin, Cindy	U.S. Environmental Protection Agency	Environmental Scientist - TMDLs	Former EPA TMDL liason to RWQCB
McNaughton, Eugenia	U.S. Environmental Protection Agency	Environmental Scientist - Selenium/ Quality Assurance	STRC/NSMP Se SSO
Oros, Daniel	U.S. Environmental Protection Agency	Water Quality Assessment Office	Current EPA TMDL liason to RWQCB-8; CTR revisions
Saucerman, Suesan	U.S. Environmental Protection Agency	Water Quality Standards	Se SSO water quality standards liason
Smith, David	U.S. Environmental Protection Agency	Manager, NPDEs Permits and Stormwater	Provided input on TMDL permit compliance options and WLAs
Lemly, Dennis	U.S. Forestry Service (retired)	Research Biologist - Selenium fish specialist	Advisor on Draft Se TMDLs prior to 2002
Skorupa, Joseph	U.S. Fish and Wildlife Service	Environmental Contaminants Specialist	STRC/NSMP Se SSO
Roberts, Carol	U.S. Fish and Wildlife Service	Division Chief, Environmental Contaminants, Federal Projects	NSMP Se SSO Resource Agency Participant
Zeeman, Catherine T.	U.S. Fish and Wildlife Service	Biologist - Risk Assessment	NSMP Se SSO Resource Agency Participant
Hothem, Roger L.	U.S. Geological Survey	Wildlife Research Biologist	NSMP Independent Advisory Panel
Luoma, Samuel N.	U.S. Geological Survey (emeritus), University of California, Dav	Senior Research Biologist - Selenium modelling	STRC/NSMP Se SSO
Presser, Theresa	U.S. Geological Survey	Geologist - Selenium	STRC/NSMP Se SSO
Saiki, Michael	U.S. Geological Survey	Fishery Research Biologist	NSMP Se SSO
Schroeder, Roy A.	U.S. Geological Survey	Geologist (Retired)	STRC/NSMP Independent Advisory Panel
Benson, Sally M.*	Stanford University	Director, Global Climate & Energy Project	STRC
Cutter, Gregory A.**	Old Dominion University	Research Chemist, trace element speciation, Dept. of Ocean, Earth and Atmospheric Sciences.	Advisor on selenium speciation analytical methods
Hibbs, Barry	California State University, Los Angeles	Hydrogeologist - Se sources and cycling in SDC	TMDL Contract/ Grant Recipient - Hydrogeologic studies of Selenium
Meixner, Thomas	University of Arizona	Hydrologist - Se sources and cycling in SDC	Contractor - Hydrogeologic studies of Selenium
Byard, James L.	University of California, Davis (Professor Emeritus)	Toxicologist	Independent Consultant for The Irvine Company
Horne, Alex	University of California, Davis	Environmental engineering	Contractor to SWRCB and Stakeholders - Se studies in watershed
Stenstrom, Michael K.	University of California, Los Angeles	Engineering/BMPs	NSMP work plan - BMP components
Schlenk, Daniel	University of California, Riverside	Aquatic ecotoxicologist	TMDL Contract - Se accumulation in rainbow trout
Silverstein, JoAnn	University of Colorado, Boulder	Environmental engineering	NSMP Independent Advisory Panel
Vandermost, Julie	Vandermost Consulting Services, Inc.	President; CEQA specialist	NSMP working group TMDL subgroup member
Lin, Lian-Shin (Lance)	West Virginia University	Environmental Scientist/Environmental Engineering	former RWQCB Se TMDL lead staff person

* Dr. Benson, formerly of Lawrence Berkeley National Laboratory, was one of the first members of the STRC. However, Dr. Benson found that she did not have the time to commit to participating in the NSMP and dropped out prior to any real involvement with the selenium issues in the Newport Bay watershed.
** Dr. Cutter was briefly contact by Regional Water Board staff with questions regarding his analytical methods for determining speciation of selenium in water and comparison to other methods. Dr. Cutter had no other involvement with the selenium issues in the Newport Bay watershed.

List of Abbreviations Used

BMP	Best Management Practice
CalEPA	California Environmental Protection Agency
CEQA	California Environmental Quality Act
CTR	California Toxics Rule
EPA	US Environmental Protection Agency
NSMP	Nitrogen and Selenium Management Program
OEHHA	Office of Environmental Health Hazard Assessment
RBF	Robert Bein Frost Associates
RWQCB	Santa Ana Regional Water Quality Control Board
SAWPA	Santa Ana Watershed Project Authority
Se	Selenium
SSO	Site Specific Objectives
STRC	Selenium Technical Review Committee
SWRCB	State Water Resources Control Board
TMDL	Total Maximum Daily Load
USGS	U.S. Geological Survey

Nitrogen and Selenium Management Program
WORKING GROUP
CONTACT INFORMATION

Working Group Member	Representative	Name	Phone	Email	Address	City	State	Zip
Regional Water Quality Control Board	Primary	Jason Freshwater	951-321-4576	jason.freshwater@waterboards.ca.gov	3737 Main Street, Suite 500	Riverside	CA	92501
	Alternate	Joanne Schneider	951-782-3287	jschneider@waterboards.ca.gov	3737 Main Street, Suite 500	Riverside	CA	92501
	Alternate	Terri Reeder	(951) 782-4995	treeder@waterboards.ca.gov	3737 Main Street, Suite 500	Riverside	CA	92501
County of Orange	Primary	Jian Peng	714-955-0650	jian.peng@ocpw.ocgov.com	2301 N. Glassell St	Orange	CA	92865
	Alternate	Chris Crompton	714-955-0630	chris.crompton@ocpw.ocgov.com	2301 N. Glassell St	Orange	CA	92865
Orange County Flood Control District	Primary	Robert McLean	914-647-3951	robert.mclean@ocpw.ocgov.com	300 N. Flower Street	Santa Ana	CA	92703
City of Costa Mesa	Primary	Baltazar Mejia	714-754-5378	bartazar.mejia@costamesaca.gov	77 Fair Drive	Costa Mesa	CA	92626
	Alternate	Kelly Dalton	714-754-5173	kelly.dalton@coastamesaca.gov	77 Fair Drive	Costa Mesa	CA	92626
City of Irvine	Primary	Michael Yang	949-724-6327	myang@ci.irvine.ca.us	One Civic Center Plaza	Riverside	CA	92623
	Alternate	Victor Kao		vkao@ci.irvine.ca.us	One Civic Center Plaza	Irvine	CA	92623
City of Laguna Hills	Primary	Kenneth H. Rosenfield	949-707-2655	krosenfield@ci.laguna-hills.ca.us	24035 El Toro Road	Laguna Hills	CA	92653
City of Laguna Woods	Primary	Chris Macon	949-639-0555	cmacon@lagunawoodscity.org	24264 El Toro Road	Laguna Woods	CA	92637
City of Lake Forest	Primary	Devin Slaven	949-461-3436	dslaven@lakeforestca.gov	25550 Commercentre Drive	Lake Forest	CA	92630
City of Newport Beach	Primary	Bob Stein	949-644-3322	rstein@newportbeachca.gov	3300 Newport Blvd	Newport Beach	CA	92658
		John Kappeler		jkappeler@newportbeachca.gov	3300 Newport Blvd	Newport Beach	CA	92658
City of Orange	Primary	Gene Estrada	714-532-6480	gestrada@cityoforange.org	300 East Champman	Orange	CA	92866
City of Santa Ana	Primary	Tyrone Chesanek	714-647-5045	tchesanek@santa-ana.org	20 Civic Center Plaza	Santa Ana	CA	92701
	Alternate	Thomas Lo	714-647-5659	tlo@santa-ana.org	20 Civic Center Plaza	Santa Ana	CA	92701
City of Tustin	Primary	Alex Waite		awaite@tustinca.org	300 Centennial Way	Tustin	CA	92780
IRWD	Primary	Ian Swift	(949) 453.5864	swift@irwd.com	PO Box 57000	Irvine	CA	92619
	Alternate	Fiona Sanchez	949-453-5325	fsanchez@irwd.com	PO Box 57000	Irvine	CA	92619
Irvine Company	Primary	Dean Kirk	949-720-2878	dkirk@irvinecompany.com	550 Newport Center Dr.	Newport Beach	CA	92660
	Alternate	Sat Tamaribuchi		sat.tamaribuchi@gmail.com				
Orange County Coastkeeper	Primary	Garry Brown	(949) 723-5424	garry@coastkeeper.org	3151 Airway Ave. Suite F-110	Costa Mesa	CA	92626
	Alternate	Ray Heimstra		ray@coastkeeper.org				
Stop Polluting Our Newport	Primary	Jack Skinner	949-646-8635	jskinnermd@aol.com	1724 Highland Drive	Newport Beach	CA	92660
Surfrider	Primary	Darrell Ferguson		darrel1953@aol.com				

WORKING GROUP
CONTACT INFORMATION

Other Interested Party	Working Group Member Association	Name	Phone	Email	Address	City	State	Zip
Latham & Watkins LLP	The Irvine Company	Shanda Beltran Esq.	714-755-8040	shanda.beltran@lw.com	650 Town Center Drive	Costa Mesa	CA	92626
County of Orange	Member	Richard Boon	714-955-0670	richard.boon@ocpw.ocgov.com	2301 N. Glassell St	Orange	CA	92865
MCAS Tustin	Non-Member	Marc Smits	619-532-0793	marc.smits@navy.mil	1230 Columbia Street, Suite 870	San Diego	CA	92101
City of Newport Beach	Member	John Kappeler		jkappeler@newportbeachca.gov	P.O. Box 1768	Newport Beach	CA	92658
		Dave Kiff		dkiff@newportbeachca.gov	P.O. Box 1768	Newport Beach	CA	92658
		Davi Webb		DaAWebb@newportbeachca.gov	P.O. Box 1768	Newport Beach	CA	92658
Regional Water Quality Control Board	Member	Doug Shibberu	9517827959	dshibberu@waterboards.ca.gov				
		Linda Candelaria	951-782-4991	lcandelaria@waterboards.ca.gov	3737 Main Street, Suite 500	Riverside	CA	92501
		Wanda Cross	951-782-4468	wcross@waterboards.ca.gov	3737 Main Street, Suite 500	Riverside	CA	92501
University of California -- Irvine	Non-Member	Dick Sun	949-824-2188	dtsun@uci.edu				
Nossaman Guthner Knox & Elliott, LLP	TLCP	Mary Lynn Coffee	949-477-7675	mlcoffee@nossaman.com	18101 Von Karman Avenue, #1800	Irvine	CA	92612
Vandermost Consulting Services, Inc.	TLCP	Julie Vandermost	949-489-2700 x203	jvandermost@vandermostconsulting.com	27312 Calle Arroyo	San Juan Capist	CA	92675
SAWPA	Non-Member	Larry McKenney	951-354-4256	lmckenney@sawpa.org	11615 Sterling Ave	Riverside	CA	92503
ECS	Consultant to US Navy	Dhananjay Rawal	714-972-9990	ecsdr@sbcglobal.net	1651 East Edinger Ave, Suite 101	Santa Ana	CA	92705
Brock Bernstein	Consultant to WG	Brock Bernstein	805-646-8369	brockbernstein@sbcglobal.net				
Great Park Corp	Non-Member	Christina Lo		clo@ocgp.org				
UC Natural Reserve System	Non-Member	Peter Bowler	949-824-0157	pabowler@uci.edu	University of California Irvine	Irvine	CA	92697
Southern California Water Company	Member	Brandy O'Gorman		bogormon@scwater.com				

Adams WJ, Brix KV, Edwards M, Tear LM, DeForest DK, Fairbrother A. 2003. Analysis of field and laboratory data to derive selenium toxicity thresholds for birds. Environmental Toxicology and Chemistry. Volume 22, Number 9, pp. 2020-2029.

Agency for Toxic Substances and Disease Registry (ATSDR). 2003. Toxicological Profile for Selenium. http://www.atsdr.cdc.gov/toxprofiles/tp92.pdf

Allaway WH, Cary EE and Ehlig CF. 1967. The cycling of low levels of selenium in soils, plants, and animals. In: Selenium in Biomedicine. Muth OH, editor. Avi Publishing Company, Westport, CT. pp. 273-296

Allen MJ, Diehl DW, and Zeng EY. 2004. Bioaccumulation of Contaminants in Recreational and Forage Fish in Newport Bay, California in 2000-2002. Final report submitted to the Santa Ana Regional Water Quality Control Board. Southern California Coastal Water Research Project (SCCWRP) Technical Report 436.

Allen MJ, Mason AZ, Gosset RW, Diehl DW, Raco-Rands V, Schlenk D. 2008. Assessment of Foodweb Transfer of Organochlorine Compounds and Trace Metals in Fishes in Newport Bay, California in 2005-2006. Final report prepared for the State Water Resources Control Board. Agreement No. 04-025-558-0.

Arnér ESJ and Holmgren A. 2000. Physiological functions of thioredoxin and thioredoxin reductase. European Journal of Biochemistry. Volume 267, Issue 20, pp. 6102-6109.

Arukwe A. and Goksøyr A. 2003. Eggshell and egg yolk proteins in fish: hepatic proteins for the next generation: oogenetic, population, and evolutionary implications of endocrine disruption. Comparative Hepatology. Volume 2, pp. 4-21.

Ayouni L, Barbier F, Imbert J, Gauvrit J, Lantéri P, Grenier-Loustalot M. 2006. New separation method for organic and inorganic selenium compounds based on anion exchange chromatography followed by inductively coupled plasma mass spectrometry. Analytical and Bioanalytical Chemistry. Volume 385, Issue 8, pp. 1504-1512.

Barceloux, D.G. 1999. Selenium. Clinical Toxicology. Volume 37. Issue 2. pp.145-172.

Bechtel National, Inc. 1998. Discharge of Extracted Groundwater Containing High Selenium to the Storm Drain, Marine Corps Air Facilities, Tustin, California. Draft Technical Note dated June 1998. Prepared for the U.S. Navy, Southwest Division, Naval Facilities Engineering Command for the Comprehensive Long Term Environmental Action Navy, Clean 2 program. Contract No. N68711-92-D-4670. 45 p.

Beckon WN, Parkins C, Maximovich A, and Beckon AV. 2008. A general approach to modeling biphasic relationships. Environmental Science & Technology. Volume 42. pp. 1308- 1314.

Bergeron CM, Bodinof CM, Unrine JM, and Hopkins WA. 2010. Bioaccumulation and maternal transfer of mercury and selenium in amphibians. Environmental Toxicology and Chemistry. Volume 29, No, 4, pp. 989-997.

Blackburn DG. 1998. Structure, function and evolution of the oviducts of squamate reptiles with special reference to viviparity and placentation. Journal of Experimental Zoology. Volume 282, Issue 4-5, pp. 560-617.

Blackburn DG. 2000. Classification of the reproductive patterns of amniotes. Herpetological Monographs. Volume 14, pp. 371-377.

Bowes GW. 2006. California Environmental Protection Agency (CalEPA) External Scientific Peer Review Guidelines. Exhibit F. The Regents of the University of California, Berkeley. Agreement No. 06-104-600-0.

Bowie GL, Sanders JG, Riedel GF, Gilmour CC, Breitburg DL, Cutter GA, Porcella DB. 1996. Assessing selenium cycling and accumulation in aquatic ecosystems. Water, Air, and Soil Pollution. Volume 90, pp. 93-104.

Brown J. and Bay S. 2005. Assessment of Best Management Practice (BMP) Effectiveness. Southern California Coastal Water Research Project (SCCWRP) Technical Report #461.

Bügel S, Larsen EH, Sloth JJ, Flytlie K, Overvad K, Steenberg LC, Moesgaard S. 2008. Absorption, excretion, and retention of selenium from a high selenium yeast in men with a high intake of selenium. Food and Nutrition Research. Volume 52. DOI:I0.3402/fnr.v52iO.I642.

Byard JL. 2003. Selenium Concentrations in Waterfowl Eggs from the San Joaquin Wildlife Refuge: A Preliminary Assessment of the Potential Hazard to Aquatic Biota. Report dated January 24, 2003. Prepared for The Irvine Company.

Calabrese EJ. 2008. Hormesis: Why it is important to toxicology and toxicologists. Environmental Toxicology and Chemistry. Volume 27, Number 7, pp. 1451-1474.

Camp Dresser & McKee, Incorporated. 1985. Shallow groundwater investigation, West Central part of the Irvine Subbasin. Prepared for The Irvine Company.

Carolina Power & Light (CP&L). 1997. Largemouth Bass Selenium Bioassay- Report. Carolina Power & Light Company, Environmental Services Section, NC. December 1997.

CH2MHill. 2005-2007. Monitoring data collected for the Nitrogen and Selenium Management Program.

CH2MHill. 2006a. Identification of Data Gaps for Selenium, San Diego Creek/Newport Bay Watershed. Interim report dated March 23, 2006. Prepared for the Nitrogen and Selenium Management Program (NSMP).

CH2MHill. 2006b. Field Sampling Plan for Selenium, Newport Bay Watershed. Interim report dated April 27, 2006. Prepared for the Nitrogen and Selenium Management Program (NSMP).

CH2MHill. 2007. Simple Treatment Model. Final Report dated June 2007. Prepared for the Nitrogen and Selenium Management Program (NSMP).

CH2M Hill. 2008. Big Canyon Wash Wetlands Restoration: Baseline Selenium Results. Technical report prepared by E. Byron and G. Santolo for the City of Newport Beach and the Santa Ana Regional Water Quality Control Board. Dated November 6, 2008.

CH2MHill. 2009a. Site-Specific Objectives for Selenium, Newport Bay Watershed, Orange County, California. Draft technical report dated March 2009 prepared for the Santa Ana Regional Water Quality Control Board.

CH2MHill. 2009b. Conceptual Model for Selenium, Newport Bay Watershed. Final report dated May 26, 2009 prepared for the Nitrogen and Selenium Management Program (NSMP).

CH2MHill. 2009c. Summary of Monitoring Data/Results and Report on Bioavailability and Effects of Selenium. Final report dated May 26, 2009. Prepared for the Nitrogen and Selenium Management Program (NSMP).

CH2MHill. 2009d. Sources and Loads for Selenium in the Newport Bay Watershed. Final report dated June 12, 2009. Prepared for the Nitrogen and Selenium Management Program (NSMP).

CH2MHill. 2009e. Big Canyon Creek Restoration: Selenium Source Tracking. Draft technical report prepared by E. Byron and G. Santolo for the City of Newport Beach. Dated June 2009.

CH2M Hill. 2010. 2010 Selenium Monitoring Results: Fish and Bird Egg Tissue Chemistry, Newport Bay Watershed. Draft Report to Orange County. August 12, 2010.

CH2M Hill. 2012. 2011 Selenium Monitoring Results: Fish and Bird Egg Tissue Chemistry, Newport Bay Watershed. Draft Report to Orange County. January 18, 2012.

CH2M Hill. 2013. Selenium and Organochlorine Compounds in Newport Bay Watershed Fish and Bird Eggs, 2012. Draft Report to Orange County. January 7, 2013.

CH2M Hill. 2014. Selenium and Organochlorine Compounds in Newport Bay Watershed Fish and Bird Eggs, 2013. Draft Report to Orange County. January 13, 2014.

CH2M Hill and Center for Water, Ecosystems, and Climate Science (CWECS). 2008. Development of a Selenium Standard for the Open Waters of Great Salt Lake. Report dated May 2008 prepared for the State of Utah, Department of Environmental Quality, Division of Water Quality. http://www.deq.utah.gov/Issues/GSL_WQSC/docs/GLS_Selenium_Standards/index.htm

Chadwick & Associates, Inc. (C&A [now GEI Consultants, Inc.]). 1992. Santa Ana River Use-Attainability Analysis, Volume II: Aquatic Biology, Habitat, and Toxicity Analysis. Prepared for Santa Ana Watershed Project Authority, Riverside, CA.

Chapman PM. 2007. Perspective: Selenium thresholds for fish from cold freshwaters. Human Ecological Risk Assessment. Volume 13: pp. 20-24.

Chapman PM, Adams WJ, Brooks ML, Delos CG, Luoma SN, Maher WA, Ohlendorf HM, Presser TS, and Shaw DP. 2009. Ecological Assessment of Selenium in the Aquatic Environment. Summary of a SETAC Pellston Workshop, 22-28 February 2009, Pensacola, Florida.

Chen YW., Truong HYT, Belzile N. 2008. Abiotic formation of elemental selenium and role of iron oxide surfaces. Chemosphere. Volume 74, Issue 8, pp. 1079-1084.

Cleveland L, Little EE, Buckler DR, and Wiedmeyer RH. 1993. Toxicity and bioaccumulation of waterborne and dietary selenium in juvenile bluegill (*Lepomis macrochirus*). Aquatic Toxicology. Volume 27, pp. 265-280.

