

**NATIONAL WATER RESEARCH INSTITUTE**

**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)*

Prepared November 21, 2006  
Fountain Valley, California

## **Introduction**

In 2005, the County of Orange, California, requested that the National Water Research Institute (NWRI) of Fountain Valley, California, organize an independent third-party advisory panel (Panel) to review and provide guidance on the County's Nitrogen and Selenium Management Program (NSMP). The NSMP is a 5-year process to address selenium (Se) and nitrogen in the Newport Bay Watershed, with a focus on surface water contamination resulting from the discharge of contaminated groundwater.

The overall charge to the Panel is to assist the NSMP in determining whether to pursue the development of site-specific objectives (SSO) for Se.

The Panel includes:

- Chair: Brock B. Bernstein, Ph.D., Independent Consultant
- Gerald Combs, Ph.D., Agricultural Research Service, U.S. Department of Agriculture
- Roger L. Hothem, U.S. Geological Survey
- Mohsen Mehran, Ph.D., Rubicon Engineering, Inc.
- Roy A. Schroeder, Ph.D., U.S. Geological Survey
- JoAnn Silverstein, Ph.D., P.E., University of Colorado, Boulder

Short biographies of each Panel member are included in Appendix A.

The Panel met with County representatives, NSMP working group members, and consultants in Anaheim, California, on November 2, 2006. An agenda from that meeting is included in Appendix B.

This interim report presents the Panel's recommendations on the NSMP's provisional decision to pursue an SSO for Se, based on reviews of written material, presentations, and discussions at the November 2006 meeting. The Panel's comments are organized into three sets of recommendations that address the decision to proceed with an SSO, the methods to be used in developing the SSO, and specific technical issues involved in developing and justifying the SSO.

## **Recommendations**

The Panel understands that the NSMP's decision to proceed with developing an SSO for Se is a key decision point for the program as a whole that will have important consequences for virtually every aspect of the program. Consequently, the Panel believes that the process of developing the SSO must be carefully planned and executed. The process should take into account not only a number of key technical issues, but also the regulatory environment and related efforts on Se, both statewide and nationally.

### **1. Proceed with Developing an SSO**

The Panel supports the NSMP's provisional decision to proceed with developing an SSO for Se. The NSMP's reports and presentations documented that, although Se concentrations in certain matrices are at or near threshold levels of concern, it is questionable whether the existing Se standard could be met across the region, in light of

the significant and inherent management, cost, and technical feasibility constraints. Further, given the NSMP findings on Se levels in tissue, it is at least debatable whether compliance with the existing 5 parts per billion (ppb) Se standard on all discharges would be necessary to protect wildlife and aquatic life in the watershed. These two factors, in combination, are significant enough to justify development of a Se SSO.

In addition, the Se monitoring data, combined with the foodweb data, suggest that this watershed may be one in which the conversion of inorganic Se to organic (and, thus, bioavailable) Se proceeds at a relatively low rate. If so, this would be similar to the situation in the Kesterson Reservoir, and in certain streams in Canada, where very high levels of total Se in water were associated with lower than expected levels of bioaccumulation in target species. These systems are similar in that the dominant species of Se present is selenate. Therefore, as discussed in the Panel's previous report, there appears to be aspects of Se speciation and metabolism in the Newport Bay watershed that make it relatively less bioavailable and, thus, an appropriate candidate for an SSO.

As the NSMP proceeds with developing the SSO, it should ensure that the following three conditions are met:

- a) Any SSO must meet all applicable regulatory requirements, particularly those related to preventing any degradation or deterioration of existing water quality and related beneficial uses. This will require careful attention to the spatial and temporal distribution of Se in the watershed – in water, sediments, and tissues. Meeting these applicable regulatory requirements may necessitate modeling separate Se transformation, transport, and bioaccumulation processes and/or compartments in the watershed, to determine the nature, location, and operation of best management practices (BMPs) needed to meet the SSO.
- b) The NSMP should work closely with the current interagency effort, the State Technical Review Committee (STRC), to develop Se standards for the State of California. Until now, the NSMP has had an informal working relationship with the STRC. The Panel recommends that, once the decision to proceed with an SSO is finalized, the NSMP should formalize this relationship. This will ensure that technical information is efficiently exchanged and adequately discussed, that related analytical and modeling efforts can be coordinated as needed, and that the regulatory implications of monitoring data and modeling results are fully examined. The Panel recommends that the NSMP establish a small workgroup to engage with the STRC, consisting of the NSMP program manager, a representative of the Santa Ana Regional Water Quality Control Board, and one or two higher-level technical staff from the consulting team. This group should be small enough to work effectively with the STRC, yet also have sufficient expertise to cover all the relevant issues adequately.
- c) The Panel recommends that the NSMP periodically revisit the findings and assumptions underlying the decision about how to proceed with an SSO. This is important in case new information arises that modifies the conclusions previously made, requiring changes to the monitoring, data analysis, and/or modeling plans. The NSMP should remain alert to this possibility by working through the original

decision process at key points in the SSO and BMP development processes and/or whenever significant amounts of new data become available.

