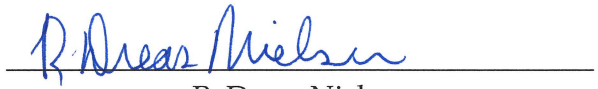
EVALUATION OF ALTERNATIVE COST-EFFECTIVENESS CALCULATION APPROACHES FOR THE REMEDIAL ALTERNATIVES AT THE SAN DIEGO SHIPYARD SITE

R. Dreas Nielsen
Integral Consulting Inc.
Seattle, WA

March 11, 2011



R. Dreas Nielsen
Senior Managing Scientist
Marine Scientist, Quantitative Analyst

INTRODUCTION

My name is R. Dreas Nielsen and I have been retained by BAE Systems San Diego Ship Repair to evaluate the cost effectiveness of the remedial alternative recommended by the Regional Water Quality Control Board (SDRWQCB 2010), specifically including the analysis conducted by Arcadis (2011).

OPINION ON COST EFFECTIVENESS

Information presented by Arcadis (2011) on the costs and surface-area-weighted chemical concentrations of chemicals of concern at the shipyard site indicates that the remedial option recommended by the Regional Water Quality Control Board (SDRWQCB 2010) is equivalent to the most cost-effective option with an additional margin of protectiveness.

Cost-Effectiveness Calculation

Information presented in Arcadis' *Expert Report on Economic Feasibility, Shipyard Sediment Site* (Arcadis 2011) has been reviewed, and supplementary calculations of cost effectiveness have been carried out. Those results are presented herein, and briefly discussed.

Arcadis (2011) presents information on the costs and surface area-weighted average concentrations (SWACs) of three remedial alternatives, the DTR-recommended option (SDRWQCB. 2010), the background option, and an option developed by Arcadis that is less extensive than the DTR option. That information—specifically, the data in Tables 10 and 13 of Arcadis (2011)—is used here to evaluate cost effectiveness. SWACs are used to assess remediation effectiveness as in the DTR (SDRWQCB 2010) and Arcadis (2011).

The data on costs and SWACs for pre-remedial conditions and the cleanup alternatives are shown in Table 1.

Cost effectiveness is represented by the fractional reduction in concentration (SWAC) per million dollars expended. There are three ways in which the reduction in SWAC can be calculated:

- The difference between pre-remedial and post-remedial SWACs divided by the pre-remedial SWAC (Method 1).
- The difference between pre-remedial and post-remedial SWACs divided by the difference between pre-remedial and background SWACs (Method 2).
- The incremental difference in SWAC for each remedial alternative, ordered from least to most extensive (Method 3).

Cost-effectiveness estimates have been made using all three of these approaches.

Method 1

Reductions in SWAC calculated using this method are based on the true scale of the concentrations, and therefore this method is considered to be the most representative of the changes in chemical exposures that would be experienced by marine organisms in the shipyards.

The reductions in SWAC relative to pre-remedial conditions are shown in Table 2, using data presented in Table 1. Cost effectiveness of the remedial options is shown in Table 3.

Method 2

Reductions in SWAC calculated using this method are rescaled so that the reference condition corresponds to zero exposure to sediment chemicals. This is not a realistic representation of the actual results of remediation, and this method is therefore considered to be less accurate than the first method. However, this method has been evaluated for consistency with the DTR (SDRWQCB 2010) and with Arcadis (2011).

The reductions in SWAC calculated using this method are shown in Table 4. Cost effectiveness of the remedial options using this method of representing SWAC reductions are shown in Table 5.

Method 3

The area and cost of remediation increase from the Arcadis alternative to the DTR-recommended option and further to the background option. Cost effectiveness can be evaluated by determining whether the additional benefit achieved by stepwise progression through this sequence is more cost effective than the benefit already achieved. For this method, incremental costs are calculated as the difference in cost between successive options, and incremental effectiveness is calculated as the difference in fractional reduction of SWAC between successive options.

The incremental changes in cost and in fractional reductions in SWAC calculated using this method are shown in Table 6. The corresponding cost effectiveness values are shown in Table 7.