Colorado Department of Public Health and Environment, 2013, The Basic Standards and Methodologies for Surface Water, Water Quality Control Commission Regulation No. 31 (5 CCR-1002-31) dated January 31, 2013.

Colorado Department of Public Health and Environment, 2016a, Classifications and Numeric Standards for South Platte River Basin, Laramie River Basin, Republican River Basin, Smokey Hill River Basin, Water Quality Control Commission Regulation No. 38 (5 CCR-1002-38) dated March 1, 2016.

Colorado Department of Public Health and Environment, 2016b, Classifications and Numeric Standards for Arkansas River Basin, Water Quality Control Commission Regulation No. 32 (5 CCR-1002-32) dated March 1, 2016.

County of Orange. 2005. Urban nutrient best management practice evaluation—Warner Channel evaluation. Draft Report dated December 8, 2005. Submitted to the State Water Resources Control Board in partial compliance with SWRCB Agreement No. 02-165-258-0 – Task 6.9. 69 p.

County of Orange. 2005-2008. Annual Storm Water Reports. Santa Ana River Basin Bioassessment Site Data.

County of Orange. 2008. NPDES Dry Weather Reconnaissance Monitoring Program.

County of Orange. 2011. Big Canyon Watershed Selenium Management Plan: Internal Memo. September 2, 2011.

Coyle JJ, Buckler DR, Ingersoll CG, Fairchild JF, and May TW 1993. Effect of dietary selenium on the reproductive success of bluegills (*Lepomis macrochirus*). Environmental Toxicology and Chemistry. Volume 12, pp. 551-565.

Cumbie PM and Van Horn SL. 1978. Selenium accumulation associated with fish mortality and reproductive failure. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies. Volume 32, pp. 612-624.

Cutter GA. 1978. Species determination of selenium in natural waters. Analytica Chimica Acta. Volume 98, pp. 59-66.

Cutter GA. 1983. Elimination of nitrite interference in the determination of selenium by hydride generation. Analytica Chimica Acta. Volume 149, pp. 391-394.

Cutter GA. 1989a. The estuarine behavior of selenium in San Francisco Bay. Estuarine, Coastal, and Shelf Science. Volume 28, pp. 13-34.

Cutter GA. 1989b. Freshwater systems. In Occurrence and Distribution of Selenium. Chapter 10. CRC Press, Boca Raton, Florida. pp. 243-262.

Cutter GA and Church TM. 1976. Selenium in western Atlantic precipitation. Nature. Volume 322, pp. 720-722.

Daniel B. Stephens & Associates (DBSA). 2013. Hydrogeologic Characterization and Water Balance Development, Newport Bay Watershed Swamp of the Frogs, Orange County, California. Prepared for Orange County Public Works. October 29, 2013.

Daniel B. Stephens & Associates (DBSA). 2014. DRAFT Water Balance Development Report, Upper Big Canyon Watershed, Newport Beach, California. Prepared for City of Newport Beach. April 11, 2014.

DeForest DK, Brix KV, and Adams WJ. 1999. Critical review of proposed residue-based selenium toxicity thresholds for freshwater fish. Human and Ecological Risk Assessment. Volume 5, p. 1187-1228.

DeForest DK, and Adams WJ. 2011. Selenium accumulation and toxicity in freshwater fishes. pp. 193-229. *In*: Beyer WN, and Meador JP, editors. Environmental Contaminants in Biota: Interpreting Tissue Concentrations. 2nd edition. CRC Press, Boca Raton, Florida.

DeFores DK, Gilron G, Armstrong SA, and Robertson EL. 2012. Species sensitivity distribution evaluation for selenium in fish eggs: Considerations for development of a Canadian tissue-based guideline. Integrated Environmental Assessment and Management. Volume 8, pp. 6-12.

de Rosemond SC, Liber K, and Rosaasen A. 2005. Relationship between embryo selenium concentrations and early life stage development in white sucker (*Catostomus commersoni*) from a Northern Canadian Lake. Bulletin of Environmental Contamination and Toxicology. Volume 74, pp. 1134-1142.

De Vink J-MA, Clark RG, Slattery SM, Wayland M. 2008. Is selenium affecting body condition and reproduction in boreal breeding scaup, scoters and ring-necked ducks? Environmental Pollution. Volume 152, pp. 116-122.

Doroshov SI, Eenennaam JV, Alexander C, Hallen E, Bailey H, Kroll K, and Restreppo C. 1992. Development of water quality criteria for resident aquatic species of the San

Joaquin River. Draft final report to the California State Water Resources Control Board, Contract No. 7-197-250-0.

Dowdle PR and Oremland RS. 1998. Microbial oxidation of elemental selenium in soil slurries and bacterial cultures. Environmental Science and Toxicology. Volume 32, pp. 3749-3755.

Duellman WE and Trueb L. 1986. Biology of Amphibians. Baltimore MD (USA). The Johns Hopkins University Press, pp. 493-494.

Eisler R. 2000. Handbook of Chemical Risk Assessment: Health Hazards to Humans, Plants, and Animals. Vol. 3. Lewis Publishers. Boca Raton, Florida.

Electric Power Research Institute. 1986. Speciation of selenium and arsenic in natural waters and sediments: Volume 1: Selenium speciation. EPRI EA-4641, Research Project 2020-1, prepared by GA Cutter, Old Dominion University, Norfolk VA (USA).

Engberg RA, Westcot DW, Delamore M, and Holz DD. 1998. Federal and State perspectives on regulation and remediation of irrigation-induced selenium problems. *In* Frankenberger Jr. WT and Engberg RA, editors. Environmental Chemistry of Selenium. Marcel Dekker Inc., New York, pp. 153-182.

Estay F, Díaz A, Pedrazza R, Colihueque N. 2003. Oogenesis and plasma levels of sex steroids in cultured females of brown trout (Salmo trutta Linnaeus, 1758) in Chile. Journal of Experimental Zoology. Volume 298, Part A: Comparative Experimental Biology, pp. 60-66.

Fairbrother A, Fix M, O'Hara T, Ribic C. 1994. Impairment of growth and immune function of avocet chicks from sites with elevated selenium, arsenic, and boron. Journal of Wildlife Diseases. Volume 30, pp. 222-233.

Fan TWM, Teh SJ, Hinton DE, Higashi RM. 2002. Selenium biotransformations into proteinaceous forms by foodweb organisms of selenium-laden drainage waters in California. Aquatic Toxicology. Volume 57, pp. 65-84.

Franke KW. 1934. A new toxicant occurring naturally in certain samples of plant foodstuffs. I. Results obtained in preliminary feeding trials. The Journal of Nutrition. Volume 8:597, pp. 609-613.

Franke KW and Moxon AL. 1936. A comparison of the minimum fatal doses of selenium, tellurium, arsenic, and vanadium. Journal of Pharmacology and Experimental Therapy. Volume 58, p. 454.

Franke KW and Painter EP. 1936. Selenium in proteins from toxic foodstuffs. I. Remarks on the occurrence and nature of the selenium present in a number of foodstuffs or their derived products. Cereal Chemistry. Volume 13, p. 67.

Frankenberger Jr. WT and Benson S, editors. 1994. Selenium in the Environment. Marcel Dekker, Inc., New York.

Frankenberger Jr. WT and Engberg RA, editors. 1998. Environmental Chemistry of Selenium. Marcel Dekker, Inc. New York.

Frankenberger Jr. WT and Zhang YQ. 2008. Bioaccumulation and Biotransformations of Organic Material-Borne Selenium in Mosquitofish (Determination of Dimethylselenoxide in Solution Using HPLC-HG-AAS). Technical Completion Report SD-006, University of California Water Resources Center, UC Berkeley, CA (USA).

Ganser LR, Hopkins WA, O'Neil L, Hasse S, Roe JH, Sever DM. 2003. Liver histopathology of the southern watersnake, *Nerodia fasciata fasciata*, following chronic exposure to trace element-contaminated prey from a coal ash disposal site. Journal of Herpetology. Volume 37, No. 1, pp. 219-226.

Gatlin DM and Wilson RP. 1984. Dietary selenium requirement of fingerling channel catfish. The Journal of Nutrition. Volume 114, pp. 627-633.

GEI Consultants, Inc. 2008. Maternal transfer of selenium in fathead minnows, with modeling of ovary tissue-to-whole body concentrations. Technical Report prepared on behalf of Conoco-Phillips.

GEI Consultants, Inc. 2014. Review of Selenium Data and Fish Tissue Numeric Targets for San Diego Creek Watershed. Technical memo prepared for the Orange County Public Works (OCPW). Revised Draft, April 2014.

GEI Consultants, Inc., Golder Associates, Parametrix, and University of Saskatchewan Toxicology Centre. 2008. Selenium tissue thresholds: tissue selection criteria, threshold development endpoints, and field application of tissue thresholds. Report to: North American Metals Council-Selenium Working Group, Washington, DC. http://namc.org/docs/00043675.PDF.

Gilbert RO. 1987. Statistical Methods for Environmental Pollution Monitoring. Van Nostrand Reinhold, New York.

Gillespie RB and Baumann PC. 1986. Effects of high tissue concentrations of selenium on reproduction by bluegills. Transactions of the American Fisheries Society. Volume115(2), pp. 208-213.

Girling CA. 1984. Selenium in Agriculture. Agriculture, Ecosystems and Environment. Volume 11, pp. 37-65.

Great Lakes Environmental Center. 2003. Compilation of Existing Guidance for the Development of Site-Specific Water Quality Objectives in the State of California. Draft report prepared for the State Water Resources Control Board (SWRCB). Contract No. 9-195-250-1.

Goede AA. 1993. Selenium in marine waders. PhD Thesis, Department of Reactor Physics, Delft University of Technology, The Netherlands. 159 p.

Goede AA and Walterbeek H Th. 1993. The bioavailability of various selenium compounds to a marine wading bird. Biological Trace Element Research. Volume 39, pp. 191-201.

Good IJ. 1985. Weight of Evidence: A Brief Survey. *In* Bernardo JM, Degroot MH, Lindley DV, and Smith AFM, editors. Bayesian Statistics 2. John Wiley and Sons, publisher.

Grosell. M. No date given. Personal communication to R. Stewart re selenium effects in a saline green algae, *Dunaliella viridis*. As quoted in Stewart R, Grosell M, Buchwalter D, Fisher N, Luoma S, Mathews T, Orr P, Wang W-X. 2010. Bioaccumulation and Trophic Transfer of Selenium. Chapter 5, p. 102, Ecological Assessment of Selenium in the Aquatic Environment, Chapman et al., editors. Society of Environmental Toxicology and Chemistry (SETAC) Publications. CRC Press, Boca Raton FL (USA).

Hamilton SJ. 2002. Rationale for a tissue-based selenium criterion for aquatic life. Aquatic Toxicology. Volume 57, pp. 85-100.

Hamilton SJ. 2003. Review of residue-based selenium toxicity thresholds for freshwater fish. Ecotoxicology and Environmental Safety. Volume 56, pp. 201-210.

Hamilton SJ. 2004. Review of selenium toxicity in the aquatic food chain. Science of the Total Environment. Volume 326, pp. 1-31.

Hamilton SJ. and Lemly DA, 1999. Commentary: Water-sediment controversy in setting environmental standards for selenium. Ecotoxicology and Environmental Safety. Volume 44, pp. 227-235.

Hamilton SJ, Buhl KJ, Faerber NL, Wiedmeyer RH, and Bullard FA. 1990. Toxicity of organic selenium in the diet of Chinook salmon. Environmental Toxicology and Chemistry. Volume 9, pp. 347-358.

Hamilton SJ, Buhl KJ, Bullard FA, and McDonald SF. 1996. Evaluation of Toxicity to Larval Razorback Sucker of Selenium-laden Food Organisms from Ouray NWR on the Green River, Utah. National Biological Survey, Yankton, South Dakota. Final Report. Recovery Implementation Program for the Endangered Fishes of the Upper Colorado River Basin, Denver, CO.

Hamilton SJ, Buhl KJ, Bullard FA, and McDonald SF. 2005. Reduced growth and survival of larval razorback sucker fed selenium-laden zooplankton. Ecotoxicology and Environmental Safety. Volume 61, pp. 190-208.

Hamilton SJ, Holley KM, Buhl KJ, and Bullard FA. 2005a. Selenium impacts on razorback sucker, Colorado River CO: II. Eggs. Ecotoxicology and Environmental Safety. Volume 61, pp. 32-43.

Hamilton SJ, Holley KM, Buhl KJ, and Bullard FA. 2005b. Selenium impacts on razorback sucker, Colorado River, Colorado, III. Larvae. Ecotoxicology and Environmental Safety. Volume 61, pp. 168-189.

Hamilton SJ, Holley KM, Buhl KJ, and Bullard FA, Weston KL, and McDonald SF. 2005. Selenium impacts on razorback sucker, Colorado River CO: I. Adults. Ecotoxicology and Environmental Safety*.* Volume 61, pp. 7-31.

Harding LE. 2008. Non-linear uptake and hormesis effects of selenium in red-winged blackbirds (*Agelaius phoeniceus*). Science of the Total Environment. Volume 389, Issue 2. pp. 350-366.

Hardy RW. 2005. Final Report: Effects of Dietary Selenium on Cutthroat Trout *(Oncorhynchus clarki)* Growth and Reproductive Performance. Prepared for Montgomery Watson Harza, Bellevue, WA.

Hardy RW, Oram LL, and Möller G. 2010. Effects of Dietary Selenium on Cutthroat Trout *(Oncorhynchus clarki)* Growth and Reproductive Performance Over a Life Cycle. Archives of Environmental Contamination and Toxicology. Volume 58, pp. 237-245.

Hayes DC and Young RL. 2005. Comparison of Peak Discharge and Runoff Characteristic Estimates from the Rational Method to Field Observations for Small Basins in Central Virginia. U.S. Geological Survey Scientific Investigations Report 2005-5254.

Haygarth PM. 1994. Global importance and global cycling of selenium. *In* Selenium in the Environment, Frankenberger Jr. WT and Bensen S, editors. Marcel Dekker Inc.

Heinz GH. 1993. Selenium accumulation and loss in mallard eggs. Environmental Toxicology and Chemistry. Volume 12, pp. 775-778.

Heinz GH. 1996. Selenium in birds. In: Beyer WN, Heinz GH, Redmon-Norwood AW, editors. Environmental Contaminants in Wildlife: Interpreting Tissue Concentrations. Chapter 20. Boca Raton, FL (USA). CRC Lewis Press, pp. 447-458.

Heinz GH, Hoffman DJ, Krynitsky AJ, and Weller DMG. 1987. Reproduction in mallards fed selenium. Environmental Toxicology and Chemistry. Volume 6, pp. 423-433.

Heinz GH, Hoffman DJ, and Gold LG. 1989. Impaired reproduction of mallards fed an organic form of selenium. Journal of Wildlife Management. Volume 53. Number 2, pp. 418-428.

Hermanutz RO, Allen KN, Roush TH, and Hedtke SF. 1992. Effects of elevated Se concentrations on bluegills (*Lepomis macrochirus*) in outdoor experimental streams. Environmental Toxicology and Chemistry. Volume 11, pp. 217-224.

Hermanutz RO, Allen KN, Detenbeck NE, and Stephan CE. 1996. Exposure of bluegill (*Lepomis macrochirus*) to selenium in outdoor experimental streams. U.S. EPA Report. Mid-Continent Ecology Division. Duluth, MN.

Hibbs BJ. and Lee MM. 2000. Sources of Selenium in the San Diego Creek Watershed . Prepared for Defend the Bay and California Urban Environmental Research and Education Center.

Hibbs BJ, Andrus R, Lopez A. 2008. Selenium, Nitrate, and Other Constituents San Diego Creek and Newport Bay Watersheds. Final report prepared for the State Water Resources Control Board. Agreement No. 03-117-558-0.

Hilton JW, Hodson PV, Slinger SJ. 1980. The requirement and toxicity of selenium in rainbow trout (*Salmo gairdneri*). The Journal of Nutrition. Volume 110, pp. 2527-2535.

Hodson PV and Hilton JW. 1983. The nutritional requirements and toxicity to fish of dietary and water-borne selenium. Ecological Bulletins. Number 35: Environmental Biogeochemistry, pp. 335-340.

Hoffman DJ. 2002. Role of selenium toxicity and oxidative stress in aquatic birds. Aquatic Toxicology. Volume 57, pp. 11-26.

Hoffman DJ and Heinz GH. 1988. Embryonic and teratogenic effects of selenium in the diet of mallards. Journal of Toxicology and Environmental Health. Volume 24, Isuue 4, pp. 477-490.

Holm J, Palace VP, Wautier K, Evans RE, Baron CL, Podemski C, Siwik P, Sterling G. 2003. An Assessment of the Development and Survival of Wild Rainbow Trout (*Oncorhynchus mykiss*) and Brook Trout (*Salvelinus fontinalis*) Exposed to Elevated Selenium in an Area of Active Coal Mining. *In* Browman HI and Skiftesvik AB, editors. The Big Fish Bang. The Institute of Marine Research, Proceedings of the 26th Annual Larval Fish Conference, Bergen, Norway, pp. 257-273

Holm J, Palace V, Siwik P, Sterling G, Evans R, Baron C, Werner J, and Wautier K. 2005. Developmental effects of bioaccumulated selenium in eggs and larvae of two salmonid species. Environmental Toxicology and Chemistry. Volume 24, pp. 2373-2381.

Hopkins WA, Congdon JD, Ray JK. 2000. Incidence and impact of axial malformations in larval bullfrogs (*Rana catesbeiana*) developing in sites polluted by a coal burning power plant. Environmental Toxicology and Chemistry. Volume 19, pp. 862-868.

Hopkins WA, Snodgrass JW, Baionno JA, Roe JH, Staub BP, Jackson BP. 2005. Functional relationships among selenium concentrations in the diet, target tissues, and nondesctructive tissue samples of two species of snakes. Environmental Toxicology and Chemistry. Volume 24, pp. 344-351.

Hopkins WA, DuRant SE, Staub BP, Rowe CL, Jackson BP. 2006. Reproduction, embryonic development, and maternal transfer of contaminants in an amphibian, *Gastrophryne carolinensis*. Environmental Health Perspectives. Volime 114, Number 5, pp. 661-666.

Horne A, Fleming-Singer M, West N, Toms C, Roth J. 2006. Selenium in Biota, Water, and Sediments in the Lower San Diego Creek Watershed: Fall 2004 Results and Comparisons with 2002-2003, Possible Toxicity and Its Solution. Report prepared for the Irvine Ranch Water District, County of Orange, and the State Water Resources Control Board.

Ihnat M. 1989a. Occurrence and Distribution of Selenium. CRC Press, Boca Raton, Florida, 354 pp.

Ihnat M. 1989b. Plants and agricultural materials. In Ihnat M. editor. Occurrence and Distribution of Selenium. Chapter 5. CRC Press, Boca Raton FL (USA). pp. 33-106.

Irvine Ranch Water District (IRWD). 1999. Irvine Ranch Water District Wetland Water Supply Project Monitoring Data Base 1997-1999. Irvine Ranch Water District. Irvine, California.

Janz DM, DeForest DK., Brooks ML, Chapman PM, Gilron G, Hoof D, Hopkins WA, McIntyre DO, Mebane CA, Palace VP, Skorupa JP, Wayland M. 2010. Selenium Toxicity to Aquatic Organisms. In Chapman PM, Adams WJ, Brooks ML, Delos CG, Luoma SN, Maher WA, Ohlendorf HM, Presser TS, Shaw DP, editors. Ecological Assessment of Selenium in the Aquatic Environment. Chapter 6. Society of Environmental Toxicology and Chemistry (SETAC) Publications. CRC Press, Boca Raton FL (USA). pp. 141-231.

Keating KI and Dagbusen BC. 1984. Effect of selenium deficiency on cuticle integrity in the Cladocera (Crustacea). Proceedings of the National Academy of Sciences, USA. Volume 81, pp. 3433-3437.

Kennedy CJ, McDonald LE, Loveridge R, Strosher. 2000 MM. The effect of bioaccumulated selenium on mortalities and deformities in the eggs, larvae, and fry of a wild population of cutthroat trout (*Oncorhynchus clarki lewisi*). Archives of Environmental Contamination and Toxicology. Volume 39, p. 46-52.