## **2. Use of a Hybrid Approach to Developing the SSO**

The Panel appreciates the detail provided by the NSMP on the alternative approaches to developing SSOs and agrees that a hybrid approach, using a combination of recalculation and modeling, is most appropriate. While we believe that the NSMP, in coordination with the STRC, is best positioned to resolve the technical details involved in implementing a hybrid approach, we suggest four issues that deserve special emphasis.

- a) Modeling should be compatible with the Luoma/Presser model being used by the STRC. This represents the most logical common ground between the two efforts and ensures that the NSMP's efforts will fit within the overall technical/regulatory framework being developed for the State of California as a whole.
- b) The hybrid approach should accurately incorporate key elements of the spatial and temporal heterogeneity of Se transport and bioaccumulation processes in the watershed (see Recommendation Number 3 for more details).
- c) The SSO, and the methods used to develop it, should reflect key bioaccumulation processes in the watershed. At a minimum, these include the original conversion of inorganic to organic Se and the movement of Se through the major producer and consumer categories already identified. This may require further monitoring to fill in gaps in current understanding of the foodweb structure.
- d) Since permits and other regulatory actions will be based on water column levels, it is essential that the approach used in this watershed must be capable of back-calculating to water-column concentrations that would provide the basis for a water quality objective.

## **3. Resolve Key Technical Issues**

The Panel has identified a number of important technical issues that must be successfully resolved to develop an SSO for Se.

- a) **Obtain relevant data in a timely manner.** The Panel notes that key samples collected by the California Department of Fish and Game have not yet been analyzed. While these samples were collected as part of a separate Fish and Game effort, the NSMP designed its sampling program in coordination with Fish and Game to avoid duplicating efforts, with the expectation that data from the Fish and Game samples would be available to the NSMP for its mapping, analysis, and modeling. In addition, key data on the distribution of Se in the watershed have been collected by Dr. Barry Hibbs, but have not yet been made available to the NSMP. Although reports from Dr. Hibbs have been provided, there is a vital need for actual data files that can be combined with NSMP data to construct maps that are more detailed and conduct analyses that are more inclusive.

- b) **Develop a more detailed description of the foodweb (1).** The Panel appreciates the difficulty in collecting adequate numbers of target species in all parts of the watershed. However, additional effort should be focused on ensuring that tissue data from as many foodweb components as possible are available from as many watershed compartments as possible. The data presented to the Panel suggest that Se levels in tissues and other matrices, as well as bioaccumulation processes, differ across the watershed. As a result, conclusions about bioaccumulation within the foodweb, drawn from data aggregated across the watershed, may not be valid at this level of generalization. The NSMP should create a matrix showing available samples for each foodweb component in each watershed compartment to identify key data gaps that may affect the development of an SSO. Where such data simply are not available, gaps could be filled with data from a nearby watershed compartment, from a similar foodweb elsewhere, or from a modeled estimate. Whatever approach is decided upon, a more spatially explicit description of the foodweb will enable the NSMP to more fully identify and evaluate proposed mechanisms of Se bioaccumulation, a process essential to development of the SSO.
- c) **Develop a more detailed description of the foodweb (2).** The NSMP's current representation of the foodweb contains little or no information on processes occurring at the base of the foodweb (e.g., at the microbial level) that may ultimately control the amount of bioavailable Se produced in the watershed (see the Panel's previous report for a fuller discussion of this issue). The NSMP should investigate the nature of these processes, the role of microbial and plant taxa, as well as the location(s) and environmental conditions in the watershed where such processes operate. This information would be invaluable both in developing an SSO and in designing BMPs.
- d) **Improve the description of Se partitioning between water and particulates.** A distribution coefficient,  $K_d$ , can be used to describe the partitioning of Se between water-column particulate and dissolved phases. It is defined as the concentration in suspended particulate material ( $\mu\text{g}/\text{kg}$ ) divided by the concentration in water ( $\mu\text{g}/\text{L}$ ). The relationship between the aqueous concentration of Se and the  $K_d$  can help to understand relative levels of bioaccumulation and risk. For example,  $K_d$  is as low as  $0.2 \times 10^3$  at Kesterson and as high as  $4 \times 10^4$  in the San Francisco Bay/Delta. The result is elevated levels of Se in biota at Kesterson, and elsewhere in the San Joaquin Valley, because of extremely high aqueous concentrations there and moderately high levels in biota at San Francisco Bay despite aqueous concentrations well below the  $5 \mu\text{g}/\text{L}$  criterion.  $K_d$  values presented for the Newport Bay watershed are based on analyses of only one sample of particulates at each of three locations. Given that the distribution between dissolved and particulate phases is one of the most important links controlling the bioavailability and effects of Se, additional analyses of particulates should be undertaken. While it can be difficult to collect sufficient particulate mass for analysis, such data are essential for modeling Se dynamics in the watershed. Continuous flow centrifugation may be a feasible method for obtaining needed sample sizes.