DISCUSSION

All three of these methods of calculating cost-effectiveness based on SWACs produce equivalent results. All three methods identify Arcadis' alternative as the most cost effective. The spatial extent of the remedial area represented by Arcadis' alternative is a strict subset of the DTR-recommended option (Arcadis 2011). Therefore the DTR option will remediate all of the areas addressed by Arcadis' option, plus some additional areas. The DTR option therefore goes beyond the most cost-effective option evaluated. Although this results in a total cost

effectiveness that is less than the maximum (i.e., Arcadis' alternative), the DTR option includes all of the areas addressed by the most cost effective option. The DTR option can be considered to incorporate the most cost effective remediation, with an additional margin of protectiveness.

STATEMENT OF QUALIFICATIONS FOR R. DREAS NIELSEN

Mr. R. Dreas Nielsen's qualifications to evaluate the cost-effectiveness of sediment remediation at the shipyards site include degrees in biology and oceanography, 26 years of professional experience collecting, analyzing, and interpreting data from contaminated sites, and extensive experience with the Shipyard Site itself. Mr. Nielsen managed the sediment investigation conducted in 2001–2003 (Exponent 2003), personally conducted many of the data analyses for that study, and was a primary author of the final report. Since the completion of the sediment investigation study, he has been retained by BAE and kept current with the technical analyses and conclusions of the Cleanup and Abatement Order and the Detailed Technical Report for the shipyard site.

Mr. Nielsen's full curriculum vita is attached.

REFERENCES

Arcadis. 2011. Expert Report on Economic Feasibility, Shipyard Sediment Site. Prepared by Arcadis for DLA Piper and BAE Systems. March 2011.

Exponent. 2003. NASSCO and Southwest Marine Detailed Sediment Investigation. Prepared for NASSCO and Southwest Marine, San Diego, California, by Exponent, Bellevue, WA. October 2003.

SDRWQCB. 2010. Draft technical report for tentative cleanup and abatement, Order No. R9-2011-0001, for the Shipyard Sediment site, San Diego Bay, San Diego, CA. California Regional Water Quality Control Board, San Diego Region, San Diego, CA. September 15, 2010.

Tables

Table 1. SWACs and Costs

Alternative	Cost ($M, nondiscounted)[a]	SWACs[b] Cu (mg/kg)	Mercury (mg/kg)	HPAH (µg/kg)	PCB (µg/kg)	TBT (µg/kg)
Pre-remedial condition	$0.0	187	0.75	3509	308	162
Arcadis alternative	$29.7	165	0.70	2780	211	129
DTR recommended (SMU)	$58.1	159	0.68	2451	194	110
Background option	$379.5	121	0.57	663	84	22

Notes

[a]From Arcadis Table 10

[b]From Arcadis Table 13

Table 2. Reductions in SWACs Relative to Pre-Remedial Conditions (method 1)[a]

Alternative	Cost ($M, nondiscounted)	Percent Reduction Relative to Pre-remedial Condition: Copper	Mercury	HPAH	PCB	TBT
Pre-remedial condition	$0.0	0.0%	0.0%	0.0%	0.0%	0.0%
Arcadis alternative	$29.7	11.8%	6.7%	20.8%	31.5%	20.4%
DTR recommended (SMU)	$58.1	15.0%	9.3%	30.2%	37.0%	32.1%
Background option	$379.5	35.3%	24.0%	81.1%	72.7%	86.4%

Notes

[a]Reduction in SWAC is used as a metric for remedial effectiveness. The reduction is calculated as the difference between the SWAC for each option (and chemical) and the SWAC for the pre-remedial condition, divided by the SWAC for the pre-remedial condition.