Klasing S. and Brodberg R. 2008. Development of Fish Contaminant Goals and Advisory Tissue Levels for Common Contaminants in California Sport Fish: Chlordane, DDTs, Dieldrin, Methymercury, PCBs, Selenium, and Toxaphene. State of California, Office of Environmental Health Hazard Assessment (OEHHA). http://www.oehha.ca.gov/fish/gtlsv/pdf/FCGsATLs27June2008.pdf

LaFuente JMG, Dlaska M, Sanchez MLF, Sanz-Medel A. 1998. Organic and inorganic selenium speciation in urine by on-line vesicle mediated high-performance liquid chromotography-focused microwave digestion-hydride generation-inductively coupled plasma mass spectrometry. Journal of Analytical Atomic Spectrometry, Volume 13, Issue 5, pp. 423-429.

Lam JCW, Tanabe S, Lam MHW, and Lam PKS. 2005. Risk to breeding success of waterbirds by contaminants in Hong Kong: Evidence from trace elements in eggs. Environmental Pollution. Volume 135, pp. 481-490.

Larry Walker Associates. 2006. A Comparison of Methods for Measuring Total Selenium and Selenium Species in Water. Final report dated May 8, 2006. Prepared for the Nitrogen and Selenium Management Program.

Larry Walker Associates. 2014. Summary of Key Points of Consensus and Modifications Agreed to through the Selenium TMDLs Workshop Process. February 20, 2014.

Lee GF and Taylor S. 2001. Results of Aquatic Toxicity Testing During 1999-2000 in the Upper Newport Bay Watersheds. USEPA 319(h) project report. May, 2001.

Lemly AD. 1985. Toxicology of selenium in freshwater reservoir: implications for environmental hazard evaluation and safety. Ecotoxicology and Environmental Safety. Volume 10, pp.314-338.

Lemly AD. 1993a. Metabolic stress during winter increases the toxicity of selenium to fish. Aquatic Toxicology. Volume 27, pp. 133-158.

Lemly AD. 1993b. Guidelines for Evaluating Selenium Data from Aquatic Monitoring and Assessment Studies. Environmental Monitoring and Assessment. Volume 28, pp. 83-100.

Lemly AD. 1997. Ecosystem recovery following selenium contamination in a freshwater reservoir. Ecotoxicology and Environmental Safety. Volume 36, pp.275-281.

Lemly AD. 1997. A teratogenic deformity index for evaluating impacts of selenium on fish populations. Ecotoxicology and Environmental Safety. Volume 37, pp. 259-266.

Lemly AD. 1998. A position paper on selenium in ecotoxicology: A procedure for deriving site- specific water quality criteria. Ecotoxicology and Environmental Safety. Volume 39, pp. 1-9.

Lemly AD. 1999a. Selenium transport and bioaccumulation in aquatic ecosystems: a proposal for water quality criteria based on hydrological units. Ecotoxicology and Environmental Safety. Volume 42, pp. 150-156.

Lemly AD. 1999b. Selenium Impacts on Fish: An Insidious Time Bomb. Human Ecological Risk Assessment. Volume 5. Number 6, pp. 1139-1151.

Lemly AD. 2002. Symptoms and implications of selenium toxicity in fish: the Belews Lake case example. Aquatic Toxicology. Volume 57, pp. 39-49

Lemly AD and Smith GJ. 1987. Aquatic cycling of selenium: Implications for fish and wildlife. Fish and Wildlife Leaflet 12. U.S. Fish and Wildlife Service, Washington, DC.

Lin YH and Shiau SY. 2005. Dietary selenium requirements of juvenile grouper, *Epinephelus malabarious*. Aquaculture. Volume 250, pp. 356-363.

Lobinski R, Edmonds JS, Suzuki KT, Uden PC. 2000.Species-selective determination of selenium compounds in biological materials. Pure Applied Chemistry. Volume 72, Number 3, pp. 447-462.

Lonzarich DG, Harvey TE, Takekawa JE. 1992. Trace element and organochlorine concentrations in California clapper rail (*Rallus longirostris obsoletus*) eggs. Archives of Environmental Contamination and Toxicology. Volume 23, pp.147-153.

Losi ME and Frankenberger Jr. WT. 1997. Reduction of selenium oxyanions by Enterobacter cloacae SLD1a-1: isolation and growth of the bacterium and its expulsion of selenium particles. Applied Environmental Microbiology. Volume 63, Number 8, pp. 3079-3084.

Luoma SN and Presser TS. 2000. Forecasting Selenium Discharges to the San Francisco Bay- Delta Estuary: Ecological Effects of a Proposed San Luis Drain Extension. U.S. Geological Survey Open-File Report 00-416.

Luoma SN and Presser TS. 2009. Emerging opportunities in management of selenium contamination: Environmental Science and Technology, v. 43, no. 22, p. 8483-88487.
http://wwwrcamnl.wr.usgs.gov/Selenium/Library_articles/luoma_presser_Nov15_2009_viewpoint_EST_final.pdf]

Luoma SN and Rainbow PS. 2005. Why is metal bioaccumulation so variable? Biodynamics as a unifying concept: Critical Review. Environmental Science and Technology. Volume 39. Number 7, pp. 1921-1931.

Luoma SN, Johns C, Fisher N, Steinberg NA, Oremland RS, Reinfelder JR. 1992. Determination of selenium bioavailability to a benthic bivalve from particulate and solute pathways. Environmental Science and Technology. Volume 26, pp. 485-491.

Maier KJ, Foe CG, Knight AW. 1993. Comparative toxicity of selenate, selenite, seleno- DL-methionine, and seleno-DL-cysteine to Daphnia Magna. Environmental Toxicity and Chemistry. Volume 12, pp. 755-763.

Maher W, Roach A, Doblin M, Fan T, Foster S, Garrett R, Möller G, Oram L, Wallschläger D. 2010. Environmental Sources, Speciation, and Partitioning of Selenium. In Chapman PM, Adams WJ, Brooks ML, Delos CG, Luoma SN, Maher WA, Ohlendorf HM, Presser TS, Shaw DP, editors. Ecological Assessment of Selenium in the Aquatic Environment. Chapter 4. Society of Environmental Toxicology and Chemistry (SETAC) Publications. CRC Press, Boca Raton FL (USA). pp. 47-92.

McIntyre DO, Pacheco MA, Garton MW, Wallschläger D, Delos CG. 2008. Effect of selenium on juvenile bluegill sunfish at reduced temperature. Health and Ecological Criteria Division, Office of Water, EPA, Washington, DC. EPA-822-R-08-020.

Malloy JC, Meade ML, Olsen EW. 1999. Small-Scale Spatial Variation of Selenium Concentrations in Chironomid Larvae. Bulletin of Environmental Contamination and Toxicology. 62:122-129.

Marn CM. 2003. Post-hatching survival and productivity of American avocets at drainwater evaporative ponds in the Tulare Basin, California. Ph.D Dissertation. Oregon State University, Corvallis, OR (USA).

Martens BA and Suarez DL. 1997. Selenium speciation of marine shales, alluvial soils, and evaporation basin soils of California. Journal of Environmental Quality. Volume 26, pp. 424-432.

Mayland HF. 1997. Selenium in plant and animal nutrition. In Frankenberger Jr. WT and Benson S, editors. Selenium in the Environment. Marcel Dekker, Inc. New York, NY (USA). Chapter 2, pp.29-45.

Meixner T, Hibbs B, Sjolin J, Walker J. 2004. Sources of Selenium, Arsenic and Nutrients in the Newport Bay Watershed. SWRCB- Agreement #00-200-180-01 Final Report of April 30th, 2004. 145 pp.

Morton PK and Miller RV. 1981. Geologic Map of Orange County California, Showing Mines and Mineral Deposits. California Division of Mines and Geology Bulletin 204, Plate 1.

Mosher BW and Duce RA. 1989. The Atmosphere. *In* Occurrence and Distribution of Selenium*.* M. Ihnat, Ed. CRC Press, Inc. Florida. pp. 309.

MSE, 2001- MSE Technology Applications, Inc. 2001. "Selenium Treatment/Removal Alternatives Demonstration Project." For National Risk Management Research Laboratory, Office of Research and Development, and the US Department of Energy's Federal Energy Technology Center. June 2001.

Muscatello JR, Bennett PM, Himbeault KT, Belknap AM, Janz DM. 2006. Larval deformities associated with selenium accumulation in northern pike (*Esox lucius*) exposed to metal mining effluent. Environmental Science and Technology*.* Volume 40, pp. 6506–6512.

National Academy of Sciences. 1972. Water Quality Criteria. A report of the Committee on Water Quality Criteria, Environmental Studies Board, National Academy of Sciences, National Academy of Engineering. Washington, D.C., 1972. At the request of, and funded by, the U.S. Environmental Protection Agency.

National Research Council (NRC). 1980. Mineral tolerance of domestic animals. National Academy Press, Washington, DC (USA).

National Research Council (NRC). 2005. Mineral tolerance of animals, second revised edition. National Academy Press, Washington, DC (USA)

National Water Research Institute (NWRI). 2006. Final Interim Report of the Third Meeting of the Independent Advisory Panel on Reviewing the County of Orange's Nitrogen and Selenium Management Program (November 2, 2006). Task 6. November 21.

Nitrogen and Selenium Management Program (NSMP). 2005. Work Plan and Compliance Strategy. June 20, 2005.

Novoselov SV, Roa M, Onoshko NV, Zhi H, Kryukov GV, Xiang Y, Hatfield DL, Gladyshev VN. 2002. Selenoproteins and selenocysteine insertion system in the model plant cell system, *Chlamydomonas reinhardii*. The EMBO Journal. Volume 21, No. 14, pp. 3681-3693.

Nriagu JO. 1989. A Global Assessment of Natural Sources of Atmospheric Trace Metals. Nature. Volume 338, pp. 47-49.

Ohlendorf HM. 2002. The birds of Kesterson Reservoir: a historical perspective. Aquatic Toxicology. Volume 57, pp. 1-10.

Ohlendorf HM. 2003. Ecotoxicology of selenium. Pp. 465-500 *In* : D.J. Hoffman, B.A. Rattner, G. A. Burton, Jr., and J. Cairns, Jr., (eds.), Handbook of Ecotoxicology (2nd Edition). Lewis Publishers, Boca Raton, FL.

Ohlendorf HM. 2007. Threshold Values for Selenium in Great Salt Lake: Selections by the Science Panel. Final Technical Memorandum. Prepared by CH2MHill for the Great Salt Lake Science Panel. February 28, 2007.

Ohlendorf HM. 2008a. Technical Justification for Proposed Fish and Bird Egg Standards. Technical Memo prepared by CH2M Hill for NSMP, Orange County, CA.

Ohlendorf HM. 2008b. Trophic transfer factors from diet to bird eggs. Technical Memorandum dated October 27, 2008 to K. Cowan, County of Orange and NSMP Chair from H.O. Ohlendorf, CH2MHill.

Ohlendorf HM and Harrison CS. 1986. Mercury, selenium, cadmium and organochlorines in eggs of three Hawaiian seabird species. Environmental Pollution (Series B) 11:169-191.

Ohlendorf HM and Heinz GH. 2011. Selenium in Birds. Excerpt from Environmental Contaminants in Biota, Interpreting Tissue Concentrations (Second Edition). Edited by W.N. Beyer and J.P. Meador. CRC Press. Chapter 21. Pp. 669-701.

Ohlendorf HM, Kilness AW, Simmons JL, Stroud RK, Hoffman DJ, Moore JF. 1988. Selenium toxicosis in wild aquatic birds. Journal of Toxicology and Environmental Health. Volume 24, pp. 67-92.

Olson OE, Novacek EJ, Whitehead EI, Palmer IS. 1970. Investigations on selenium in wheat. Phytochemistry. Volume 9, pp.1181-1188.

Oram LL, Strawn DG, Marcus MA, Fakra SC, Möller G. 2008. Macro- and microscale investigation of selenium speciation in Blackfoot River, Idaho sediments. Environmental Science and Technology. Volume 42, pp. 6830-6836.

Oremland RS. 1994. Biogeochemical Transformations of Selenium in Anoxic Environments. In Frankenberger Jr. WT and Benson S, editors. Selenium in the Environment. Marcel Dekker, Inc. New York, NY (USA). Chapter 16, pp. 389-419.

Oremland RS, Hollibaugh JT, Maest AS, Presser TS, Miller LG, Culbertson SW. 1989. Selenate reduction to elemental selenium by anaerobic bacteria in sediments and culture: biogeochemical significance of a novel, sulfate-independent respiration. Applied Environmental Microbiology. Volume 55, Number 9, pp. 2333-2343.

Oremland RS, Steinberg NA, Maest AS, Mlller LG, Hollibaught JT. 1990. Measurement of in situ rates of selenate removal by dissimilatory bacterial reduction in sediments. Environmental Science & Technology. Volume 24, Number 8, pp. 1157-1164.

Palace VP, Spallholz JE, Hom J, Watier K, Evans RE, Baron CL. 2004. Metabolism of selenomethionine by rainbow trout (*Oncorhynchus mykiss*) embryos can generate oxidative stress. Ecotoxicology and Environmental Safety. Volume 58, pp. 17-21.

Peterson JA and Nebeker AV. 1992. Estimation of waterborne selenium concentrations that are toxicity thresholds for wildlife. Archives of Environmental Contamination and Toxicology. 23(2):154-162.

Polatajka A, Jakubowski N, Szpunar J. 2006. State of the art report of selenium speciation in biological samples. Journal of Analytical Atomic Spectrometry. Volume 21, Issue 7, pp. 639-654.

Presser TS and Luoma SN. 2006. Forecasting Selenium Discharges to the San Francisco Bay- Delta Estuary: Ecological Effects of a Proposed San Luis Drain Extension. US Geological Survey Professional Paper 1646.

Presser TS and Luoma SN. 2009. Modeling of Selenium for the San Diego Creek Watershed and Newport Bay, California. U.S. Geological Survey Open-file Report 2009-1114

Presser TS and Luoma SN. 2010. A methodology for ecosystem-scale modeling of selenium: Integrated Environmental Assessment and Management, v. 6, no. 4, p. 685-710.
[http://wwwrcamnl.wr.usgs.gov/Selenium/Library_articles/Presser_Luoma_2010_IEAMv6no4_685_710p.pdf]

Presser TS and Skorupa JP. 2010. Linking Selenium Sources to Ecosystems: Local and Global Perspectives – Introduction. USGS web site last updated August 28, 2014. http://wwwrcamnl.wr.usgs.gov/Selenium/

Presser TS, Piper DZ, Bird KJ, Skorupa JP, Hamilton SJ, Detwhiler SJ, Huebner MA. 2004. The Phosphoria Formation: A Model for Forecasting Global Selenium Sources to the Environment. *In* J.R. Hein, ed. *Life Cycle of the Phosphoria Formation: From Deposition to the Post-Mining Environment*. Volume 8 of the Handbook of Exploration and Environmental Geochemistry. Elsevier.

Presser TS, Sylvester MA, Low WH. 1994. Bioaccumulation of selenium from natural geologic sources in Western States and its potential consequences. *Environmental Management*. Volume 18. Number 3, pp. 423-436.

Puls R. 1988. Mineral Levels in Animal Health: Diagnostic Data. Clearbrook, British Columbia, CAN. Sherpa International.

Rayman MP. 2002. The argument for increasing selenium intake. Proceedings of the Nutrition Society. Volume 61, pp. 203-215.

RBF Consulting. 2013. BMP Strategic Plan: Santa Ana-Delhi and San Diego Creek Sub-Watersheds. Prepared for the Nitrogen and Selenium Management Program (NSMP) Working Group. December 4, 2013.

Reiley MC, Stubblefield WA, Adams WJ, Di Toro DM, Hodson PV, Erickson RJ, Keating Jr. FJ. 2003. Reevaluation of the State of the Science for Water-Quality Criteria Development. Proceedings of the 1998 Pellston Workshop, Fairmont Hot Springs, MT. SETAC Press, Pensacola, FL.

Reinfelder JR, Fisher NS, Wang WX, Nichols J, Luoma SN. 1998. Trace element trophic transfer in aquatic organisms: a critique of the kinetic model approach. Science of the Total Environment. Volume 219, Issues 2-3, pp. 117-135.

Rinchard J and Kestemont P. 1996. Comparative study of reproductive biology in single- and multiple-spawner cyprinid fish. I. Morphological and histological features. Journal of Fish Biology. Volume 49, Issue 5, pp. 883-894.

Roe JH, Hopkins WA, Baionno JA, Staub BP, Rowe CL, Jackson BP. 2004. Maternal transfer of selenium in Alligator mississippiensis downstream from a coal burning power plant. Environmental Toxicology and Chemistry. Volume 23, pp. 1969-1972.

Romano M, Rosnova P, Anteo C, Limatola E. 2004. Vetebrate yolk proteins: a review. Molecular Reproductive Development. Volume 69, Issue 1, pp. 109-116.

Ross HB. 1984. Atmospheric Selenium. National Technical Report Library (NTIS) Report No. CM-66. Springfield, VA (USA).

Rowe CL, Kinney OM, Nagle RD, Congdon JD. 1998. Elevated maintenance costs in an anuran (*Rana catesbeiana*) exposed to a mixture of trace elements during the embryonic and early larval periods. Physiological Zoology. Volume 71, Number 1, pp. 27-35.

Rudolph BL, Andreller I, Kennedy CJ. 2008. Reproductive success, early life stage development, and survival of Westslope cutthroat trout (*Oncorhynchus clarki lewisi*) exposed to elevated selenium in an area of active coal mining. Environmental Science and Technology. 42: 3109-3114.

Saiki MK, Martin BA, May TM. 2004. Reproductive status of western mosquitofish inhabiting selenium-contaminated waters in the grassland water district, Merced County, California. Archives of Environmental Contamination and Toxicology 47:363-369.

Salton Sea Authority. 2005. Salton Sea Ecosystem Management Plan, Draft Technologies and Management Techniques to Limit Exposures to Selenium. Draft report dated February 2005.

Salton Sea Authority. Undated web publication. Selenium and the Salton Sea. Downloaded March 2, 2009. http://www.saltonsea.ca.gov/media/archives/selenium.pdf

San Joaquin Valley Drainage Improvement Program (SJVDIP) and University of California Salinity/Drainage Program. 1999. Drainage Water Treatment Technical Committee Task 2: Drainage Water Treatment Final Report dated February 1999.

Santolo GM, Yamamot JT, Pisenti JM, Wilson BW. 1999. Selenium accumulation and effects on reproduction in captive American kestrals fed selenomethionine. Journal of Wildlife Management. Volume 63, pp. 205-511.

Schwartz K and Foltz CM. 1957. Selenium as an integral part of factor 3 against dietary ecrotic liver degeneration. Journal of the American Chemical Society. Volume 79, No. 12, pp 3292–3293.

Schultz R and Hermanutz R. 1990. Transfer of toxic concentrations of selenium form parent to progeny in the fathead minnow. Bulletin of Environmental Contamination and Toxicology 45:568-573.

Schwarzbach SE, Albertson JD, Thomas CM. 2006. Effects of predation, flooding, and contamination on reproductive success of California clapper rails (*Rallus longirostris obsoletus*) in San Francisco Bay. Auk. 123:45-60.

Seiler RL. 1995. Prediction of areas where irrigation drainage may induce selenium contamination of water. Journal of Environmental Quality. Volume 24, pp. 973-979.

Seiler RL, Skorupa JP, Peltz LA. 1999, Areas susceptible to irrigation-induced selenium contamination of water and biota in the western United States: U.S. Geological Survey Circular 1180, 36p. http://www.fws.gov/mountain-prairie/contaminants/papers/circ1180.pdf

Sevilla CP. 2003. Water Quality Dynamics at the Estuarine Interface of San Diego Creek, Orange County, California. Unpublished Masters of Science Thesis. Departments of Geology and Geography, California State University, Los Angeles. December 2003.

Skorupa JP. 1998. Selenium Poisoning of Fish and Wildlife in Nature: Lessons from Twelve Real World Examples. *In* W. Frankenberger and R.A.Engberg, eds. Environmental Chemistry of Selenium. Marcel Dekker Inc., New York., p. 315-354.

Skorupa JP. 2008. Great Salt Lake Selenium Standard: Written Recommendation to the Steering Committee. *In* Appendix M, *Development of a Selenium Standard for the Open Waters of the Great Salt Lake*. Final report prepared by CH2MHill for the State of Utah Department of Environmental Quality.

Skorupa JP. March 6, 2008. Re: Use of bird egg tissue selenium guidelines for turtle eggs. Electronic communication to T. Reeder, SARWQCB.

Skorupa JP. May 28, 2008. Re: Use of California State Listing Policy delisting criteria for bird eggs and appropriate/necessary triggers/ceiling or not-to-exceed-concentration to remain in compliance with the MBTA. Notes from conversation between T. Reeder, SARWQCB and J.P. Skorupa, USFWS.