- e) **Develop a more detailed description of the role of physical and hydrologic processes.** The Panel agrees that the conceptual model presented by the NSMP is an effective way of organizing current knowledge and representing the overall effect of key physical/chemical and biological mechanisms. However, to fully support the development of an SSO, with related BMPs, data on flow, Se concentrations in surface and groundwater, and channel location and morphology must be combined into a more quantitative representation of the watershed's hydrology. This need not be a complex hydrological network model, but it should enable an assessment of where water and Se enter the system, where they end up, and how they got there, at the same time satisfying a general mass balance on Se. Such an approach can be used to formulate a compartmental model that provides insight into the flows and fluxes, thereby guiding the program to develop an efficient investigation strategy.
- f) **Assess how the Luoma/Presser model would be applied in the watershed.** Before undertaking a complete application of this model to the Newport Bay watershed, the NSMP should conduct a dry run using the existing data set that would identify both the model's ability to adequately represent important processes, including their spatial and temporal features, and any additional data requirements. The dry run should enable an assessment of the effort needed to adapt the model to the watershed, as well as any limitations in the model's structure or output that could affect the development of an SSO. The STRC should have input into the design and evaluation of the model dry run, which should include a preliminary review of whether and how the model's approach is applicable to the Newport Bay watershed. This preliminary review could simplify the dry run exercise.
- g) **Assess uncertainty and risk associated with alternative SSO structures.** The Panel heard discussion that there might be alternative structures for an SSO, including one standard at one location for the entire watershed, or different target levels for different compartments of the watershed with one or more compliance points. Such alternative implementation strategies have implications for modeling and analysis approaches, as well as their attendant data requirements. In addition, alternative approaches such as these will necessarily be associated with varying degrees of uncertainty. Uncertainty can stem from the data themselves, from simplifying assumptions about modeled processes, and from the unavoidable variability in natural processes in the watershed. The NSMP should attempt to quantify, at least roughly, the kinds and amounts of uncertainty associated with alternative approaches to SSO structure and implementation. These uncertainty estimates should then be used to estimate the amount of risk (e.g., of exceedances or impacts) inherent in each approach and identify tradeoffs that would help provide a basis for decision making.

## Appendix A: Panel Biographies

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### ***Brock B. Bernstein, Ph.D.***

*Independent Consultant*

Brock Bernstein is an environmental scientist and consultant with broad experience in designing and evaluating environmental programs, structuring management and research initiatives, and developing policy. He has field research experience in a range of coastal and oceanic environments, and has also worked on a wide variety of management and policy issues, including the redesign of core compliance monitoring programs for major regional management efforts, the evaluation and/or development of regional assessment programs, and methods to improve fisheries management. In addition, he has served on numerous technical advisory and review committees, including several National Academy of Sciences panels on issues such as improving marine monitoring nationwide and improving the governance and management systems used to manage coastal and ocean resources.

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### ***Gerald Combs, Ph.D.***

*Center Director, Grand Forks Human Nutritional Center, Agricultural Research Service  
U.S. Department of Agriculture*

Gerald Combs is an expert in nutrition and health, and his research interests include the nutritional biochemistry of minerals and vitamins (especially selenium, vitamin E, and the factors affecting their metabolic functions), ranging from basic biochemical studies to human metabolic and clinical investigations. A prolific author, Combs has written many key research reviews, as well as two leading text/reference books, *The Role of Selenium in Nutrition* (1986) and *The Vitamins: Fundamental Aspects in Nutrition and Health* (1992). He is currently the Center Director of the Grand Forks Human Nutritional Center of the Agricultural Research Service for the U.S. Department of Agriculture., where he directs the functions of the Center and its staff. His team conducts clinical intervention studies and was the first to demonstrate the efficacy of nutritional supplements of selenium in reducing cancer risk.

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### ***Roger L. Hothem***

*Research Wildlife Biologist  
U.S. Geological Survey*

Roger Hothem has conducted research for the U.S. Department of the Interior for the last 29 years. Early efforts focused on evaluating the effects of selenium and other contaminants on avian reproduction in various regions of California. At present, his primary research emphasis is on measuring, evaluating, and predicting the effects of various anthropogenic contaminants on wildlife, including amphibians, fish, and birds. Examples of his studies include population and food-chain interactions, the transfer of pollutants in the environmental complex, and effects of pollutants on the survival, reproduction, and behavior of wild species. Recent work includes studies of the effects of contaminants on avian reproduction at Edwards Air Force Base in the Mojave Desert and

studies of mercury contamination in birds and amphibians in the Cache Creek, Bear and Yuba River, and Trinity River watersheds. Hothem received a B.S. in Zoology and M.S. in Wildlife Management from Ohio State University.