Table 3. Cost Effectiveness, Method 1

Alternative	Cost ($M, nondiscounted)	Fractional Reduction in SWAC per Million Dollars Expended				
		Copper	Mercury	HPAH	PCB	TBT
Pre-remedial condition	$0.0					
Arcadis alternative	$29.7	**0.0040**	**0.0022**	**0.0070**	**0.0106**	**0.0069**
DTR recommended (SMU)	$58.1	0.0026	0.0016	0.0052	0.0064	0.0055
Background option	$379.5	0.0009	0.0006	0.0021	0.0019	0.0023

Notes

Maximum (most cost-effective) values are in bold

Table 4. Reductions in SWACs Relative to the Difference Between Pre-Remedial and Background Conditions

Alternative	Cost ($M, nondiscounted)	Percent Reduction Relative to Pre-remedial Condition				
		Copper	Mercury	HPAH	PCB	TBT
Pre-remedial condition	$0.0	0.0%	0.0%	0.0%	0.0%	0.0%
Arcadis alternative	$29.7	33.3%	27.8%	25.6%	43.3%	23.6%
DTR recommended (SMU)	$58.1	42.4%	38.9%	37.2%	50.9%	37.1%
Background option	$379.5	100.0%	100.0%	100.0%	100.0%	100.0%

Table 5. Cost Effectiveness, Method 2

Alternative	Cost ($M, nondiscounted)	Fractional Reduction in SWAC per Million Dollars Expended: Copper	Mercury	HPAH	PCB	TBT
Pre-remedial condition	$0.0					
Arcadis alternative	$29.7	**0.0112**	**0.0094**	**0.0086**	**0.0146**	**0.0079**
DTR recommended (SMU)	$58.1	0.0073	0.0067	0.0064	0.0088	0.0064
Background option	$379.5	0.0026	0.0026	0.0026	0.0026	0.0026

Notes

Maximum (most cost-effective) values are in bold

Table 6. Incremental Reductions in SWACs Relative to Pre-Remedial Conditions

Alternative	Incremental cost ($M, nondiscounted)	Incremental Percent Reduction Relative to Pre-remedial Condition: Copper	Mercury	HPAH	PCB	TBT
Pre-remedial condition	$0.0	0.0%	0.0%	0.0%	0.0%	0.0%
Arcadis alternative	$29.7	11.8%	6.7%	20.8%	31.5%	20.4%
DTR recommended (SMU)	$28.4	3.2%	2.7%	9.4%	5.5%	11.7%
Background option	$321.4	20.3%	14.7%	51.0%	35.7%	54.3%

Table 7. Cost Effectiveness, Method 3

Alternative	Incremental cost ($M, nondiscounted)	Incremental Fractional Reduction in SWAC per Million Dollars Expended				
		Copper	Mercury	HPAH	PCB	TBT
Pre-remedial condition	$0.0					
Arcadis alternative	$29.7	**0.0040**	**0.0022**	**0.0070**	**0.0106**	**0.0069**
DTR recommended (SMU)	$28.4	0.0011	0.0009	0.0033	0.0019	0.0041
Background option	$321.4	0.0006	0.0005	0.0016	0.0011	0.0017

Notes

Maximum (most cost-effective) values are in bold

Integral Consulting Inc.
411 1st Avenue S.
Suite 550
Seattle, WA 98104

telephone: 206.230.9600
facsimile: 206.230.9601
dnielsen@integral-corp.com

Dreas Nielsen

Senior Managing Scientist

Marine Scientist, Quantitative Analyst

PROFESSIONAL PROFILE

Mr. Dreas Nielsen is a senior managing scientist at Integral Consulting Inc., who specializes in quantitative analysis of environmental data. Mr. Nielsen's scientific expertise is principally in the areas of sediment contamination, chemical bioaccumulation, biological effects of contaminants, and chemical transport and fate. His approach to scientific topics stresses analytical and quantitative methods, with an emphasis on computer applications. During his 24 years of experience, Mr. Nielsen has performed and managed the collection and analysis of biological, physical, chemical, and geographic data from sites throughout the United States. Potential impacts at these sites were associated with heavy manufacturing, petrochemical manufacturing, wood treatment, wood pulp and paper production, shipbuilding, mining, and smelting. Mr. Nielsen's experience with these sites covers a broad range of contaminants, media, pathways, and exposures. Throughout this diverse range of conditions, he has collected, analyzed, modeled, and presented data to support ecological and human health risk assessments, RI/FSs, natural resource damage assessments, and cost allocation.

Mr. Nielsen's technical expertise includes data management, statistical analysis, integration of database and geographic information systems, mathematical modeling, programming, and information delivery via web sites. Mr. Nielsen has designed and developed numerous databases customized to meet specialized needs of projects and clients and has developed project-specific web pages, including GIS-based interfaces, to facilitate broad and straightforward access to project data and analyses.