Skorupa JP. October 20, 2008. Re: Fish and bird egg tissue recommendations and justification for Se SSOs with references. Electronic communication: MicroSoft™ Word document sent via electronic mail to T. Reeder, SARWQCB.

Skorupa JP. May 27, 2009. Re: Ceiling concentrations for selenium in fish and bird egg tissue. Electronic communication to J. Peng, County of Orange, Department of Public Works.

Skorupa JP. June 29, 2009. Re: Newport Bay Se SSO for fish tissue of 5.0 µg/g - effects level or no effects level. Electronic communication to T. Reeder, SARWQCB.

Skorupa JP. July 7, 2009. Re: Beckon et al. 2008 and Newport Bay watershed bird egg tissue SSO of 8 ppm. Electronic communication to T. Reeder, SARWQCB.

Skorupa JP. October 28, 2009. Re: Reanalysis of stilt egg hatchability database. Electronic communication to T. Reeder, SARWQCB.

Skorupa JP. October 29, 2009. Re: Specifics of reanalysis of stilt egg hatchability database. Electronic communication to T. Reeder, SARWQCB.

Skorupa JP. 2010. Unpublished data as referenced in Janz et al. 2010.

Skorupa JP and Ohlendorf HM. 1991. Contaminants in drainage water and avian risk thresholds. *In* The Economics and Management of Water and Drainage in Agriculture. Dinar A and Zilberman D, editors. Kluwer Academic Publishers.

Smith GJ, Heinz GH, Hoffman DJ, Spann JW, and Krynitsky AJ. 1988. Reproduction in black-crowned night-herons fed selenium. Lake and Reservoir Management. Volume 4, Issue 2, pp. 175-180.

Snodgrass JW, Hopkins WA, Roe JH. 2003. Relationships among developmental stage, metamorphic timing and concentrations of elements in bullfrogs (*Rana catesbeiana*). Environmental Toxicology & Chemistry. Volume 22, Number 7, pp. 1597-1604.

Snodgrass JW, Hopkins WA, Broughton J, Gwinn D, Baionno JA, Burger J. 2004. Species-specific responses of developing anurans to coal combustion wastes. Aquatic Toxicology. Volume 66, pp. 171-182.

Snodgrass JW, Hopkings WA, Jackson BP, Baionno JA, Broughton J. 2005. Influence of larval period on responses of overwintering green frog (*Rana clamitans*) larvae exposed to contaminated sediments. Environmental Toxicology and Chemistry. Volume 24, Number 6, pp. 1508-1514.

Sonstegard, J., J. Harwwod, T. Pickett. 2007. Full Scale Implementation of GE ABMet® Biological Technology for the Removal of Selenium from FGD Wastewaters. GE Water & Process Technologies, Salt Lake City, UT. Report presented at the 2007 International Water Conference, Orlando, Florida.

Spallholz JE and Hoffman DJ. 2002. Selenium toxicity: cause and effects in aquatic birds. Aquatic Toxicology. Volume 27, pp. 27-37.

Spear MJ and McInnis RR. 2000. Biological Opinion on EPA's "Water Quality Standards: Establishment of Numeric Criteria for Priority Toxic Pollutants in the State of California". U.S. Fish and Wildlife Service and National Marine Fisheries Service.

Stanley TR, Smith GJ, Hoffman DJ, Heinz H, Rosscoe R. 1996. Effects of boron and selenium on mallard reproduction and duckling growth and survival. Environmental Toxicology and Chemistry. Volume 15, Issue 5, pp. 1124-1132.

State of California, Department of Fish and Game (CDFG). 2006. Tissue, sediment and water quality monitoring for bioaccumulative contaminants and metals in the San Diego Creek/Newport Bay (SDC/NB) Watershed. Monitoring Data. SWRCB Contract No. 05-279-250-0.

State of California, Department of Fish and Game (CDFG). 2011. Information accessed on April 28, 2011 from: http://www.dfg.ca.gov/invasives/.

State of California, Los Angeles Regional Water Quality Control Board. 2006. Proposed Amendment to the Water Quality Control Plan - Los Angeles Region to Incorporate the Total Maximum Daily Load for Metals and Selenium in the Calleguas Creek, its Tributaries and Mugu Lagoon. Attachment A to Resolution No. R4-2006-012.

State of California, Santa Ana Regional Water Quality Control Board. 1995. Water Quality Control Plan, Santa Ana River Basin. Updated 2008, 2011. http://www.waterboards.ca.gov/santaana/water_issues/programs/basin_plan/index.shtml

State of California, Santa Ana Regional Water Quality Control Board. 1998. Attachment to Resolution No. 98-100, Resolution Revising the Amendment to the Water Quality Control Plan for the Santa Ana River Basin Incorporating a Nutrient TMDL for the Newport Bay/San Diego Creek Watershed (Resolution No. 98-9). http://www.waterboards.ca.gov/santaana/board_decisions/adopted_orders/orders/1998/98_100_tmdl_nutrients_newport_bay_sandiego_crk.pdf

State of California, Santa Ana Regional Water Quality Control Board. 2000. Final Problem Statement for the Total Maximum Daily Load for Toxic Substances in Newport Bay and San Diego Creek. Staff report.

State of California, Santa Ana Regional Water Quality Control Board. 2006. Total Maximum Daily Loads for Organochlorine Compounds; San Diego Creek: Total DDT and Toxaphene; Upper and Lower Newport Bay: Total DDT, Chlordane, Total PCBs; Orange County, California. Staff report prepared by Kathy L. Rose, Ph. D. November 17, 2006.

State of California, Santa Ana Regional Water Quality Control Board. 2011. Geology, Hydrology, and Water Quality with a Focus on Selenium Sources and Potential Impacts, Big Canyon Wash Watershed, Newport Beach, California. Santa Ana Regional Water Quality Control Board Final Staff Report dated August 17, 2011.

State of California, Santa Ana Regional Water Quality Control Board. 2012. Basin Plan Amendments Revisions to Recreational Standards for Inland Fresh Surface Waters in the Santa Ana Region. Staff report. January 12, 2012.

State of California, State Water Resources Control Board. 1999. Consolidated Toxic Hot Spots Cleanup Plan.

State of California, State Water Resources Control Board. 2000. Nonpoint Source Program Strategy and Implementation Plan, 1998-2013 (PROSIP): Volume I. California Coastal Commission. January 2000.

State of California, State Water Resources Control Board. 2004a. Water Quality Control Policy for Developing California's Clean Water Act Section 303(d) List .

State of California, State Water Resources Control Board. 2004b. Final Functional Equivalent Document. Water Quality Control Policy for Developing California's Clean Water Act Section 303(d) List.

State of California, State Water Resources Control Board. 2004c. Policy for Implementation and Enforcement of the NonPoint Source Pollution Control Program. California Environmental Protection Agency. May 20, 2004.

State of California, State Water Resources Control Board. 2005. Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California.

State of California, State Water Resources Control Board. 2006. Clean Water Act Section 303(d) List of Water Quality Limited Segments.

Stephen CE, Mount DI, Hansen DJ, Gentile JH, Chapman GA, Brungs WA. 1985. Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses. USEPA Office of Water, Washington, D.C. National Technical Information Service (NTIS) Document No. PB85-227049.

Stewart R, Grosell M, Buchwalter D, Fisher N, Luoma S, Mathews T, Orr P, Wang W-X. 2010. Bioaccumulation and Trophic Transfer of Selenium. *In* Chapman PM, Adams WJ, Brooks ML, Delos CG, Luoma SN, Maher WA, Ohlendorf HM, Presser TS, Shaw DP, editors. Ecological Assessment of Selenium in the Aquatic Environment. Chapter 5. Society of Environmental Toxicology and Chemistry (SETAC) Publications. CRC Press, Boca Raton FL (USA). pp. 93-139.

Stolz JF, Basu P, Santini JM, Oremland, RS. 2006. Arsenic and selenium in microbial metabolism. Annual Review of Microbiology. Volume 60, pp. 107-130.

Sutula M, Brown J, Fetscher E, Mattson M, Madon S, Santolo G, Byron E, Stansky C. 2008. Habitat value and treatment effectiveness of freshwater urban wetlands. Southern California Coastal Water Research Project (SCCWRP) Technical Report No. 559. March 2008.

Tian Y and Liu F. 1993. Selenium requirements of shrimp *Penaeus chinensis*. Chinese Journal of Oceanology and Limnology. Volume 11, No. 3, pp. 249-253.

Trimble SW. 1998. Historical hydrographic and hydrologic changes in the Newport Bay-San Diego Creek watershed. Report prepared for the Orange County Public Facilities and Resources Department.

U.S. Department of the Interior. 1998. Guidelines for the Interpretation of the Biological Effects of Selected Constituents in Biota, Water, and Sediment. National Irrigation Quality Program Information Report No. 3.

U.S. Environmental Protection Agency. 1987. Ambient Water Quality Criteria for Selenium - 1987. USEPA Office of Water Regulation and Standards, Criteria and Standards Division. Washington, D.C.

U.S. Environmental Protection Agency. 1994. Water Quality Standards Handbook: Second Edition (EPA 823-B-94-005a). USEPA, August 1994.

U.S. Environmental Protection Agency. 1999. Update of Ambient Water Quality Criteria for Ammonia. EPA-822-R-99-014. Office of Water, Washington, DC.

U.S. Environmental Protection Agency. 2000. Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California; Rule. 40 CFR Part 131. May 18, 2000.

U.S. Environmental Protection Agency. 2002a. Total Maximum Daily Loads for Toxic Pollutants – San Diego Creek and Newport Bay, California. http://www.epa.gov/region/water/tmdl/final.html

U.S. Environmental Protection Agency. 2002b. Establishing Total Maximum Daily Load (TMDL) Wasteload Allocation (WLAs) for Storm Water Sources and NPDES Permit Requirements Based on Those WLAs. Memorandum from Robert H. Wayland III, Director of Office of Wetlands, and James A. Hanlon, Director of Wastewater Management, to Water Division Directors Regions 1 – 10. Office of Water. November 22, 2002.

U.S. Environmental Protection Agency. 2002c. Toxicity Relationship Analysis Program (TRAP). http://cfpub.epa.gov/si/si_public_record_Report.cfm?dirEntryId=231579

U.S. Environmental Protection Agency. 2004. Draft Aquatic Life Water Quality Criteria for Selenium. Office of Water, Office of Science and Technology, Washington, D.C. Federal Register 69(242):75541-75546; December 17, 2004.

U.S. Environmental Protection Agency. 2006a. Establishing TMDL “Daily” Loads in Light of the Decision by the U.S. Court of Appeals for the D.C. Circuit in Friends of the Earth, Inc. v. EPA, et al., No.05-5015, (April 25, 2006) and Implications for NPDES permits. Memorandum from Benjamin Grumbles, assistant administrator, Office of Water. U.S. Environmental Protection Agency, Washington, DC. to Water Division Directors, Regions I-X.

U.S. Environmental Protection Agency. 2006b. Clarifications Regarding "Phased" Total Maximum Daily Loads. USEPA memorandum dated August 2, 2006 from B. Best-Wong, Director, Assessment and Watershed Protection Division, Washington, D.C. to Water Division Directors, Regions I-X.

U.S. Environmental Protection Agency. 2007a. Draft Options for Expressing Daily Loads in TMDLs. USEPA Office of Wetlands, Oceans & Watersheds. Washington, D.C. June 22, 2007.

U.S. Environmental Protection Agency. 2007b. Water Quality Trading Toolkit for Permit Writers. EPA-833-R-07-004. Office of Water, Washington, DC. Published August, 2007 and Updated in June, 2009.

U.S. Environmental Protection Agency. 2009. Draft 2009 Update Aquatic Life Ambient Water Quality Criteria for Ammonia – Freshwater. EPA-822-D-09-001. Office of Water, Washington, DC.

U.S. Environmental Protection Agency. 2011. RE: EPA Action on the Gilbert Bay Selenium Criterion and Footnote (14). Letter dated December 12, 2001 to Amanda Smith, Utah Department of Environmental Quality from Carol L. Campbell, USEPA. USEPA Region 8. Ref: 8EPR-EP. December 12, 2011.

U.S. Environmental Protection Agency. 2014a. External Peer Review Aquatic Life Ambient Water Quality Criterion for Selenium – Freshwater 2014. Office of Water, Office of Science and Technology. EPA 822-P-14-001, May 2014. https://www.epa.gov/wqc/aquatic-life-criterion-selenium#draft

U.S. Environmental Protection Agency. 2014b. Revisions to the November 22, 2002 Memorandum "Establishing Total Maximum Daily Load (TMDL) Wasteload Allocation (WLAs) for Storm Water Sources and NPDES Permit Requirements Based on Those WLAs". Memorandum from Andrew D. Sawyer, Director, Office of Wastewater Management, and Benita Best-Wong, Director, Office of Wetlands, Oceans, and Watersheds to Water Division Directors Regions 1 – 10. Office of Water, November 26, 2014. https://www.epa.gov/sites/production/files/2015-10/documents/epa_sw_tmdl_memo.pdf

U.S. Environmental Protection Agency. 2015. Draft Aquatic Life Ambient Water Quality Criterion for Selenium – Freshwater 2015. Office of Water, Office of Science and Technology. EPA 822-P-15-001, July 2015. https://www.epa.gov/wqc/aquatic-life-criterion-selenium#draft

U.S. Environmental Protection Agency. 2016. Aquatic Life Ambient Water Quality Criterion for Selenium – Freshwater 2016. Office of Water, Office of Science and Technology. EPA 822-R-16-006, June 30, 2016. https://www.epa.gov/wqc/aquatic-life-criterion-selenium

U.S. Fish and Wildlife Service. 2005. USFWS public comment package to U.S. EPA on Draft Aquatic Life Criteria Document for Selenium. Letter dated May 19, 2005 to S.L. Johnson, USEPA from E.F. Wilson, USFWS. EPA Office of Water Selenium Docket Document Nos. EPA- HQ-OW-2004-0019-0208 and EPA-HQ-OW-2004-0019-209. [100 pp. and 41 pp]

U.S. Fish and Wildlife Service. 2009. USFWS staff opinion on the proposed numeric water quality selenium standard for the Great Salt Lake. Letter dated 5-18-2009 to C. Rushin, USEPA from N.E. Walsh, USFWS.

Ullrey DE. 1992. Basis for Regulation of Selenium Supplement in Animal Diets. Journal of Animal Science. Volume 70, pp. 3922-3927

Unrine JM, Jackson BP, Hopkins WA, Romanek C. 2006. Isolation and partial characterization of proteins involved in the maternal transfer of selenium in the western fence lizard (Sceloporus occidentalis). Environmental Toxicology and Chemistry. Volume 25, Number 7, pp. 1864-1867.

Unrine JM, Jackson BP, Hopkins WA. 2007. Selenomethionine biotransformation and incorporation into proteins along a simulated terrestrial food chain. Environmental Science and Technology. Volume 41, Number 10, pp. 3601-3606.

Wallschläger D. and Bloom NS. 2001. Determination of selenite, selenate and selenocyanate in waters by ion chromatography-hydride generation-atomic fluorescence spectrometry (IC-HG-AFS). Journal of Analytical Atomic Spectrometry. Volume 16, pp. 1322-1328.

Wallschläger D and Roehl R. 2001. Determination of inorganic selenium speciation in waters by ion chromatography-inductively-coupled plasma-mass spectrometry using eluent elimination with a membrane suppressor. Journal of Analytical Atomic Spectrometry. Volume 16, pp. 922-925.

Wang, W.X. 2002. Interactions of trace metals and different marine food chains. Marine Ecology Progress Series, v. 243, p. 295-309.

Wang T, Wang J, Burken JG, Ban H, Ladwig K. 2007. The leaching characteristics of selenium from coal fly ashes. Journal of Environmental Quality. Volume 36, pp. 1784-1792.

Wen HJ and Carignan J. 2007. Reviews on atmospheric selenium: emissions, speciation, and fate. Atmosphere and the Environment. Volume 41, pp. 7151-7165.

Wendelberger J. and Campbell K. 1994. Non-detect data in Environmental Investigations. *Proceedings of the American Statistical Association.* Toronto, Canada, August 14-18, 1994. Los Alamos National Laboratory Report LA-UR-94-1856.

Weston Solutions, Inc. 2007. Big Canyon Creek Flow and Water Quality Assessment. Final report prepared for WRC Consulting Services, Inc.

Weston Solutions, Inc. 2008. Monitoring data for Big Canyon Creek (unpublished data).

Wiemeyer SN and Hoffman DJ. 1996. Reproduction in eastern screech owls fed selenium. Journal of Wildlife Management. Volume 60, pp. 332-341.

Wilber, C.G., 1980, Toxicology of Selenium: A Review. *Clinical Toxicology* . Volume 17, pp. 171- 230.

Williams ML, Hothem RL, Ohlendorf HM. 1989. Recruitment failure in American avocets and black-necked stilts nesting at Kesterson Reservoir, California, 1984-1985. Condor. Volume 91, pp. 797-802.

Wozniak B. 2013. Applied Speciation Consulting, LLC, electronic mail communication dated January 25, 2013.

WRA Environmental Consultants. 2007. Monitoring and Flow Management Program (Revised). San Joaquin Freshwater Marsh Reserive, Phase II Restoration Project, Irvine, Orange County, California. Revised report dated October 2007. Prepared for Dr. Peter Bowler, University of California, Irvine (UCI) Department of Ecology and Evolutionary Biology and Dr. William Bretz, University of California Natural Reserve System, UCI

Zhang YQ, Moore JN, Frankenberger Jr. WT. 1999. Speciation of soluble selenium in agricultural drainage waters and aqueous soil-sediment extracts using hydride generation atomic absorption spectrometry. Environmental Science and Technology. Volume 33, pp. 1652-1656.

Zhang YQ, Zahir ZA, Frankenberger Jr. WT. 2004. Fate of colloidal-particulate elemental selenium in aquatic systems. Journal of Environmental Quality. Volume 33, pp. 559-564.

State Water Resources Control Board

March 20, 2017

Marjorie L. Brooks, Ph.D.
Associate Professor, Department of Zoology
Southern Illinois University
335E, Life Sciences II
Carbondale, IL 62901

SUBJECT: INITIATION OF REVIEW OF DRAFT BASIN PLAN AMENDMENT TO INCORPORATE TOTAL MAXIMUM DAILY LOADS (TMDLs) FOR SELENIUM IN FRESHWATER, NEWPORT BAY WATERSHED, ORANGE COUNTY, CA

Dear Dr. Brooks:

My letter today is intended to initiate the external peer review.

All components for the review, and a Table of Contents, are posted at a secure FTP site. They include, but are not restricted to, the following:

1. November 10, 2016, memorandum from Terri S. Reeder, Santa Ana Regional Water Quality Control Board to me. The subject of the memorandum is “Request for Peer Review of Draft Basin Plan Amendment to Incorporate Total Maximum Daily Loads (TMDLs) for Selenium in Freshwater, Newport Bay Watershed, Orange County, CA,” transmitting these attachments:

   - Attachment 1: Summary
   - Attachment 2: Description of Scientific Assumptions, Findings, and Conclusions That Have Been Identified By Regional Board Staff As Requiring Review
   - Attachment 3: List of Participants/Contacts (3A) and Working Group Members (3B)
   - Attachment 4: List of References

   PLEASE NOTE: The first page of the memorandum has been modified at the top right corner to state: Revised March 7, 2017, in red text. The revision refers to addition of text associated solely with Attachment 2 in two locations, also in red text: a) On third page of request letter to me; and b) On pages 1 and 2 of Attachment 2 as four paragraphs, preceded by the notation, Note to Reviewers.

2. January 7, 2009, Supplement to the Cal/EPA Peer Review Guidelines.

Comments on the Foregoing

1. You have been sent a copy of the original November 10, 2016, request memorandum by Dr. Dan McGrath (without the red text additions) during the solicitation process for reviewer candidates conducted by the University of California, Berkeley Institute of the Environment. ***Delete that version from your files, and base your review on the revised November 10, 2016 request provided at the FTP site, access to which is given below.***

2. Attachment 2 to the request memorandum provides focus for the review. I ask that you address all topics, as expertise allows, in the order listed. The Staff Report sections that provide support for each of the 12 Assumptions, Findings and Conclusions are identified beside them.

3. The January 7, 2009, Supplement. In part, the Supplement provides guidance to ensure the review is kept confidential through its course. It also notes reviewers are under no obligation to discuss their comments with third-parties after reviews have been submitted. We recommend they do not. All outside parties are provided opportunities to address a proposed regulatory action through a well-defined regulatory process. Please direct third parties to me.

Access to the FTP site:

https://ftp.waterboards.ca.gov/

User name: PRFTP
Password: Water123

Questions about the review, or material, should be for clarification, in writing – email is fine, and addressed to me. My responses will be in writing also.