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***Mohsen Mehran, Ph.D.***

*Chief Executive Officer and Principal Hydrologist  
Rubicon Engineering Corporation*

Mohsen Mehran is the Chief Executive Officer and Principal Hydrologist at Rubicon Engineering Corporation, an environmental, civil, and structural engineering firm and a licensed general contractor. At Rubicon, Mehran is responsible for developing and directing site characterization and remediation projects. He also provides environmental consulting services related to cost allocation and recovery and expert witness testimony cases. For the past 30 years, his research has focused on groundwater flow and migration of chemical constituents in fractured/porous media, with particular emphasis on site restoration, water-resources management, and groundwater/contaminant transport modeling. He has published more than 50 articles related to soil and groundwater investigation/remediation, and has been a faculty member at both the University of California, Davis, and University of California, Berkeley.

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***Roy A. Schroeder, Ph.D.***

*Retired Hydrologist  
U.S. Geological Survey*

Roy Schroeder had worked for the U.S. Geological Survey as a hydrologist for 24 years before retiring in 2002. During that time, he was involved in projects such as studying PCBs in the Hudson River, jet-fuel and gasoline contamination in Orange County and Death Valley, irrigation drainage (including selenium contamination) in the Salton Sea Basin, and the infiltration of municipal wastewater in spreading basins in Los Angeles County. Since retiring, he has continued to work part time as a contract employee through California State University, Sacramento, as well as for others on a volunteer basis. Examples of current research include on-going water-quality sampling in the Russian River and the sampling of desert springs from Palm Springs to Death Valley for a variety of water-quality constituents and stable and radiometric isotopes. He is extensively published and had taught at both the University of Utah and Yale University.

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***JoAnn Silverstein, Ph.D., P.E.***

*Professor of Civil and Environmental Engineering  
University of Colorado, Boulder*

JoAnn Silverstein has been a professor at the University of Colorado, Boulder since 1982. Her teaching interests include environmental engineering (biological process analysis, design, and wastewater and water treatment) and thermodynamics. Her research projects involve the application of biological processes to water treatment, including: nitrogen transformation, bioremediation of acid mine drainage, wastewater recycling, and nitrate removal from drinking water. She is also interested in research to develop and

demonstrate novel water treatment technologies so that they can be deployed in operating facilities. In 2001, the College of Engineering at the University of Colorado honored Silverstein with both the Clarence Eckel Faculty Achievement Award and the Outstanding Faculty Award.

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## Appendix B: Panel Meeting Agenda

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# NATIONAL WATER RESEARCH INSTITUTE

## Independent Advisory Panel on the County of Orange's Nitrogen and Selenium Management Program - Third Meeting

### FINAL Meeting Agenda

November 2, 2006

#### Meeting Location

DoubleTree Guest Suites  
Anaheim Resort/Convention Center  
2085 S. Harbor Boulevard  
Anaheim, CA 92802

#### On-Site Contacts

Jeff Mosher (NWRI)  
Cell: 714-705-3722  
Tammy Russo (NWRI)  
Cell: 714-614-7386

#### Meeting Objectives:

1. Review Draft Rationale for a Selenium Site-Specific Objective (SSO) determination under the County of Orange's Nitrogen and Selenium Management Program.
  2. Evaluate the selenium SSO determination based on available data.
  3. Review of regulatory approach(es) for ensuring protection of aquatic life and wildlife
  4. Develop recommendation(s) regarding the selenium SSO determination as well as the proposed approaches.
  5. Provide recommendations regarding potential modeling approaches
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8:00 am	Welcome and Introductions - Jeff Mosher (NWRI) and Brock Bernstein (Chair)	
8:15 am	Overview of SSO Regulatory Framework	Joanne Schneider
8:30 am	Summary of Monitoring Data/Results and Interim Report on Bioavailability and Effects of Selenium	Earl Byron (CH2M Hill)
9:30 am	Draft Report on Selenium SSO Decision	Mike Casterline (Larry Walker Assoc.)
10:30 am	<b>BREAK</b>	
10:45 a.m.	Comments by Regional Board Advisors	Joseph Skorupa
11:15 am	Panel: Open Discussion and Q&A	Brock Bernstein
12:15 pm	<b>WORKING LUNCH</b>	
1:00 pm	Panel-Only Discussion	Brock Bernstein
3:30 pm	<b>ADJOURN</b>	

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