CREDENTIALS AND PROFESSIONAL HONORS

M.S., Oceanography, Oregon State University, 1982
B.S., Biology, Union College, 1976

RELEVANT EXPERIENCE

Ecological Risk Assessment and Natural Damage Assessment

Natural Resource Damage Assessment, Tombigbee River, Alabama—Evaluated potential damages in a DDT-contaminated estuary for a variety of receptors and exposure

conditions, incorporating spatial variability in conditions throughout the site, and addressing different remedial scenarios. Developed time- and area-weighted exposure estimates for mosquitofish based on preferred habitat and the timing of seasonal flooding of the site, and related to measured DDT concentrations in tissue. Used the results to inform the design of post-remedial monitoring.

Natural Resource Damage Assessment, Greens Bayou, Texas—Conducted analyses of the spatial and vertical distribution of chlorinated solvents and pesticides. Developed estimates of exposure and damage to the benthic community to be used as a basis for compensatory restoration estimates. Estimated the post-remedy recovery period based on remedial design and sediment accumulation rate estimates, and developed recommendations for the post-remedial monitoring plan.

Natural Resource Damage Assessment, Saginaw River, Michigan—Coordinated the compilation, review, and analysis of data from three decades of sampling of a PCB-contaminated river and bay. Performed temporal and 3-dimensional spatial analyses of the data, including computation of mass-based assessment and cleanup thresholds. Presented results to oversight agencies, and prepared position papers to support litigation of a natural resource damage claim.

Natural Resource Damage Assessment, St. Lawrence River—Developed the database of sediment and tissue PCB data used jointly by PRPs and Trustee agencies in the cooperative natural resource damage assessment conducted on the St. Lawrence River.

Ecological Impacts of Ichthyoplankton Entrainment, Gulf of Mexico—Evaluated environmental impact statements that were prepared for liquefied natural gas regasification facilities in the Gulf of Mexico, focusing on the assessment of entrainment and impingement impacts to fish eggs and larvae. The evaluation produced qualitative and quantitative estimates of the effect of the data, assumptions, calculation methods, and models used on the overall impact assessments. Recommended alternative approaches to improve substantially the accuracy and precision of these impact assessments.

Ecological Risk Assessment, Newport, Delaware—Managed the compilation of tabular and GIS data for an ecological risk investigation at a former wood-treating facility in the eastern United States. This project evaluated and rectified data integrity problems in data sets produced by a previous contractor and integrated the tabular data with spatial data to facilitate site-specific ecological risk assessment. Also used these data to characterize exposure of receptors at the site.

Ecological Risk Assessment, Fox River, Wisconsin—Provided technical review of the development and application of a food web model to predict PCB dynamics in an industrial estuary, focusing on ecological, physiological, and computational issues.

Ecological Damage Assessment Following a Chemical Spill, Ohio River—Evaluated species abundance data in samples from impacted and unimpacted areas. Assessed the appropriateness of different statistical models for estimating the probability that any rare (threatened or endangered) species were affected.

Natural Resource Damage Assessment in Commencement Bay, Washington—Evaluated natural resource damages resulting from contamination of sediment of an urban waterway with metals, PCBs, and other organic chemicals. Automated the calculation for a spatially complex site to allow rapid evaluation of alternative scenarios.

Sediment Assessment

Sediment Data Analysis, Upper Columbia River, Washington and British Columbia—Coordinated the analysis of both recent and historical sediment chemistry data from the Upper Columbia River to assist in the planning of future sampling programs. Analyses included multivariate analyses of element abundances, analysis of spatial and vertical variation in concentrations, characterization of background conditions and comparison to site conditions, and evaluation of partitioning to pore water. These analyses identified several different classes of sediment in the river, characterized by different chemical and physical characteristics. Evaluation of the fingerprints of these classes relative to potential source materials provided insights into both the spatial and proportional influence of potential sources.

Evaluation of Groundwater-Sediment Interactions, Patrick Bayou, Texas—Evaluated the potential contributions of groundwater, based on measured concentrations and flow gradients, to influence ecological risk in an adjacent waterway. Contrasted predictions of groundwater transport calculations with results of toxicity testing in the waterway.