Please send your reviews to me on April 20, 2017, not before. I will subsequently forward all reviews to Terri Reeder, Santa Ana Regional Water Quality Control Board, with Curriculum Vitae for each reviewer. All this information will be posted at the Regional Board program website, and at the State and Regional Water Boards Scientific Peer Review Website.

Your acceptance of this review assignment is most appreciated.

Sincerely,

Gerald W. Bowes

Gerald W. Bowes, Ph.D.
Manager, Cal/EPA Scientific Peer Review Program
Office of Research, Planning and Performance
State Water Resources Control Board
1001 “I” Street, 16th Floor
Sacramento, California 95814

Telephone: (916) 341-5567
FAX: (916) 341-5284
Email: GBowes@waterboards.ca.gov

California
Water Boards

State Water Resources Control Board

March 20, 2017

Dirk Wallschläger, Ph.D.
Professor, School of the Environment
Director, Water Quality Center; Trent University
1600 West Bank Drive
Peterborough, ON K9L 0G2
Canada

SUBJECT: INITIATION OF REVIEW OF DRAFT BASIN PLAN AMENDMENT TO INCORPORATE TOTAL MAXIMUM DAILY LOADS (TMDLs) FOR SELENIUM IN FRESHWATER, NEWPORT BAY WATERSHED, ORANGE COUNTY, CA

Dear Dr. Wallschläger:

My letter today is intended to initiate the external peer review.

All components for the review, and a Table of Contents, are posted at a secure FTP site. They include, but are not restricted to, the following:

1. November 10, 2016, memorandum from Terri S. Reeder, Santa Ana Regional Water Quality Control Board to me. The subject of the memorandum is "Request for Peer Review of Draft Basin Plan Amendment to Incorporate Total Maximum Daily Loads (TMDLs) for Selenium in Freshwater, Newport Bay Watershed, Orange County, CA," transmitting these attachments:

   - Attachment 1: Summary
   - Attachment 2: Description of Scientific Assumptions, Findings, and Conclusions That Have Been Identified By Regional Board Staff As Requiring Review
   - Attachment 3: List of Participants/Contacts (3A) and Working Group Members (3B)
   - Attachment 4: List of References

   PLEASE NOTE: The first page of the memorandum has been modified at the top right corner to state: Revised March 7, 2017, in red text. The revision refers to addition of text associated solely with Attachment 2 in two locations, also in red text: a) On third page of request letter to me; and b) On pages 1 and 2 of Attachment 2 as four paragraphs, preceded by the notation, Note to Reviewers.

2. January 7, 2009, Supplement to the Cal/EPA Peer Review Guidelines.

Comments on the Foregoing

1. You have been sent a copy of the original November 10, 2016, request memorandum by Dr. Dan McGrath (without the red text additions) during the solicitation process for reviewer candidates conducted by the University of California, Berkeley Institute of the Environment. ***Delete that version from your files, and base your review on the revised November 10, 2016 request provided at the FTP site, access to which is given below.***

2. Attachment 2 to the request memorandum provides focus for the review. I ask that you address all topics, as expertise allows, in the order listed. The Staff Report sections that provide support for each of the 12 Assumptions, Findings and Conclusions are identified beside them.

3. The January 7, 2009, Supplement. In part, the Supplement provides guidance to ensure the review is kept confidential through its course. It also notes reviewers are under no obligation to discuss their comments with third-parties after reviews have been submitted. We recommend they do not. All outside parties are provided opportunities to address a proposed regulatory action through a well-defined regulatory process. Please direct third parties to me.

Access to the FTP site:

https://ftp.waterboards.ca.gov/

User name: PRFTP
Password: Water123

Questions about the review, or material, should be for clarification, in writing – email is fine, and addressed to me. My responses will be in writing also.

Please send your reviews to me on April 20, 2017, not before. I will subsequently forward all reviews to Terri Reeder, Santa Ana Regional Water Quality Control Board, with Curriculum Vitae for each reviewer. All this information will be posted at the Regional Board program website, and at the State and Regional Water Boards Scientific Peer Review Website.

Your acceptance of this review assignment is most appreciated.

Sincerely,

Gerald W. Bowes

Gerald W. Bowes, Ph.D.
Manager, Cal/EPA Scientific Peer Review Program
Office of Research, Planning and Performance
State Water Resources Control Board
1001 "I" Street, 16th Floor
Sacramento, California 95814

Telephone: (916) 341-5567
FAX: (916) 341-5284
Email: GBowes@waterboards.ca.gov

March 20, 2017

Judson Harvey, Ph.D.
Senior Research Hydrologist
National Research Program, USGS
436 National Center
Reston, VA 20192

SUBJECT: INITIATION OF REVIEW OF DRAFT BASIN PLAN AMENDMENT TO INCORPORATE TOTAL MAXIMUM DAILY LOADS (TMDLs) FOR SELENIUM IN FRESHWATER, NEWPORT BAY WATERSHED, ORANGE COUNTY, CA

Dear Dr. Harvey:

My letter today is intended to initiate the external peer review.

All components for the review, and a Table of Contents, are posted at a secure FTP site. They include, but are not restricted to, the following:

1. November 10, 2016, memorandum from Terri S. Reeder, Santa Ana Regional Water Quality Control Board to me. The subject of the memorandum is "Request for Peer Review of Draft Basin Plan Amendment to Incorporate Total Maximum Daily Loads (TMDLs) for Selenium in Freshwater, Newport Bay Watershed, Orange County, CA," transmitting these attachments:

   - Attachment 1: Summary
   - Attachment 2: Description of Scientific Assumptions, Findings, and Conclusions That Have Been Identified By Regional Board Staff As Requiring Review
   - Attachment 3: List of Participants/Contacts (3A) and Working Group Members (3B)
   - Attachment 4: List of References

   PLEASE NOTE: The first page of the memorandum has been modified at the top right corner to state: Revised March 7, 2017, in red text. The revision refers to addition of text associated solely with Attachment 2 in two locations, also in red text: a) On third page of request letter to me; and b) On pages 1 and 2 of Attachment 2 as four paragraphs, preceded by the notation, Note to Reviewers.

2. January 7, 2009, Supplement to the Cal/EPA Peer Review Guidelines.

Comments on the Foregoing

1. You have been sent a copy of the original November 10, 2016, request memorandum by Dr. Dan McGrath (without the red text additions) during the solicitation process for reviewer candidates conducted by the University of California, Berkeley Institute of the Environment. ***Delete that version from your files, and base your review on the revised November 10, 2016 request provided at the FTP site, access to which is given below.***

2. Attachment 2 to the request memorandum provides focus for the review. I ask that you address all topics, as expertise allows, in the order listed. The Staff Report sections that provide support for each of the 12 Assumptions, Findings and Conclusions are identified beside them.

3. The January 7, 2009, Supplement. In part, the Supplement provides guidance to ensure the review is kept confidential through its course. It also notes reviewers are under no obligation to discuss their comments with third-parties after reviews have been submitted. We recommend they do not. All outside parties are provided opportunities to address a proposed regulatory action through a well-defined regulatory process. Please direct third parties to me.

Access to the FTP site:

https://ftp.waterboards.ca.gov/

User name: PRFTP
Password: Water123

Questions about the review, or material, should be for clarification, in writing – email is fine, and addressed to me. My responses will be in writing also.

Please send your reviews to me on April 20, 2017, not before. I will subsequently forward all reviews to Terri Reeder, Santa Ana Regional Water Quality Control Board, with Curriculum Vitae for each reviewer. All this information will be posted at the Regional Board program website, and at the State and Regional Water Boards Scientific Peer Review Website.

Your acceptance of this review assignment is most appreciated.

Sincerely,

Gerald W. Bowes

Gerald W. Bowes, Ph.D.
Manager, Cal/EPA Scientific Peer Review Program
Office of Research, Planning and Performance
State Water Resources Control Board
1001 "I" Street, 16th Floor
Sacramento, California 95814

Telephone: (916) 341-5567
FAX: (916) 341-5284
Email: GBowes@waterboards.ca.gov

January 7, 2009

Supplement to Cal/EPA External Scientific Peer Review Guidelines – "Exhibit F" in Cal/EPA Interagency Agreement with University of California

Gerald W. Bowes, Ph.D.

Guidance to Staff:

1. Revisions. If you have revised any part of the initial request, please stamp "Revised" on each page where a change has been made, and the date of the change. Clearly describe the revision in the cover letter to reviewers, which transmits the material to be reviewed. The approved reviewers have seen your original request letter and attachments during the solicitation process, and must be made aware of changes.

2. Documents requiring review. All important scientific underpinnings of a proposed science-based rule must be submitted for external peer review. The underpinnings would include all publications (including conference proceedings), reports, and raw data upon which the proposal is based. If there is a question about the value of a particular document, or parts of a document, I should be contacted.

3. Documents not requiring review. The Cal/EPA External Peer Review Guidelines note that there are circumstances where external peer review of supporting scientific documents is not required. An example would be "A particular work product that has been peer reviewed with a known record by a recognized expert or expert body." I would treat this allowance with caution. If you have any doubt about the quality of such external review, or of the reviewers' independence and objectivity, that work product – which could be a component of the proposal - should be provided to the reviewers.

4. Implementation review. Publications which have a solid peer review record, such as a US EPA Criteria document, do not always include an implementation strategy. The Cal/EPA Guidelines require that the implementation of the scientific components of a proposal, or other initiative, must be submitted for external review.

5. Identity of external reviewers. External reviewers should not be informed about the identity of other external reviewers. Our goal has always been to solicit truly independent comments from each reviewer. Allowing the reviewers to know the identity of others sets up the potential for discussions between them that could devalue the independence of the reviews.

6. Panel Formation. Formation of reviewer panels is not appropriate. Panels can take on the appearance of scientific advisory committees and the external reviewers identified through the Cal/EPA process are not to be used as scientific advisors.

7. Conference calls with reviewers. Conference calls with one or more reviewers can be interpreted as seeking collaborative scientific input instead of critical review. Conference calls with reviewers are not allowed.

Guidance to Reviewers from Staff:

1. Discussion of review.

Reviewers are not allowed to discuss the proposal with individuals who participated in development of the proposal. These individuals are listed in Attachment 3 of the review request.

Discussions between staff and reviewers are not permitted. Reviewers may request clarification of certain aspects of the review process or the documents sent to them.

Clarification questions and responses must be in writing. Clarification questions about reviewers' comments by staff and others affiliated with the organization requesting the review, and the responses to them, also must be in writing. These communications will become part of the administrative record.

The organization requesting independent review should be careful that organization-reviewer communications do not become collaboration, or are perceived by others to have become so. The reviewers are not technical advisors. As such, they would be considered participants in the development of the proposal, and would not be considered by the University of California as external reviewers for future revisions of this or related proposals. The statute requiring external review of science-based rules proposed by Cal/EPA organizations prohibits participants serving as peer reviewers..

2. Disclosure of reviewer Identity and release of review comments.

Confidentiality begins at the point a potential candidate is contacted by the University of California. Candidates who agree to complete the conflict of interest disclosure form should keep this matter confidential, and should not inform others about their possible role as reviewer.

Reviewer identity may be kept confidential until review comments are received by the organization that requested the review. After the comments are received, reviewer identity and comments must be made available to anyone requesting them.

Reviewers are under no obligation to disclose their identity to anyone enquiring. It is recommended reviewers keep their role confidential until after their reviews have been submitted.

3. Requests to reviewers by third parties to discuss comments.

After they have submitted their reviews, reviewers may be approached by third parties representing special interests, the press, or by colleagues. Reviewers are under no obligation to discuss their comments with them, and we recommend that they do not.

All outside parties are provided an opportunity to address a proposed regulatory action during the public comment period and at the Cal/EPA organization meeting where the proposal is considered for adoption. Discussions outside these provided avenues for comment could seriously impede the orderly process for vetting the proposal under consideration.

4. Reviewer contact information.

The reviewer's name and professional affiliation should accompany each review. Home address and other personal contact information are considered confidential and should not be part of the comment submittal.

BIOGRAPHICAL SKETCH FOR MARJORIE L. BROOKS

Department of Zoology, 1125 Lincoln Dr., MC 6501, Southern Illinois University, Carbondale, IL 62901, C: 307-399-0576, F: 618-453-2806, mlbrooks@siu.edu

(a) Professional Preparation

University of Wyoming	Laramie, WY	Natural Science/Mathematics	B.S.	1991
University of Wyoming	Laramie, WY	Archaeology/Anthropology	M.A.	1995
University of Wyoming	Laramie, WY	Zoology	Ph.D.	2003
Colorado State University	Fort Collins, CO	Aquatic Community Ecology	Postdoc	2003-2005
University of California	Santa Barbara, CA	NCEAS*	Postdoc	2006-2008

*National Center for Ecological Analysis and Synthesis

(b) Appointments

2015-present	Associate Professor, Department of Zoology, Southern Illinois University
2009-2015	Assistant Professor, Department of Zoology, Southern Illinois University
2006-2008	Postdoctoral Associate, NCEAS, University of California, Santa Barbara
2003-2005	Postdoctoral Fellow, Department of Fish, Wildlife, & Conservation Biology, Colorado State University
1999-2002	Fellow, Science to Achieve Results (EPA-STAR), US Environmental Protection Agency

(c) Closely Related Products

Brooks, ML, JH Behnke, EM Anderson, and JR Lovvorn. In prep. Detecting silent stressors: Bioaccumulation of Cd, Hg, and Se and body condition of declining surf and white-winged scoter populations in Puget Sound. Based on completed Master's thesis.

Lovvorn, JR, MF Raisbeck, LW Cooper, GA Cutter, MW Miller, ML Brooks, JM Grebmeier, AC Matz, CM Schaefer, 2013. Wintering eiders acquire exceptional Se and Cd burdens in the Bering Sea: physiological and oceanographic factors. ***Mar Ecol-Prog Ser*** 489:245–261

Brooks, ML, E Fleishman, LR Brown, PW Lehman, I Werner, N Scholz, CL Mitchelmore, JR Lovvorn, ML Johnson, D Schlenk, S vanDrunick, JI Drever, DM Stoms, AE Parker, and R Dugdale. 2012. Life histories, salinity zones, and sublethal contributions of contaminants to pelagic fish declines illustrated with a case study of San Francisco Estuary, California, USA ***Estuar Coasts*** 35:603-621

Byron, ER, HM Ohlendorf, A Redman, WJ Adams, B Marden, M Grosell, and ML Brooks. 2011. Predictive modeling of selenium accumulation in brine shrimp in saline environments. ***Integ Environ Assess Manag*** 7:478–482

Chapman, PM, WJ Adams, ML Brooks, CG Delos, SN Luoma, WA Maher, HM Ohlendorf, TS Presser, and DP Shaw, editors. 2010. ***Ecological Assessment of Selenium in the Aquatic Environment***. CRC Press, London, New York. 339 pages

Janz, DM, DK DeForest, ML Brooks, PM Chapman, G Gilron, D Hoff, WA Hopkins, DO McIntyre, CA Mebane, VP Palace, JP Skorupa, and M Wayland. 2010. Chapter 6, pages 141-231. Selenium toxicity to aquatic organisms. In: ***Ecological Assessment of Selenium in the Aquatic Environment***. Chapman et al (eds). CRC Press, London, New York.

(c) Other Significant Products

Hallman, TA, and ML Brooks. 2016. Metal-mediated climate susceptibility in a warming world: Larval and latent effects on a model amphibian. ***Environ Toxicol Chem*** 35:1872-1882

Hallman, TA and ML Brooks. 2015. The deal with diel: temperature fluctuations, asymmetrical warming, and ubiquitous metals contaminants ***Environ Pollut*** 296:88-94

Landis, WG, JL Durda, ML Brooks, PM Chapman, CA Menzie, RG Stahl, JL Stauber. 2013. Ecological risk assessment in the context of global climate change ***Environ Toxicol Chem*** 32:79-92
North, CA, JR Lovvorn, JM Kolts, ML Brooks, LW Cooper, JM Grebmeier, 2014. Deposit-feeder diets in the Bering Sea: implications for effects of climatic loss of sea ice-related microalgal blooms ***Ecol Applic*** 24:1525–1542
Geisler-Lee, J, ML Brooks, JR Gerfen, Q Wang, C Fotis, AJ Sparer, X Ma, RH Berg, M Geisler. 2014. Reproductive toxicity and life history study of silver nanoparticle effect, uptake and transport in *Arabidopsis thaliana* ***Nanomaterials*** 4:301-318
Clements, WH, ML Brooks, DR Kashian, and RE Zuellig. 2008. Changes in dissolved organic material determine exposure of stream benthic communities to UV-B radiation and heavy metals: implications for climate change ***Global Change Biol*** 14:2201-2214
Brooks, ML, DM McKnight, WH Clements. 2007. Photochemical control of copper complexation by dissolved organic matter in Rocky Mountain Streams, Colorado USA ***Limnol Oceanogr*** 52: 766-779

(d) Current Funding

2013 -present **Federal Funding:** Partnership with US Forest Service, *Amphibian occupancy models and energetic costs of multiple stressors in the Shawnee National Forest*. Brooks: $30,000.

2013 -present Sustainability of critical areas for eiders and subsistence hunters in an industrializing nearshore zone, funded by *National Science Foundation*. Collaborators: James Lovvorn, Henry Huntington, and Tuula Hollmen. Brooks: $18,000.

(e) Scientific Service and Synergistic Activities

2014 -present **Local Collaboration:** *Climate Trends Assessment Program for Illinois (CTAP).* Scientists from Illinois Natural History Survey, Illinois Department of Natural Resources and academia (Brooks) are reviewing and commenting on publications for wildlife researchers and the public about wise use of natural resources under climate change.

2013 -present **International Collaboration:** *River ecology and trade-offs of floodplain connectivity on flood management, eutrophication, pollutants, and food safety in Hungary and Serbia.* Evaluating ecosystem services with local scientists to assess floodplain and fisheries policy. Collaborators: Nicholas Pinter), Béla Csányi (Hungarian Acad. Sci., Göd, Hungary).

2010 -present **Whole Ecosystem Collaboration:** *Pelagic Organism Decline Contaminants Work Team (POD CWT),* Interagency Ecological Program, State of California, POD CWT is a think tank reviewing research needs regarding contaminants in San Francisco Estuary and the Sacramento San Joaquin Delta. http://www.water.ca.gov/iep/about/contaminant.cfm.

(f) Collaborators & Other Affiliations

Collaborators and Co-Editors (See attached)

Graduate Advisors and Postdoctoral Sponsors (n=5): Doctoral advisors: Harold Bergman, Joseph Meyer, Univ of Wyoming), Post-doctoral advisors: William Clements, Colorado State Univ, Diane McKnight, Univ of Colorado, James Reichman, NCEAS Director.

Thesis Advisor in Last 5 Years (n=6): Master's Students: Jessi Hallman Behnke (Kauai Seabird Habitat Conservation Program, Kauai, Hawaii), Tyler Hallman (Oregon State U.), Kristen Jordan (unknown), Sara Ressing (SIU), Anthony Roberts (SIU), Doctoral students, Jenny Paul (SIU), Jared Bilak (SIU).

DIRK WALLSCHLÄGER, PH.D.

PROFESSOR, ENVIRONMENTAL CHEMISTRY,
SCHOOL OF THE ENVIRONMENT AND DEPARTMENT OF CHEMISTRY,
TRENT UNIVERSITY,
1600 WEST BANK DRIVE, PETERBOROUGH, ON K9L 0G2, CANADA
PHONE (705) 748-1011 EXT. 7378, EMAIL DWALLSCH@TRENTU.CA

EDUCATION

8/1996	Ph. D., Analytical & Environmental Chemistry, University of Bremen, Germany
2/1992	M.Sc., Analytical Chemistry, Ruhr-Universtät Bochum, Germany

WORK EXPERIENCE

7/2002 – 6/2006	Assistant Professor, ERS, Trent University, Peterborough, ON, Canada
7/2006 – 6/2008	Associate Professor, ERS
7/2008 – 6/2014	Associate Professor, ERS & Chemistry
since 9/2011	Director, Water Quality Centre
since 7/2014	Professor, ERS & Chemistry
since 7/2016	Professor, School of the Environment & Chemistry
1/1997-9/1998	Post-doctoral Research Scientist, Frontier Geosciences, Inc., Seattle, WA, USA
9/1998-6/2002	Research Scientist and Group Leader "Metal(loid) Speciation & Geochemistry"

SELECTED SCIENTIFIC PUBLICATIONS (SELENIUM RESEARCH ONLY)

PEER-REVIEWED JOURNAL ARTICLES (SELENIUM RESEARCH ONLY)

LeBlanc, K.L. & **Wallschläger, D.** (2016): *Production and release of selenomethionine and related organic selenium species by microorganisms in natural and industrial waters,* Environ. Sci. Technol. **50**, 6164-6171

LeBlanc, K.L., Ruzicka, J. & **Wallschläger, D.** (2016): *Identification of trace levels of selenomethionine and related organic selenium species in high ionic strength waters,* Anal. Bioanal. Chem. **408**, 1033-1042 and 1279 (erratum)

LeBlanc, K.L., Smith, M.S. & **Wallschläger, D.** (2012): *Production and release of selenocyanate by different green fresh water algae in environmental and laboratory studies,* Environ. Sci. Technol. **46**, 5867-5875

Petrov, P.K., Charters, J.W. & **Wallschläger, D.** (2012): *Identification and determination of selenosulfate and selenocyanate in flue gas desulfurization waters,* Environ. Sci. Technol. **46**, 1716-1723

Shaw, S.A., Hendry, M.J., Essilfie-Dughan, J., Kotzer, T. & **Wallschläger, D.** (2011): *Distribution, characterization, and geochemical controls of As, Se and Mo in uranium mine tailings, Key Lake, Saskatchewan, Canada,* Appl. Geochem. **26**, 2044-2056

Martin, A.J., Simpson, S., Fawcett, S., London, J., Wiramanaden, C.I.E., Pickering, I.J., Belzile, N., Chen, Y.-W. & **Wallschläger, D.** (2011): *Biogeochemical mechanisms of selenium exchange between water and sediments in two contrasting lentic environments,* Environ. Sci. Technol. **45**, 2605-2612

Simmons, D.B.D. & **Wallschläger, D.** (2011): *Release of reduced inorganic selenium species into waters by the green fresh water algae Chlorella vulgaris,* Environ. Sci. Technol. **45**, 2165-2171

Simmons, D. B. D. & **Wallschläger, D.** (2005): *A critical review of the biogeochemistry and ecotoxicology of selenium in lotic and lentic environments,* Environ. Toxicol. Chem. **24**, 1331-1343

Wallschläger, D. & London, J. (2004): *Determination of inorganic selenium species in rain and sea waters by anion exchange chromatography-hydride generation-inductively-coupled plasma-dynamic reaction cell-mass spectrometry (AEC-HG-ICP-DRC-MS)*, J. Anal. At. Spectrom. **19**, 1119-1127

Wallschläger, D. & Roehl, R. (2001): *Determination of inorganic selenium speciation in waters by ion chromatography-inductively-coupled plasma-mass spectrometry using eluant elimination with a membrane suppressor*, J. Anal. At. Spectrom. **16**, 922-925

Wallschläger, D. & Bloom, N.S (2001): *Determination of selenite, selenate and selenocyanate in waters by ion chromatography-hydride generation-atomic fluorescence spectrometry (IC-HG-AFS)*, J. Anal. At. Spectrom. **16**, 1322-1328

BOOK CHAPTERS (SELENIUM RESEARCH ONLY)

Maher, W., Roach, A., Doblin, M., Fan, T., Foster, S., Garrett, R., Möller, G., Oram, L. & **Wallschläger, D.** (2010): *Environmental sources, speciation and partitioning of selenium*, in: Chapman, P.M., Adams, W.J., Brooks, M.L., Delos, C.G., Luoma, S.N., Maher, W.A., Ohlendorff, H.M., Presser, T.S. & Shaw, D.P. (eds.): Ecological assessment of selenium in the aquatic environment, CRC Press, Boca Raton, FL, chapter 4, 47-92

Wallschläger, D. & Feldmann, J. (2010): *Formation, occurrence, significance and analysis of organoselenium and organotellurium compounds in the environment*, in: Sigel, A., Sigel, H. & Sigel, R.K.O. (eds.): Organometallics in environment and toxicology, Metal ions in life sciences, vol. 7, Royal Chemical Society, Cambridge, chapter 10, 319-364

Wallschläger, D. & Bloom, N.S (1999): *Selenium speciation in mining process waters by IC-HG-AFS*, Proc. 6th Int. Conf. Tailings and Mine Waste '99, Fort Collins, CO, 24.-27.1. 1999, A.A. Balkema, Rotterdam, 563-572

Edwards, M., Kulas, J.E., Weakley, J.O., Kuit, W., Bloom, N.S & **Wallschläger, D.** (1999): *Aquatic selenium at Cominco's Red Dog mine: sources, speciation, distribution and control*, Proc. 6th Int. Conf. Tailings and Mine Waste '99, Fort Collins, CO, 24.-27.1. 1999, A.A. Balkema, Rotterdam, 535-542

PEER-REVIEWED REPORTS (SELENIUM RESEARCH ONLY)

Ralston, N.V.C., Unrine, J. & **Wallschläger, D.** (2008): *Biogeochemistry and analysis of selenium and its species*, North American Metals Council, Washington, DC

McIntrye, D.O., Pacheco, M.A., Garton, M.W., **Wallschläger, D.** & Delos, C.G. (2008): *Effect of selenium on juvenile bluegill sunfish at reduced temperature,* report # EPA-822-R-08-020, US EPA Office of Water, Washington, DC

Judson Harvey
United States Geological Survey
National Research Program
12201 Sunrise Valley Drive, MS 430
Reston, VA 20192, telephone: 703-648-5876, jwharvey@usgs.gov
https://profile.usgs.gov/jwharvey; http://www.researcherid.com/Judson_W_Harvey_L-2047-2013;
http://orcid.org/0000-0002-2654-9873

RESEARCH INTERESTS

Groundwater-surface water interactions

Hyporheic flow and chemical reactions and cumulative influence on river water quality

Fine sediment transport and fate in rivers and wetlands

Hydrologic alteration of rivers and wetlands and effectiveness of restoration practices

BIO SKETCH

Dr. Judson Harvey investigates hydrologic transport at the interface between groundwater and surface water and effects on contaminants and aquatic ecosystems from the mountains to the sea. Jud has served on editorial boards for *Water Resources Research* and *Wetlands*, and on committees of the National Research Council, EPA's Science Advisory Board, the National Science Foundation, the National Center for Ecological Analysis and Synthesis, the Canadian Government's Science Review Board, and standing committees of the American Geophysical Union and the American Society of Limnology and Oceanography. Jud has lectured widely, and delivered plenary talks at meetings such as the IAH in Lisbon, the Sustainable Watersheds meeting in Beijing, and the Gordon Research Conference on Catchment Science in Plymouth. He has taught "Groundwater-Surface Water Relationships" for twenty-four years at the USGS and he has supervised numerous graduate theses and postdoctoral fellows. Jud is author of over 100 peer-reviewed articles, including a paper reprinted in "*Benchmark Papers in Hydrology: Groundwater*", the first chapter of the widely used textbook *Streams and Ground Waters* and its recent revision *Streams in a Changing Environment*, a National Academies book entitled *Riparian Areas*, and a popular USGS circular "*Groundwater and Surface Water: A Single Resource*" with 44,000 copies in print. For ground-breaking research Jud was elected as a Fellow of the *American Geophysical Union* (2016) and the *Geological Society of America* (2010).

PROFESSIONAL PREPARATION

University of Virginia, Charlottesville, VA	Hydrology, Ph.D. 1990
University of Virginia, Charlottesville, VA	Hydrology, M.S. 1986
New College, Sarasota, FL	Environmental Sciences, B.A. 1979

PROFESSIONAL APPOINTMENTS

2009 – present.	Research Hydrology Team Leader, National Research Program, USGS, Reston
2003 – 2009.	Research Hydrologist and Advisor to Research Chief, USGS, Reston
1998 – 2009.	Research Hydrologist and Project Chief, USGS, Reston
1995 – 1998.	Research Hydrologist, USGS National Research Program, Reston
1992 – 1995.	Hydrologist. USGS Arizona Water Science Center, Tucson
1990 – 1992.	National Research Council Postdoctoral Fellow, USGS, Menlo Park

HONORS

2016 Fellow of the *American Geophysical Union*
2010 Fellow of the *Geological Society of America*
2002 Superior Service Award, U.S. Geological Survey

1995, 2000, 2007, 2008, 2012, 2014 STAR (Science to Achieve Results) Award, U.S. Geological Survey
1989 Maury Research Award, University of Virginia, Charlottesville, VA
1987 Governor's Fellowship, University of Virginia, Charlottesville, VA

RECENT MEDIA COVERAGE

"Groundwater focus", Nature Geoscience,. "Simulations of the Mississippi River network suggest that denitrification due to flow through small-scale river bedforms exceeds that along channel banks." http://www.nature.com/ngeo/focus/groundwater, and **"Uncovering Mississippi's Natural Potential for Denitrification",** [link to press release about *Nature Geoscience* paper]

" Shallow Streambed Chemistry Filters Nitrate from Water", Environmental Monitor, December 30, 2013 http://www.fondriest.com/news/usgs-hyporheic-flow-filters-stream-nitrates.htm, and ***"Thin Ecological Skin beneath Streams Can Power Large Improvements in Water Quality"***, USGS Press Release, December 11, 2013 http://www.usgs.gov/newsroom/article.asp?ID=3748#.VMJD0CvF9PM

SELECTED PUBLICATIONS (106 total publications, Web of Knowledge **Researcher ID = L-2047-2013** analyzes 76 publications with **3758 citations**, an average of **50 citations per publication**, and an **h-index of 33**, accessed March 7, 2016)

Harvey, J.W., 2016, Hydrologic exchange flows and their ecological consequences in streams and rivers, Chapter 1 in *Streams in a Changing Environment*, Jay Jones and Emily Stanley (eds.), Academic Press, London.

Zlotnik V.A., A. Ward, J.W. Harvey, L.K. Lautz, D.O. Rosenberry, and P. Brunner, 2016, Handbook of Groundwater Engineering, 3rd Edition, Chapter 9: Groundwater-surface Water Interactions, Cushman, J. and Tartakovsky (eds.), CRC Press. ISBN 9781498703048.

Gomez-Velez, J.D., J.W. Harvey, M.B. Cardenas, and B. Kiel, 2015, Denitrification in the Mississippi river network controlled by flow through river bedforms, *Nature Geoscience,* doi: 10.1038/ngeo2567.[get publication] http://www.usgs.gov/newsroom

Harvey, J. and M. Gooseff, 2015, River corridor science: Hydrologic exchange and ecological consequences from bed forms to basins. *Water Resources Research*, Vol: 51(9), 50th Anniversary Issue, pages: 6893–6922, doi: 10.1002/2015WR017617. get pdf

Larsen, L., Harvey, J., Skalak, K., and M. Goodman, 2015, Fluorescence-based source tracking of organic sediment in restored and unrestored urban streams. *Limnology and Oceanography*, doi:10.1002/lno.10108. [get publication]

Briggs, M.A., Day-Lewis, .F.D., Zarnetske, J.P., and J.W. Harvey, 2015, A mechanistic explanation for the development of hyporheic redox microzones. *Geophysical Research Letters*, 42, doi:10.1002/2015GL064200. [get publication]

Boano, F., Harvey, J.W., Marion, A., Packman, A.I., Revelli, R., Ridolfi, L., and A Wörman, 2014 Hyporheic flow and transport processes: Mechanisms, models, and biogeochemical implications. *Reviews of Geophysics*. DOI: 10.1002/2012RG000417. [get publication]

Gomez-Velez, J.D. and J.W. Harvey, 2014, A hydrogeomorphic river network model predicts where and why hyporheic exchange is important in large basins. *Geophysical Research Letters*, DOI 10.1002/2014GL061099. [get publication]

SIU Southern Illinois University
CARBONDALE

To: Gerald Bowes, Ph.D.
Manager, Cal/EPA Scientific Peer Review Program
Office of Research, Planning and Performance
STATE WATER RESOURCES CONTROL BOARD
Sacramento, CA

From: Dr. Marjorie L. Brooks, Associate Professor
Aquatic Ecology and Biogeochemistry
Department of Zoology, MC 6501
Southern Illinois University
Carbondale, IL

Date: 27April 2017

Re: Peer review of draft Basin Plan Amendment to incorporate Total Maximum Daily Loads (TMDLs) for selenium in freshwater, Newport Bay Watershed, Orange County, CA

Summary:

This review is my response to request of the Santa Ana Regional Water Quality Control Board (Regional Board) for peer review of the scientific portions of a proposed Basin Plan Amendment (BPA) to incorporate Total Maximum Daily Loads (TMDLs) for selenium (Se) in three freshwater tributary subwatersheds in the Newport Bay watershed (San Diego Creek, Santa Ana-Delhi Channel, and Big Canyon Wash subwatersheds). It is my task to provide comments on the Draft Staff Report (2017) (Draft Staff Report 2017) and Draft Basin Plan Amendment (Draft Basin Plan Amendment - New Chapter 6 2017). My comments below follow the format of The *Description of Scientific Assumptions, Findings, and Conclusions to be Addressed by Peer Reviewers* (Attachment 2 2017).

Note when I allude to "Sections", I refer to Sections, also called "Chapters" in the Table of Contents in the Draft Staff Report (Draft Staff Report 2017) or the Draft Basin Plan Amendment (Draft Basin Plan Amendment - New Chapter 6 2017). When I allude to "Conclusions", I refer to information in The *Description of Scientific Assumptions, Findings, and Conclusions to be Addressed by Peer Reviewers* (Attachment 2 2017). My review is focused mainly on Conclusions 1 to 8, and 11, however, I include some comments about Conclusions 9, 10, and 12. It is my job to evaluate the assumptions, findings, and conclusions in the proposed TMDLs.

Overall evaluation:

To be scientifically defensible, future use of the biodynamic model needs to include quarterly rather than annual monitoring of whole-fish tissue and a minimum sample size of three species. Bird egg tissue can only be collected annually. Whenever possible, sampling should include at least three bird species. As the monitoring plan is now written, as few as one annual sample from one fish and one bird at five field sites is planned. The **<u>assumption</u>** that this plan is adequate is incorrect biologically and in terms of being scientifically defensible. Other recommendations to adaptive management protocols are discussed below.

The fundamental **<u>assumption</u>** that using the biodynamic model, which bases TMDL targets on <u>past</u> tissue concentrations in whole-fish tissue and bird egg tissue rather than total or dissolved Se water concentrations, is scientifically sound. The biodynamic model provides the highest probability of accurately assessing exposure and biological consequences because the biological availability of selenium (Se) depends on Se speciation that varies among watersheds. Among watersheds, distinctions in water temperatures promote higher solute concentrations (due to evaporative water loss). Both higher solutes and warming temperatures can lower dissolved oxygen levels. Low oxygen levels in the water column decrease redox at, and just below, the sediment-water interface where low redox promotes microbial production of selenomethionine, which is highly bioavailable (Stewart et al. 2010). Moreover, total inputs of solutes vary among watershed.

The **findings** that underlie the biodynamic model are sound and described in detail in the *Revised Newport Bay Biodynamic Model Runs Documentation* (Draft Staff Report Appendix O 2016) as well as peer reviewed scientific publications (Luoma and Rainbow 2005, Luoma and Presser 2009). Regulatory tissue values are based on the most current scientific knowledge available for the relationship between tissue concentrations and subsequent biological responses.

The implementation timeline for compliance in the proposed three-part, phased TMDL is reasonable in terms of logistical concerns and adequate time for changes in effluent inputs to be reflected in the biota within the watershed (Table 6.1) (Draft Basin Plan Amendment - New Chapter 6 2017). The structure of the TMDL Reconsideration step is vague. To be scientifically defensible, clean protocols are needed that determine when additional parameters or factors are required. As above, it is not scientifically defensible to assume that the tissue sampling frequency and tissue size are adequate to serve as the basis for future site-specific objectives (SSOs).

I support the conclusions below if and only if sampling frequency of whole-fish tissue is increased to quarterly and sample sizes are mandated at a minimum of three species for fish and bird egg tissue. Also, the number of sites for tissue monitoring is not internally consistent. Appendix R lists five sites but Appendix T lists six (Draft Staff Report Appendix R 2016, Draft Staff Report Appendix T 2016). Other caveats and concerns are discussed below.

Comments on Specific Conclusions:

Conclusion 1 (Staff Report: Sections 4, 4.1, 4.1.1, 4.4).

The most current available information informed the decision of the Regional Board staff to select the chronic criterion for Se in whole-body fish of 8.1 μg Se/g dw as the recommended numeric target for Se in fish. This is the most protective chronic criterion of three tissue-based targets recommended by the USEPA's 2014 Draft Criterion.

Although the whole-body fish concentration of 8.1 μg Se/g dw is suggested as protective of fish health, Appendix I states that the toxicity threshold for fish ranges from 4 to 6 μg Se/g dw (Draft Staff Report Appendix I 2016). This suggests that the fish tissue numeric target of 8.1 μg Se/g dw is a compromise. A brief statement about fish fecundity or other aspects that make this level acceptable would be helpful.

The assumption that monitoring whole-body Se concentration in fish rather than fish eggs is scientifically and logistically sound. The method will encourage compliance since gravid female fish are seldom collected in the Newport Bay watershed.

Conclusion 2 (Staff Report: Sections 4, 4.1, 4.1.2, 4.4).

Based on various feeding studies and the references cited, the conclusion is sound that a fish tissue numeric target of 5.0 μg Se/g dw will meet the essential dietary needs of shorebirds will little likelihood of reproductive effects. The conclusion is based on findings that the biodynamic model takes local Kds into account to show that even endangered species are protected in the three watersheds under consideration (Draft Staff Report Appendix O 2016).

Conclusion 3. (Staff Report: Sections 4, 4.2, 4.4)

The assumptions underlying the proposed regulatory bird egg tissue concentration are scientifically sound for the following reasons: 1) background concentrations of <5 μg Se/g dw in bird eggs; 2) effect levels in black-necked stilt eggs range from 6-7 μg Se/g dw to 14 μg Se/g dw; 3) a range of 3-8 μg Se/g dw provides reasonable no effects concentrations; 4) EC_{10} values overlap with no effects concentrations in many datasets; and 5) expert opinion judges 8 μg Se/g dw egg concentrations as protective of bird species in Newport Bay watershed, including federally listed least tern and Ridgway's rail. Points 1 and 2 illustrate the knife-edge between Se essentiality and toxicity and identify that boundary to the best of our knowledge.

Conclusion 4. (Staff Report: Section 4 and Table 4.3)

The assumption that it is sound conservation strategy to base the attainment of the bird egg target as the ultimate protective target for each watershed's TMDL is based on scientific findings and precautionary principles. As noted, in some instances managers must apply a more stringent fish tissue target if the bird egg tissue level of 8 μg Se/g dw is not met. Moreover as stated in the proposed Draft Basin Plan Amendment (2017), the more stringent TMDL will also better protect fish.

Conclusion 5. (Staff Report: Sections 4, 4.3, 4.4)

The initial sentence in Conclusion 5 is based on scientifically sound assumptions. Although water column concentrations of Se differ for lotic and lentic waterbodies and cannot be tied to selenium effects, until tissue-based criteria are adapted, the 5 μg Se/L water concentration is a reasonably protective numeric target.

I suggest that the timeline in the Draft Basin Plan Amendment (2017: Table 6.1, Se. 2) be placed at the beginning of the Draft Basin Plan (2017) Some of the narrative is unclear and seemingly contradicts itself mainly because a timeline for implementation for the shift from the CTR chronic criterion to the Se TMDLs is buried in narratives. For example, the text states that, "Until tissue-based objectives are approved, the CTR chronic criterion [of 5 μg Se/L] for selenium in freshwater must serve as the final numeric target for Se…for the Newport Bay watershed." In the second paragraph, the narrative states that "…at this time these selenium TMDLs do not incorporate USEPA's recommended water column elements as a TMDL numeric target. Instead the TMDLs use site-specific data and modeling to translate tissue targets into appropriate surrogate water column concentrations…"

Conclusion 6. (Staff Report: Section 6, 6.1, 6.2; Appendices N and O)

The assumption of linkages from sediments into the food webs captured by the biodynamic selenium model is scientifically sound with a very high probability that accurate Se water concentrations can be estimated from tissue concentrations and vice versa because: 1) It was based on all available data for the three subwatersheds under consideration. (i.e., data on water, sediment, algae, suspended particulates, fish, and bird egg tissue); 2) Thus, we can assume that site-specific, local variance is included in species-specific trophic transfer factors; and 3) The duration of sampling from 1999-2007 followed by targeted sampling from 2008 to 2014 is adequately long to have accurately captured the lag time between Se concentrations in water and tissue concentrations in fishes and birds via food webs.