Detailed Sediment Investigation, San Diego, California—Managed a comprehensive sediment investigation at two shipyards in San Diego Bay, focusing on the effects of metals, organo-metallic compounds, PAH, PCBs, polychlorinated triphenyls, and petroleum hydrocarbons on aquatic life, aquatic-dependent wildlife, and human health. This investigation included a sediment triad study; bioaccumulation tests; ecological and human health risk assessments using site-specific exposure data; analyses of fish histopathology, age and condition, and PAH exposure; sediment profile imaging; and analyses of sediment mineralogy. Developed a method to synthesize the many measurements of biological conditions to produce a quantitative estimate of impairment relative to reference conditions. Also developed a deductive approach to causation analysis that provides a definitive assessment of the potential impact of site-related chemicals. Developed alternate site-specific cleanup levels and assessed their predictive performance. A feasibility study also was conducted to evaluate alternative remedial designs.

Review of Regulatory Proposals—Conducted a technical review of the evaluation approaches used in EPA's July 1996 draft documents *The National Sediment Contaminant Point Source Inventory: Analysis of Facility Release Data* and *The National Sediment Quality Survey: A Report to Congress on the Extent and Severity of Sediment Contamination in Surface Waters of the United States*. Identified flaws in the technical basis and mathematical formulation of the HAZREL ranking system, and conducted an error analysis to demonstrate the impact of these flaws. Evaluated the sediment quality values used for sediment screening, and applied statistical analysis that revealed their lack of comparability. Demonstrated that the evaluation

methods used in both documents were driven by the number of samples collected in a geographic region rather than the characteristics of those samples, and recommended modifications of the methods.

Development of Sediment Assessment Guidance, Olympia, Washington—Managed a project to support the Washington State Sediment Management Unit, which included developing guidance for sediment sampling and analysis plans, reviewing approaches for deriving human health-based sediment quality criteria, and developing an action plan for creation of multi-user disposal sites.

Evaluation of Bioaccumulation-Based Sediment Standards, Olympia, Washington—Managed and carried out evaluations of bioaccumulation of organic and inorganic chemicals in fish and shellfish using data from the literature and from an extensive chemical database for Puget Sound. Evaluated the effects of sediment conditions, chemical properties, and biota characteristics on bioaccumulation potential, and prepared a critique of bioaccumulation assessment methods that includes recommendations regarding data collection and assessment approaches.

Forensics

Dioxin Source Analysis, Washington—Provided senior technical consulting and oversight of analyses using multivariate data analysis methods to evaluate potential sources of dioxins to residential soils. Multiple methods (discriminant analysis, unmixing analysis, and spatial similarity analysis) confirmed the presence of two spatially and chemically distinguishable dioxin/furan fingerprints.

Sediment Metal Pattern Classification, Washington—Planned and oversaw pattern analyses of sediment metals data, developing a classification scheme to distinguish sediments reflecting different sources or partitioning and transport mechanisms.

Beach Dust Resuspension Analysis, Washington—Planned and provided senior technical oversight of a screening-level evaluation of the potential impact on riparian soils of aerial transport of resuspended dust from sediments exposed during lake drawdown.

Cost Allocation, Anniston, Alabama—Managed a project to evaluate potential sources of metals and PCBs to a contaminated residential area, using environmental measurements, historical documents, and emission rate calculations based on industrial operating characteristics and feed materials, in support of cost-recovery litigation.

Mercury Bioaccumulation Modeling, New York—Provided senior technical consulting on the development of a bioenergetics-based food web model to evaluate the multi-year bioaccumulation response of fish to different mercury exposures.

Cost Allocation, Ohio—Reviewed documents and data generated during a multi-year assessment and cleanup of a waste disposal and recycling site. Evaluated the nature, fate, and distribution of contaminants found at the site in relation to raw materials, waste products, and practices at the client's manufacturing site. Evaluated potential formulations of industrial materials used decades ago, to determine potential contaminants of concern

originating at the client's facility, and reviewed records of waste haulers to develop independent estimates of the client's proportionate contribution to the site.