Conclusion 7. (Staff Report: Sections 6, 6.2, 6.2.4; Appendix O)

I support the assumption that biodynamic model development is scientifically sound. During model development, managers represented site-specific conditions based on a variety of findings: 1) Using a range of water-shed specific partitioning coefficients and trophic transfer factors; 2). Basing the model on either direct measures or metadata collected for Newport Bay and the San Diego Creek watershed from 1999-2007 with targeted data from 2008 to 2014 collected within the three subwatersheds; and 3) altering model parameters after verifying that predicted values were comparable to observed tissue concentrations.

Conclusion 8 (Staff Report: Sections 6, 6.2, 6.2.5; Appendix O).

I agree with the assumptions, findings, and conclusions in this section. Clearly, the ecology of the animals was understood and considered in model development—a factor that is often ignored. For example in applying the biodynamics model, the validity exercise indicated that fish tissue was a more reliable indicator of environmental exposure than bird tissue because of bird mobility and different feeding preferences among birds. Also, modelers recognized that because of sediment-detrital feeding by mosquito fish the model design for Big Canyon Wash should directly link fish tissue concentration using the Kd rather than the invertebrate trophic transfer factor. The discussion on water column concentrations demonstrates situations in which water concentrations are not predictive. For example, in the UCI wetlands Se levels in fish are below the tissue target. Whereas, in the Santa Ana-Delhi Channel, fish tissue Se over predicted the water column Se. Regardless of nuances in fit, or the desire to use the model to predict water column concentrations from tissue concentrations, Se levels in water must be made consistent with the conservative target of 5 µg Se/g dw in fish tissue, if the bird tissue target is not met.

One concern is that language specifying the timing of monitoring is not explicit in Section 8.5.3, Assessment Area Monitoring. Basing regulation on Se tissue levels in eggs is biologically irrelevant (i.e., ineffective) if monitoring does not take place during the breeding season. Some sections state that monitoring must take place during the dry season (1 April to 30 September), other sections do not. I recommend that wording throughout for the Resolution R8-2017-0014. For example, in Section 8.5.3.1 consider changing “should” to “must” for the TMDL Evaluation Monitoring *“Bird egg collection **should** be conducted during the nesting season (generally March through August). Fish collection **should** be at the same time of year to capture the potential effects of fish as bird dietary items and for effects to spring fish reproduction (common timing for most of the target species)”*.

Conclusion 9. (Staff Report: Section 7).

While the guidelines for the Tiers of sampling and frequency of sample collection are included in the Appendix A of Appendix R, (See Text above and Table 2. *Summary of Monitoring Constituents*), those details are needed in the body of the Draft Staff Report. I am sensitive to the desire of the Regional Monitoring Program to be flexible, particularly in areas such as the Santa Ana-Delhi where no birds are found nesting. The text needs a table describing sampling even though it includes guidelines stating that the WLAs are tied to sampling requirements for NPDES permits, and that permits differ among locations (USEPA 2010), and that quality assurance / quality control must meet the California’s Surface Water Ambient Monitoring Program (SWAMP). To avoid confusion among regulators searching for the information, I recommend including a table of QA/QC requirements and the specific benchmarks that determine whether sampling is sufficient to evaluate targets. Obviously, collection of bird eggs can only occur during the dry weather period and may be impossible if only endangered species occur, but fish can be sampled year round. The specific passages that concern me begin on page 8-25, at Section 8.5.3.1 (Draft Staff Report 2017):

> The frequency of sample collection must be sufficient to evaluate the WLAs and LAs (including the seasonal evaluation) and must be specified in the Regional Monitoring Program.
>
> The frequency of sample collection must be sufficient to evaluate the tissue-based numeric targets, provided sufficient samples can be collected during target sample collection times, and must be specified in the Regional Monitoring Program. At a minimum, an attempt to collect samples must be conducted annually in each assessment area.

Current wording indicates that compliance could be based on only one sample per year to be increased to two if targets are not met.

As suggested, **quarterly** sample collection of fish tissue should be separated into the fall and winter months (1 October to 31 March) versus the dry weather period (1 April to 30 September) because the influence of groundwater during the dry period increases Se concentrations in water. The dry period also coincides with breeding and development of offspring.

Conclusion 10.

The assumption that monitoring is adequate is met for all compartments **except** tissue analyses. Guidelines for TMDL Evaluation Monitoring and BMP Effectiveness Monitoring are described (e.g. must comply with NPDES permits). As stated above, I recommend including a table describing the timing and criteria for determining whether sampling is adequate. I strongly disagree that collecting a single annual sample is an acceptable minimum for determining that TMDL criteria are met.

Conclusion 11.

If and only if future monitoring of whole-fish tissue is performed quarterly and whenever possible, bird egg tissue annually with a minimum of three fish species, then I agree with Conclusion 11, which is based on the assumption that target TMDLs within each watershed will be selenium SSOs that differ depending on whether numeric targets for the recommended fish tissue and bird egg tissue concentrations (section 4.0 in the Draft Staff Report (2017).

The numeric values for fish and bird egg tissue “are currently under development” and the TMDLs discussed herein “have been purposefully structured as Phased TMDLs to account for the regulatory flux of selenium standards at the federal, state, and local levels throughout the drafting, establishment, and implementation of these TMDLs” (Section 4.1 in Draft Staff Report (2017). In other words, depending on tissue Se concentrations during monitoring, adaptive management practices will include TMDL Reconsideration of the Kds, and TTFs in each watershed, which could alter compliance targets for water TMDLs.

I strongly recommend that the thresholds for assessment criteria (e.g. lack of reduction in Se input to the watershed) and acceptable timing for compliance in the essential data that is the basis for the Se TMDL and for the SSOs (e.g. future tissue concentrations) be stated explicitly, preferably in a table format so it is easy to find.

The fundamental idea that SSOs be established according to site-specific Kds and TTFs is based on sound scientific reasoning (Stewart et al. 2010, Draft Staff Report Appendix O 2016). My concerns are that these documents do not always explicitly state how acceptance criteria are ranked among the quantitative numeric targets. For example, the USEPA 2014 Draft Criterion stated in footnote 2 that fish tissue, “overrides any water column element when both fish tissue and water concentrations are measured” (Table 4.1 in the Draft Staff Report (2017). The same protocol is inferred on page 4-6, Section 4.1.1 in the Draft Staff Report, however, as discussed above the document states that the TMDLs are in a “regulatory flux” during the Phased establishment of this TMDL. Clear criteria for changing the target TMDLs are needed.

If future bird egg concentrations exceed the proposed target of 8 μg/L, it is clear that tissue targets for fish will be set at 5 μg/L. What is not clear is the timeline by which fish tissue must meet this target, or what actions occur if the compliance timeline is not met. Finally, if the biodynamic model is used to recalculate target water concentrations, the timeline for establishing and enforcing new SSOs is unclear.

The future monitoring protocol for tissues must be improved for the SSOs. Based on what I have been able to glean, both fish and bird egg tissues will be collected only once per year. First, the assumption that annual monitoring of Se tissue concentrations in fish and bird eggs is adequate is not biologically sound or scientifically-defensible policy. Moreover, unlike the USEPA 2014 Draft Criterion (Table 4.1 in the

Draft Staff Report (2017), which states that fish whole body concentrations can never be exceeded, the proposed TMDL is based on the geometric mean of samples. The geometric mean of fish is not adequately protective, particularly if tissues are monitored only yearly using the tiny sample sizes discussed below.

In Section 4.5.2 on page 25 of Appendix A within Appendix R, contains a description of sample sizes for fish and bird egg tissues.

> *"4.5.2. Numbers of Tissue Samples. The targeted numbers of samples for fish tissue analysis should be up to three samples of composited, whole-body fish, consisting of five similar-sized, same-species fish per sample for up to three fish species (up to nine composited fish samples per site). In addition, fish eggs and ovaries from gravid females may be analyzed if USEPA adopts selenium water quality criteria that are based on selenium concentrations in fish eggs and ovaries.*
> *For bird eggs, up to eight bird eggs per site for up to three species should be analyzed. Only one egg can be taken from each nest. In the case where only one egg is in the nest, no sample will be taken.*
> *In general, for both bird eggs and fish, the total number of tissue samples per year is expected to be less than the theoretical maximum number of samples because many of the sites are limited in biota abundance, diversity, and/or accessibility."*

Thus, the SSOs for the three sub-watersheds could be based on as few as one annual sampling of one analytical sample ("up to 3 samples of composited, whole-body fish") possibly from only one fish species ("up to three fish species") could be collected annually. Similarly for bird eggs, as few as one egg from one bird species ("up to eight bird eggs per site for up to three species"). Five sample sites are proposed for Tier II, III, and IV sampling (Tier IV is tissue and algal sampling) but subject to change as needed.

Looking at Appendix T, I see that out of many millions of dollars spent, the annual analyses for fish and bird egg tissue—the linchpin upon which the TMDL rests for the SSOs—is ~$30,000 annually excluding labor. For decisions to be scientifically defensible, increase this component of the budget to cover costs of monitoring fish tissue quarterly and bird egg tissue annually.

Basing draft criteria on the USEPA's criteria is an excellent approach (see p 4-5 in (Draft Staff Report 2017). The biodynamic model protects non-piscivorous birds because invertebrates contain less Se than fish in the same system (i.e. one lower TTF) (Draft Basin Plan Amendment - New Chapter 6 2017). Similarly, any additional tissue accumulation of piscivorous fish is implicitly considered by the fish tissue numeric target of 8 µg Se/g dw.

More description for establishing SSOs is needed where invertebrates only are sampled. Invertebrates may not be valid surrogates because "contaminated sites have found effects on fish and birds in the absence of changes in invertebrate assemblages" inferring greater tolerance for Se (Draft Staff Report Appendix C 2016).

Department of Zoology
Mail Code 6501 · Southern Illinois University
Carbondale, IL 62901 USA

I applaud the inclusion of the Draft Basin Plan Amendment as a new Chapter 6, primarily because of its excellent description of the biodynamic model with a listing of K_ds and Trophic Transfer Functions (TTFs) for the proposed TMDL (Draft Basin Plan Amendment - New Chapter 6 2017). The timing for TMDL implementation and compliance is clear and reasonable (Table 6.1. Se.2). However, what are the protocols for enforcing compliance if TMDLs exceed the SSOs (see p. 25 in the Draft Basin Plan Amendment)?

Conclusion 12

The assumption that relying on the biodynamic model for establishing Se TMDL is scientifically sound for the site specific constraints of the Newport Bay watershed because: 1) water Se concentrations do not correlate will with ambient tissue concentrations in fish and bird eggs, 2) fish tissue in San Diego Creek over predicted bird egg tissue, 3) In Santa Ana-Delhi, fish tissue over-predicted water column Se concentrations, and 4) In Big Canyon Wash, bird egg tissues all exceeded 5 µg/g dw. Thus, its WLA and LA levels were established at 1 µg/L.

The big picture

Here are a few final considerations.

1. One additional benefit of quarterly monitoring of whole fish tissue is capturing differences in Se bioavailability due to interannual variability in climate.
2. What is the status of monitoring sites? The narrative indicates that monitoring sites were chosen because they constitute suitable habitat for aquatic organisms and for aquatic-dependent birds, and yet, no birds were nesting in the Santa Ana-Delhi watershed. This brings up two issues.
   a. The area is highly urbanized and thus, may never provide suitable habitat. In the short term, for the purposes of this TMDL for Se, it makes sense that when bird egg tissue is not available, tissues from surrogate parameters (e.g., macroinvertebrates, reptiles, amphibians) are used. Wise use of data might be to evaluate the extent to which surrogate tissue data might correlate with fish tissue Se in the Santa Ana-Delhi Channel as well as with Se in fish and bird egg tissue collected at the other two watersheds annually and at the end of the 8-year period.
   b. The second issue is whether sampling locations are state or federally protected. If not, then future urban sprawl might engulf all three watersheds, making it impossible to collect even surrogate tissues for assessment.

Please contact me if you have any additional questions.

Sincerely

Marjorie L Brooks

References

Attachment 2. 2017. Draft Basin Plan Amendment - Total Maximum Daily Loads for Selenium In Freshwater, Newport Bay Watershed, Descriptions of Scientific Assumptions, Findings and Conclusions to be Addressed by Peer Reviewers. Pages A2-1 to A2-17.

Draft Basin Plan Amendment - New Chapter 6. 2017. Attachment A to Resolution No R8-2017-0014, Chapter 6. Total Maximum Daily Loads (TMDLs). Pages 1-47. State Water Resources Control Board.

Draft Staff Report. 2017. Total maximum daily loads for selenium in freshwater: Newport Bay Watershed, Orange County, California, Draft Staff Report, January 2017. Pages 1-266 *in* T. Reeder, J. Schneider, K. Cowan, B. Alvarado, and K. Ashby, editors. Santa Ana Regional Water Quality Control Board.

Draft Staff Report Appendix C. 2016. Appendix C - USEPA 2014 External Peer Review Draft Aquatic Life Ambient Water Quality Criterion for Selenium - Freshwater. Page 1730 *in* T. Reeder, J. Schneider, K. Cowan, B. Alvarado, and K. Ashby, editors. Draft Staff Report (2017) with Table of Contents for appendices located on p. V. Santa Ana Regional Water Quality Control Board.

Draft Staff Report Appendix I. 2016. Appendix I - DRAFT Site-Specific Objectives for Selenium – Technical Report. Page 1730 *in* T. Reeder, J. Schneider, K. Cowan, B. Alvarado, and K. Ashby, editors. Draft Staff Report (2017) with Table of Contents for appendices located on p. V. Santa Ana Regional Water Quality Control Board.

Draft Staff Report Appendix O. 2016. Appendix O - Revised Newport Bay Biodynamic Model Runs Documentation (Prepared by Dr. Sam Luoma, UC Davis; November 2015). Page 1730 *in* T. Reeder, J. Schneider, K. Cowan, B. Alvarado, and K. Ashby, editors. Draft Staff Report (2017) with Table of Contents for appendices located on p. V. Santa Ana Regional Water Quality Control Board.

Draft Staff Report Appendix R. 2016. Appendix R - BMP Strategic Plan for the Santa Ana-Delhi and San Diego Creek Sub-Watersheds (Prepared by RBF Consulting; December 2013). Page 1730 *in* T. Reeder, J. Schneider, K. Cowan, B. Alvarado, and K. Ashby, editors. Draft Staff Report (2017) with Table of Contents for appendices located on p. V. Santa Ana Regional Water Quality Control Board.

Draft Staff Report Appendix T. 2016. Appendix T - Economic Analysis (Prepared by GEI Consultants, Inc. and RBF Consulting; January 2015). Page 1730 *in* T. Reeder, J. Schneider, K. Cowan, B. Alvarado, and K. Ashby, editors. Draft Staff Report (2017) with Table of Contents for appendices located on p. V. Santa Ana Regional Water Quality Control Board.

Luoma, S. N., and T. S. Presser. 2009. Emerging opportunities in management of selenium contamination. Environmental Science & Technology **43**:8483-8487.

Luoma, S. N., and P. S. Rainbow. 2005. Why is metal bioaccumulation so variable? Biodynamics as a unifying concept. Environmental Science & Technology **39**:1921-1931.

Stewart, R., M. Grosell, D. Buchwalter, N. Fisher, S. Luoma, T. Mathews, P. Orr, and W.-X. Wang. 2010. Chapter 5. Bioaccumulation and Trophic Transfer of Selenium. Pages 91-137 *in* P. M. Chapman, W. J. Adams, M. L. Brooks, C. G. Delos, S. N. Luoma, W. A. Maher, H. M. Ohlendorf, T. S. Presser, and D. P. Shaw, editors. Ecological Assessment of Selenium in the Aquatic Environment. SETAC Press, Pensacola, FL, USA.

USEPA. 2010. National Pollutant Discharge Elimination System (NPDES) Permit Writers' Manual. Pages 1-269. United States Environmental Protection Agency, Office of Water, Washington, DC.

REVIEW OF DRAFT PLAN FOR DEVELOPING SELENIUM TMDLs FOR THE NEWPORT BAY WATERSHED

submitted by Dirk Wallschläger, Ph.D.
April 26th 2017

I was asked to provide a review of the scientific assumptions, findings and conclusions, specifically the four points listed below, in the proposed rule relating to the development of Total Maximum Daily Loads (TMDLs) for selenium (Se) in the Newport Bay watershed. Before I do, I would like to point out that this is a very complex problem, and that, as always in such situations, one concludes that more could/should have been done, provided that more time and resources had been available. Notwithstanding my following points of criticism, I think that the SWRCB staff and their collaborators have done a respectable job of producing a scientifically-defensible report, which provides valuable guidance for managing Se in this watershed. While there are many things that were done well/right in my opinion, I will largely ignore those in the interest of time/space, and focus mostly on things that could be improved, given the availability of time and resources.

Point # 7: Linkage Analysis – Representativeness of modelling simulations, input parameters and assumptions for the three subwatersheds modelled

In response to this point, I will limit myself to discussing the treatment of the water-phytoplankton bioaccumulation step in the modelling process, since the subsequent trophic transfer steps are relatively inconsequential (by comparison) for the overall result, and are treated appropriately in accordance with the papers by Luoma and Presser, as far as I can tell.

Based on the provided information, the Se bioaccumulation model developed by Presser & Luoma (Appendix N) uses only total Se concentrations for calculating K_d values. The authors point out in the introduction that Se speciation in the water plays a crucial role in determining the magnitude of K_d, yet aqueous Se speciation is not explicitly incorporated into the bioaccumulation model. This approach has been used in subsequent work by Dr. Luoma, and is probably superior in predicting Se tissue concentrations. Provided that reliable Se speciation data are used (see my comments below), and provided that time and financial resources do not prevent any further refinement of the modelling exercise in this project, I would recommend expanding the model to include aqueous Se speciation information, and repeating the linkage analysis.

I understand that aqueous Se speciation was indirectly taken into consideration by assuming certain K_d values that may be reflective of different Se speciation scenarios in the studied waters. However, I have some concerns about the quality of some of the Se speciation data reported in Appendix F, and consequently their usefulness for estimating K_d values. Generally speaking, Se speciation results should only be used if they were generated by HPLC-ICP-MS methods. The HG-based operational Se speciation approaches (based on Cutter's work) are prone to interferences that may lead to biased results for Se(VI) and "organic" Se, so those results (Meixner et al., 2004; Hibbs et al., 2008) should not be used in the modelling process.

Furthermore, it is unclear from the provided description if the OCPW data were all generated by Weck (which is only explicitly mentioned in the legend of Table F.5), and whether Weck used HPLC or not, since US EPA method 200.8 is only for total/dissolved trace elements, so I also ignored those data for my considerations.

Also, the developed Se bioaccumulation model was only (out of the three water bodies discussed here) explicitly applied to San Diego Creek (SDC) in appendix K. I have assumed (since I didn't find any explicit evidence in the report) that it was correspondingly applied to model Se bioaccumulation in the Santa Ana-Delhi Channel (SADC) and in Big Canyon Wash (BCW).

For the SADC, only 3 Se speciation data points exist. After eliminating the Meixner et al. (2004) data point for the reasons discussed above, only 2 data points remain. Obviously, no sensible assessment of a "representative" Se speciation pattern can be made from this, and I strongly recommend generating more Se speciation data points in the future, using the appropriate HPLC-ICP-MS methods, to allow a refinement of the K_d values used for this system.

However, this very limited data set allows me to illustrate the problems potentially associated with incorporating Se speciation data into the Se bioaccumulation considerations. Using the average K_d values presented by Presser & Luoma (Appendix N, p. 1389: 317 for Se(VI), 1,760 for Se(IV) and 24,249 for SeMet), if one takes the average of the 2 results presented for organic Se in Table F.11. (p. 1043), a low fraction of organic Se of 0.36% is obtained, which results in a K_d of **421**, compared to K_d = 361 when ignoring organic Se altogether. For clarification, this value represents <u>discrete</u> organic Se species determined by HPLC-ICP-MS, and while it is not reported which particular organic Se species were found in these samples, even in the worst case (= all selenomethionine with K_d = 24,249), the K_d values assumed in the SDC modelling exercise (200 or 400) appear appropriate for SADC. On the other hand, if one assumes that all of the Se in a water sample that is neither Se(IV) nor Se(VI) is organic Se (of unknown chemical identity), then one obtains an organic Se fraction of 7.48% for SADC, and a K_d value of **2,148**, which would then not fit with the values assumed for SDC. In this scenario, most of the "organic" Se would be assumed to have <u>no discrete molecular structure</u> (e.g., it could be associated with NOM), and therefore have no known K_d value, but may have a significant impact on Se bioaccumulation in the system. The point of all this is that it cannot be ascertained from the limited existing data if the K_d values for SDC are appropriate for describing Se bioaccumulation in SADC, and thus more data are needed to evaluate this question.

For the BCW system, there are sufficient Se speciation data for surface waters presented in Table F.13, and they are were all generated with appropriate analytical methods, therefore allowing a calculation of speciation-based K_d values, as outlined in the previous paragraph. When ignoring the presence of organic Se species, the resulting K_d is **649**. This value is higher than the estimates for SDC, and could be adjusted to produce a more realistic estimate of K_d for BCW, similar to what was suggested for the UCI wetlands (K_d = 800) in the Presser & Luoma report (Appendix N).

There are some issues with the presentation of the data for organic Se in the BCW system, since there are several data points where a significant fraction (in the low % range) of organic Se is reported when all discrete organic Se species are below the detection limit. Therefore, I could only perform a worst case analysis where I assumed that any Se that is neither Se(IV) nor Se(VI) was organic Se (with the K_d for SeMet). This yields an average organic Se fraction of 11.2%, and a K_d of **3,297**. This organic Se fraction may be a little high, but for those samples where discrete organic Se species were measured, the organic Se fraction ranged from 0.9 to 10.4%, indicating that there can indeed be a significant organic Se fraction in these samples. Also, when discrete organic Se species were reported, usually methylseleninic acid, MeSe(IV), was the predominant species, and while it's K_d is unknown, it is likely to be lower than that of SeMet, which would reduce the total K_d somewhat. Still, it appears that K_d for BCW is probably higher than the values used to model Se bioaccumulation in SDC, and this should be reflected in some additional model simulations, because it may impact the water quality targets significantly.

Finally, the analysis of the Se speciation data for SDC is complicated. For my analysis, I used the data in Table F.6 and disqualified the Meixner et al. (2004), Hibbs et al. (2008), and OCPW 2012 data for the reasons outlined above. The remaining data yield K_d = **430**, when the presence of organic Se is ignored, which is in line with the 75th percentile suggested by Presser & Luoma (Appendix N). Again, since no discrete organic Se species concentrations were shown, I decided to ignore the organic Se fractions listed in Table F.6, and calculated the worst case scenarios described above, which yield 22.1% organic Se and K_d = **5,907**. I believe that this estimate of the organic Se fraction is high, although several samples show very high organic Se fractions. It is noteworthy that all of those samples are from the IRWD wetlands inlet, and were analyzed by IRWD, while the samples from the other locations within the SDC system were analyzed by ASC and showed low organic Se fractions. I would recommend a detailed re-analysis of those data sets to determine if there is really such a high organic Se fraction in the IRWD samples, because that has a significant impact on the interpretation of the Se speciation data with respect to their influence on K_d.

In summary, I suggest that the K_d values used in the modelling project may be lower than one would expect based on the apparent Se speciation, and that a careful re-examination of some of the Se speciation data might shed some light on this discrepancy. Subsequently, I would also recommend a couple of additional model simulations with higher K_d values to assess the impact of substantial organic Se fractions in SDC and BCW on the water quality targets, if those organic Se fractions prove to be real. Additionally, some more Se speciation analyses in the SADC system are required before one can even contemplate if the K_d values used by Presser & Luoma are appropriate there.

Finally, I want to point out that sulfate concentrations in waters influence (inversely) K_d for Se(VI), yet there is no mention of sulfate concentrations in any part of the report (as far as I can tell). I'm assuming that sulfate is high in these waters, and therefore, K_d for Se(VI) may be at the low end of the range suggested by Presser & Luoma (maybe in the 150 range?), and would therefore have the opposite effect on the water quality targets than the uncertainty of the organic Se fraction discussed above. I wonder if a simple correlation analysis of K_d values for Se(VI) reported in previous literature as a function of sulfate concentration could yield more site-specific K_d values for the studied water bodies.

Point # 8: Linkage Analysis – Appropriateness of modelled water column concentrations and model validation procedure

The wording of this point is misleading. It is pointless to ask if the range in water column Se concentrations derived from the different modelling scenarios is "appropriate", because depending on how the model is run, and what assumptions are made in each model run, you can obtain pretty much any water column concentration you like. The question of "appropriateness" is more one of risk assessment, and in that sense, the model seems to produce water quality targets for Se that can be assumed to be protective of the wildlife species in question, under the assumption that the parameters put into the model and optimized during the calibration process do hold true for prediction of future developments. However, there will never be a range of concentrations that's "appropriate"; there will just be one upper threshold value that is considered protective under the given set of biogeochemical assumptions. Also, while this is a nitpicky point, it is not the data that are being calibrated, but the model itself.

That said, the general approach presented in Appendices N and O is appropriate. It is first tested how well different values for K_d, determined from the statistical spread of field data for paired water-solid samples, predict the observed tissue and egg Se concentrations, and then the "best fit" K_d value is used to inversely model the water Se concentrations required to meet certain tissue Se targets. There are a couple of problems with respect to the predictive power of some parts of the model (see in the following), but the calibration process adjusts for those to represent the existing data with as much accuracy as one would expect from a simple model for such a complex system. The big question in modelling is, as always, if the model also predicts future (= unknown) data equally well, but there is no other way of finding out than to continue this process for future sampling events.

There seems to be a trend of underestimating Se concentrations in sediment when mean or median Se water concentrations are used, which leads to a choice of 75th or 85th percentile K_d data during the model calibration. The same problem propagates into fish tissue concentrations accordingly. This observation suggests to me that a) K_d is generally underestimated by the approaches used for the initial modelling runs (which is in line with my comments on point 7 above), and that b) sediment may not be the optimal choice for determining and checking K_d values. I would recommend considering adding phytoplankton and suspended matter in future studies, particularly where this hasn't been done yet, to see if that yields better K_d values. This is supported by some data in the discussion of BCW K_d values in section 7 of Appendix O. I also note that while Se concentrations in invertebrates are usually predicted quite well, Se concentrations in bird eggs are typically overestimated significantly. This isn't my area of expertise, but it seems to suggest that the TTFs for invertebrate -> bird egg appear to be problematic.

The example of K_d selection for BCW illustrates a number of problems that should probably be addressed to ensure the future success of this project. It is shown (in Table 7-3, Appendix O, p. 1483) that very different K_d values can be obtained, depending on what type of "solid material" is used as the basis of comparison. First, the solution presented (finding the "best choice" K_d value) is complicated, and highly site-specific. While this highlights the flexibility of the modelling process, and apparently leads to the "best fit" here, it also requires a lot of detail knowledge and experience to make that decision. Unfortunately, one has to assume that Dr. Luoma will not be available to support this effort indefinitely, so it would be good to develop a suite of internal and external experts who could perform such functions in the future, particularly if the Se bioaccumulation scenario changes significantly in one of the studied watersheds.

Second, this example points out the importance of collecting different types of data (here: sediment, SPM and algal samples) to get a sound estimate for this crucial K_d value. It is not inconceivable that future changes to a particular watershed may lead to a shift in receptor species or their diet, which may then in turn affect which type of K_d value is the "best choice". Therefore, I would advocate for continuing to collect these different sample types in the proposed monitoring program, rather than just focusing on one type of solid sample for K_d calculations (even if that may appear warranted at the moment).

And third, the mathematical component of the suggested process for selecting and calculating the "best" K_d value is getting increasingly complex as one tries to refine it more and more (e.g. by adding particle size normalization to any of the presented K_d options), which makes the process more prone to errors. To illustrate that point, I believe (after checking some of the calculations) that there are several errors in Table 7.4; for example, the "sediment + SPM" value in line 7 should be 2,024, if I understood the procedure correctly (and not 1,333, as listed). So, either I didn't understand the procedure properly, or there are indeed mistakes in that table; either way, such errors could be problematic when the numbers are used subsequently. The analysis of the statistical distribution of "best choice" vs. "sediment + SPM" K_d values shows that overall, this doesn't make a significant difference, but if one looks at individual sites, K_d differences can be up to a factor of 3, which makes a huge difference for the final calculations of water quality targets.

Finally, as pointed out under point 7 above (and acknowledged in the SWRCB staff report), the existing data set for SADC is very limited, and I would personally feel hesitant to derive any water quality targets for the water body from it at this time. If it is necessary to do so right now, I would at the very least recommend that many more data are generated for SADC soon after the inception of this TMDL program, and that the modelling exercise for SADC is repeated soon after those data become available to check, and adjust, if necessary, the target water concentrations for this water body.

Point # 9: TMDL and Allocations – Scientific justification of TMDL allocations, LAs and WLAs

Overall, the proposed TMDL approach with adaptive management aspects makes a lot of sense to me. I agree with the different approaches suggested for the three subwatersheds, as they seem to be most reflective of the specific situations (for SDC and BCW) and address the lack of data for SADC appropriately at this time. My only comments arise out of ignorance of critical biological parameters. For one, an averaging period of 6 months for TMDL allocations, LAs and WLAs appears long compared to the time during which egg formation and development (apparently) occurs in the receptor species. On page 7-3 of the staff report, it is acknowledged that these processes occur on the order of weeks, and even if not all fish and bird species may develop eggs at the same time, it still seems to me that shorter averaging periods (2 or 3 months) might be more appropriate for assessing the Se exposure of embryos. This is in line with discussions I've overheard for other Se impacted watersheds. I'm hoping that the temporal resolution of RMP activities is high enough that this averaging process would only be an after-the-fact mathematical exercise, aimed at developing the best predictors for receptor tissue Se concentrations, rather than result in additional monitoring activities.

Finally, I'm not sure I follow the logic of the repeated statement that "all of the results [*derived from the biodynamic model*] are deemed equally valid for predictive purposes". As far as I understand, once one has selected the appropriate endpoint for a specific subwatershed (e.g. fish tissue or bird egg), then the Se bioaccumulation model will predict the appropriate water concentration that is considered protective, based on all of the assumptions that have gone into the modeling process (including safety margins, I assume). Habitat heterogeneity along a subwatershed does not seem like a confounding factor to me in this consideration, since I assume that the critical biological species are able to migrate within a subwatershed on the spatial scale investigated here. Therefore, it appears (to me) to be most protective to pick the lowest water concentration derived for any part of the subwatershed, and apply it to the whole subwatershed, as if the receptor biological species spent the entire critical period (of egg development) in that part of the watershed.

Point # 10: Monitoring – Appropriateness of the proposed RMP

Overall, the proposed monitoring program is sensible, and will probably provide much of the desired information needed in future project supervision and decision making. Generally, I question the generation and use of total Se data on top of dissolved Se data. While I understand that regulations are always based on total element concentrations, we know that there is typically not a significant particulate Se fraction in freshwaters. To support this argument, it was shown previously for this study area (Appendix O, Table 1-1, p. 1436) that there is no significant difference between total and dissolved Se concentrations. Additionally, the analytical methods typically used for total Se determination do generally not feature a complete digestion of particulate matter, and are thus a) arbitrary (i.e. strongly dependent on the methods used by specific laboratories) and b) meaningless (because they only capture an unspecified fraction of the particulate Se). The cost of the water component of the monitoring program could thus be cut in half without losing any significant information.

Although Se speciation analyses are mentioned under "other considerations", I would suggest that their scientific value is not emphasized enough in the RMP design. As discussed above (for points 7 and 8), reliable Se speciation information is scarce for the studied watersheds, especially SADC. Due to its key role in determining K_d, and the apparent underestimation of bioaccumulation by median K_d values, I think the bioaccumulation model would benefit from the addition of more Se speciation information, possibly even directly into the algorithm. We know that most Se treatment processes change the relative speciation of Se significantly, so Se speciation monitoring would make a lot of sense as part of the BMP Effectiveness monitoring program, because you're ultimately not interested in reducing Se loads, but Se bioaccumulation potential, and there are demonstrated cases where a reduction in total Se accompanied by a change in Se speciation did not necessarily result in reduced Se bioaccumulation. I would personally advocate adding Se speciation monitoring to the other components of the RMP as well, because the presented results indicate that Se speciation can change across a watershed, due to biogeochemical transformation processes, but I understand that this leads to a significant cost increase. At the very least, I would suggest adding Se speciation analyses to monitoring activities in the short- to medium-term in areas where information is lacking (especially SADC) and when and where biological populations are most at risk (i.e. before/during the breeding season) to see how that refines the understanding of the bioaccumulation process. Within one watershed, Se speciation might also be an interesting and relevant aspect of a trading program, if one source emits a different species of Se than another one, so that the impact of a 1-for-1 trade (in term of total Se concentrations or loads) would not be net neutral in terms of Se bioaccumulation potential.

Related, it would also be a good idea to add a biological community monitoring component to the RMP. My concern would be that in a few years, as a result of change in a subwatershed, for example due to climate change or reduction in Se emissions, the structure of certain aquatic food chains might change to the point where the current Se bioaccumulation model is no longer appropriate. I'm not a biologist, so I'm not sure of the appropriate frequency and extent of such monitoring programs, but I suspect that it may be adequate to conduct such an effort every couple of years, or when the Se tissue concentrations in key receptors do not respond as predicted.

In addition to the proposed monitoring activities, I would strongly recommend to accompany the generation of more data with continued modelling efforts, in order to test and refine, if necessary, the Se bioaccumulation model and its underlying assumptions. The model is a key component in the derivation of the water quality targets for the watersheds, and (as discussed above for points 7 and 8) there are many aspects of it (such as the selection of appropriate K_d values) that are based on limited data sets and have been numerically optimized rather than being based on a sound fundamental understanding of the underlying biogeochemical processes. Therefore, it is advisable to test continuously if the water quality developments in the watersheds, e.g. after BMP implementation, fall in line with the model predictions that their target values are based on.

Peer review of selected sections of the report ***Draft Basin Plan Amendment – Total Maximum Daily Loads for Selenium in Freshwater in the Newport Bay Watershed***

Peer review by Judson Harvey, USGS, May 10, 2017

Background: The reviewers were asked to comment on whether the scientific portion of the proposed rule was based upon sound scientific knowledge, methods, and practices through examination of the Staff Report and associated materials. Peer reviewer comments about selenium TMDLs given in this document **only apply** to three freshwater tributary subwatersheds in the Newport Bay watershed (San Diego Creek, Santa Ana-Delhi Channel, and Big Canyon Wash subwatersheds), and do not apply to any other watershed or to saltwater bodies that are further downstream in in the Newport Bay watershed.

Scope of this review: This peer review examines certain aspects of the "linkage analysis" relating to the translation between fish tissue or bird egg concentrations of Selenium to water column concentrations, and aspects of the TMDL and Allocations analysis, aspects of the TMDL and Allocations, and aspects of the TMDL evaluation monitoring, BMP effectiveness monitoring, special studies, etc., and aspects of the site-specific objectives. The reviewer specifically examined aspects of TMDL numeric targets 7-8, 9-10, and 12 in Attachment 2 as summarized by Attachment 1 of the "***Proposed Basin Plan Amendment – Total Maximum Daily Loads for Selenium in Freshwater in the Newport Bay Watershed".*** The peer reviewer further examined the ***"Staff Report" entitled Total Maximum Daily Loads for Selenium in Freshwater: Newport Bay Watershed, Orange County, California*** and its supporting appendices. The Staff Report provides the scientific, technical, and regulatory basis for the development and adoption of an amendment to the Water Quality Control Plan for the Santa Ana River Basin, termed a Basin Plan amendment (BPA), to incorporate these selenium TMDLs for the Newport Bay watershed.

Review comments:

Linkage Analysis, targets 7-8

1) The Staff Report documents that the currently available criteria has been underprotective in the freshwater parts of the Newport Bay watershed, and argues effectively for the use of dominant tissue-based Se concentrations to drive the analysis, using a thoroughly peer-reviewed biodynamic model, with a provision that the fish tissue criterion should be thresholded at two levels based on whether the bird egg concentration criterion has been met, and using as a fall back criterion the water column-based criteria that matches the currently applicable CTR criterion in freshwater.

2) The data set collected between 1999 and 2007 and its targeted updates collected between 2008 and 2014 are well suited for the purpose, representing fish and bird egg tissue concentrations as well as sediment, algae, suspended particulates from the three sub-watersheds.

3) In summary, the biodynamic model results in a range of water column concentrations that can be protective of fish and wading bird consumers. This site specific application in the Newport Bay watershed has a good working data set to support the present

modeling. The data set will be updated and model rerun-as new monitoring data become available.

TMDL and Allocations, target 9

4) The primary source of selenium is mobilization in groundwater of selenium derived from the Monterey formation and transport through the subsurface to the streams. Groundwater levels have been rising over time, and streams flow perennially now unlike in the past as a result of numerous hydrologic changes that have occurred in the basins, including water management practices involving residential and commercial spaces, and water management on municipal open spaces including reservoirs. There are currently widely varying concentrations of selenium measured in groundwater wells and surface water seeps with concentrations throughout the entire watershed varying over a factor of 40. Further isolation of source pathways and evaluation of treatment options would require considerable investment, and may not be practical given uncertain treatment options for selenium, limited space for treatment facilities in the highly urbanized watershed, and given that water quality regulations for selenium are under revision at the federal, state, and local level. Nonetheless it would be of interest to better understand groundwater selenium sources, in particular whether loading is primarily from shallow or flow deep flow paths, residence times, and oxidation/reduction characteristics of water flowing along those pathways.

5) Seasonality was accounted for in the development of the TMDL and Allocations that considers the negative correlation between flow and selenium concentration. Wet and dry season measurements were made in the main channels and used to calibrate flow on the basis of stage measurements. These were supplemented with groundwater measurements, seep measurements, storm drain measurements, etc. Many focused studies were conducted to specifically isolate selenium sources as they relate to subsurface flow generated by golf course irrigation, reservoir storage, etc. This reviewer found the quantity and scope of the available dataset to be impressive and entirely supportive of the analysis that was undertaken. The load analysis itself concentrated on baseflow time periods, which is reasonable given that baseflow is sustained by groundwater discharge which is the source of selenium, which is independently supported by geologic analysis, concentrations measurements in potentials source waters, and hydrogeochemical source tracking. The Staff report shows conclusively that recharge of local precipitation is too small to account for measured mobilization of selenium that is occurring. The hydrogeochemical source tracking analysis identified that there are different sources of recharge to the shallow perched aquifer, apart from the very small contribution from precipitation, that become the primary pathway for mobilizing selenium. If mitigation is ever to be envisioned there could be more learned about the relative contributions from, for example, local residential and commercial irrigation operations, storm drains, reservoir leakage, etc., by expanding the footprint of the hydrogeochemical analysis.

6) The staff report and associated materials argue effectively for the development of SSOs in the coming years based on monitoring of biologic tissue and water column concentrations (rather than sediment concentrations, which are relevant but enormously variable). The SSOs are to be based on monitoring the biological tissue criteria are to be used to derive site-specific water column-based criteria for the sub watersheds. The

SSOs are intended to eventually replace the currently applicable CTR chronic criterion of 5 ug/L for selenium in freshwater with site specific objectives.

TMDL Evaluation Monitoring, BMP Effectiveness Monitoring, special studies, etc. targets 9-10

7) The frequency of Assessment Point Monitoring does not seem to be specified, except to say that is “must be sufficient to evaluate WLAs and Las”. The difficulty of such monitoring is representing storm peaks, however the present problem involves subsurface mobilization of selenium which often may be well represented by baseflow monitoring, and thus there is less concern for this application. The degree of selenium dilution during storm peaks should be evaluated in any non-point waste load allocation analysis. No doubt such an analysis was conducted for the present problem, although this reviewer was not successful in finding the analysis in the report materials.

8) All monitoring programs describe water column and flow measurements, from which one of the important outcomes is a load analysis. Substantial load analysis has been conducted, concentrating on baseflow time periods, which is reasonable given that baseflow is sustained by groundwater discharge which is the source of selenium (which is independently supported by geologic analysis, concentrations measurements in potentials source waters, and hydrogeochemical source tracking). The Staff report shows conclusively that recharge of local precipitation is too small to account for measured mobilization of selenium that is occurring. The hydrogeochemical source tracking analysis identified that there are different sources of recharge to the shallow perched aquifer, apart from the very small contribution from precipitation, that become the primary pathway for mobilizing selenium. If mitigation is ever to be envisioned there could be more learned about the relative contributions from, for example, local residential and commercial irrigation operations, storm drains, reservoir leakage, etc., by expanding the footprint of the hydrogeochemical analysis.

Site-Specific Objectives for targets 12

9) In the future the TMDL and allocations are expected to be adjusted iteratively in an adaptive management framework based on a monitoring program that will be used to update and re-run the biodynamic model. For the reasons stated in Attachement 2, the Newport Bay Watershed TMDL will not adopt site specific objectives in water for selenium, instead the tissue concentrations known to be of concern will drive the targets, as informed by the biodynamic modeling, using a fallback water concentrations criterion where necessary, and updating targets as appropriate based on the expanded data sets that become available as a result of monitoring programs. This reviewer finds the stated arguments and approaches chosen to be convincing.