Data Management, Analysis, and Communication

Ecological Risk Assessment and Remediation Alternative Assessment—Developed an interactive web application that integrates a database of chemical data with spatial (GIS) data to allow users to explore changes in ecological risks associated with different remediation approaches in a forested wetland. Chemical data were loaded into a database from electronic laboratory deliverables, GIS data were organized and standardized, and a web mapping interface was implemented. The tool allows users to select different areas for remediation and to apply different cleanup levels and residual levels, and calculates surface area-weighted average chemical concentrations and ecological hazard indexes for several receptor species.

Calcasieu Impact Assessment, Calcasieu Estuary, Louisiana—Developed an integrated GIS and relational database application to assess natural resource damages in a Gulf Coast ecosystem. Developed and applied data quality objectives, data quality assurance procedures, and data summarization rules for the acquisition, review, and interpretation of historical data from the estuary, including sediment, water, and tissue chemistry, species abundance, and toxicity test data. Created a software interface to the integrated application for use by an industry coalition and a public agency, and created a customized version for a private client. Conducted analyses to highlight spatial and temporal variation throughout the estuary, as well as systematic differences between historical data sets.

Document Management for Toxic Tort Litigation Support—Designed an on-line system to allow client access to a database of technical documents relating to exposure and health effects of a widely used industrial material. The on-line system provides the ability to search for documents using citation information and keywords and allows display of document text and technical comments.

Data Explorer for Human Health Exposure Assessment—Developed a desktop application that integrates tabular and GIS data to allow users to explore potential human health exposures to residual industrial wastes in a residential area. Spatial information on the locations of contaminated areas and of homes and businesses was integrated with tabular data on chemical concentrations and the history of individuals' residential and employment locations. The application provides the user with a map-based interface that allows exploration of both temporal and spatial relationships between contaminant locations and individuals' potential exposures.

Management of Photographic Data on Human Activities—Developed software tools to automate the acquisition and review of automatically collected photographs of human use activity at a contaminated site.

Post-Katrina Damage Assessments to Insured Properties, Gulf Coast—Developed web-based interfaces to display the locations of insured properties, peak wind speeds, and storm surge heights in the track of Hurricane Katrina.

Health Risk Assessment, Detroit, Michigan—Developed a database to support screening and detailed characterization of potential mercury contamination in houses following servicing of mercury-containing natural gas pressure regulators. This database supported real-time data collection via data entry forms on handheld computers, with daily uploading of data, reporting of results, and scheduling of multiple field crews for several different phases of assessment and cleanup. The database included a map interface to support efficient assignment of sampling locations to field crews and was deployed on the client's network.

California Earthquake Authority Rapid Damage Assessment System, California—Designed an on-line system to automatically acquire real-time data on earthquake ground motion from U.S. Geological Survey processing centers, integrate that with a database of client properties, and present the information in a GIS-based web interface.

Landslide Litigation Support, California—Developed map-based, on-line systems to present narrative and photographic data on environmental and structural damage resulting from severe weather and geological subsidence.

RCRA Assessment at a Pulp Mill, Savannah, Georgia—Designed and implemented database features to store the topology of a drainage pipe network so that the downstream effects of facility processes and discharges could be evaluated, and the potential sources of downstream contamination identified. Pipe data stored in the database were linked with GIS data to allow visual querying and display of the pipe and discharge information.

Ecological Assessment, Rocky Flats, Colorado—Developed a database to integrate information collected during 7 years of ecological monitoring at the Rocky Flats Environmental Technology Site in Colorado. This database integrated the disparate data formats used by different monitoring programs during several years and presented the user with a single, consistent interface to all of the data.

Cost Allocation, Commencement Bay, Tacoma, Washington—Designed and implemented a database to support Superfund site administration, including PRP search, source control tracking, and remedial action tracking. Wrote the user's and programmer's guides for this database.

Site Characterization

Remedial Investigation and Feasibility Study, Onondaga Lake, New York—Conducted evaluations of the potential effects of alternate remedial actions for a feasibility study for cleanup of Onondaga Lake, New York. Coordinated the management of sampling data, which involved more than 1,500 samples of sediment, water, and tissue. The samples were analyzed for organic, inorganic, and conventional parameters by five separate laboratories.

Focused Feasibility Study, Crawfordsville, Indiana—Managed a project to evaluate remedial options for a wooded floodplain containing PCBs released from an industrial facility upstream, as well as downstream transport through a channel draining the wooded area.

Smelter Hill Remedial Investigation and Feasibility Study, Anaconda, Montana—Refined the specifications and implemented the software to transfer RI/FS data from the Smelter Hill Superfund site to EPA's Clark Fork Data Management System.

Property Damage Litigation Support, Texarkana, Arkansas—Managed a project to assess the transport of PAH downstream from several historical and current sources, in support of expert testimony in a property-damage litigation case.

Chemical Fate and Transport

Remedial Investigation and Feasibility Study, Ward Cove, Alaska—Managed the development of screening and 3-dimensional models of contaminant transport and fate in Ward Cove (Ketchikan), Alaska, and carried out other analyses of sediment accumulation and bioaccumulation for the determination of areas of concern and appropriate remedial actions. The predominant influence of organic matter degradation required model customization to account for effects such as *in situ* production of 4-methylphenol. Also specified statistical methods for long-term monitoring of biological and chemical conditions.

Modeling of Permitted Discharge Impacts on Sediment, Puget Sound, Washington—Conducted an evaluation of models for assessing the potential impact on sediment of permitted discharges in the State of Washington. Performed modeling of several example sites, developed application guidance for the WASP4 model, and conducted training in model usage.

Other Technical Reviews

Ecological Impact Assessment, National Engineering Laboratory, Idaho—Managed the quality assurance review of organic and inorganic analysis data from the Idaho National Engineering Laboratory.

Development of Reference Area Performance Standards, Puget Sound, Washington—Completed a quality assurance review and evaluation of marine bioassay data to support the establishment of reference area performance standards. Participated in refining these standards and co-authored the final report.

PRP Search, Commencement Bay, Washington—Participated in the data summarization and review for a PRP search at a CERCLA NPL site with 9 problem areas, approximately 500 facilities, and 1,000 parties. EPA and site-specific evaluation criteria were applied to identify PRPs.

Litigation Support

Damage Claims from Volatile Organic Chemicals in Groundwater, Multiple Sites Nationwide—Managed a litigation support project to perform technical review of more than 8,800 documents from 16 contaminated sites and provide appropriate documents and site summaries to 10 different testifying experts. Developed a customized bibliographic database that included document descriptions, site descriptions, and experts' requirements,

but also supported document tracking and overall document management tasks. Conducted database development, document review, and data entry all on an accelerated schedule: in 4 months, the product of 3 years of document collection efforts was compiled and reviewed.

Cost Allocation, Anniston, Alabama—Managed a project to evaluate potential sources of metals and PCBs to a contaminated residential area, using environmental measurements, historical documents, and emission rate calculations based on industrial operating characteristics and feed materials, in support of cost-recovery litigation.

Cost Allocation, Ohio—Reviewed documents and data generated during a multi-year assessment and cleanup of a waste disposal and recycling site, to provide litigation support for a client named as a PRP. Evaluated the nature, fate, and distribution of contaminants found at the site in relation to raw materials, waste products, and practices at the client's manufacturing site. Evaluated potential formulations of industrial materials used decades ago, to determine potential contaminants of concern originating at the client's facility, and reviewed records of waste haulers to develop several independent estimates of the client's proportionate contribution to the site. Thorough review of available data demonstrated that the client's contribution to the site was minimal in terms of both volume and hazard. All of the documents reviewed were compiled into an electronic database that could be searched by document type, title, authors, date, and Bates number, and that would display scanned images of selected documents.

PUBLICATIONS

Pastorok, R.A., M.K. Butcher, and R.D. Nielsen. 1996. Modeling wildlife exposure to toxic chemicals: trends and recent advances. *Hum. Ecol. Risk Assess.* 2(3):444–480.

Pastorok, R.A., R.D. Nielsen, and M.K. Butcher. 1996. Future directions in modeling wildlife exposure to toxic chemicals. *Hum. Ecol. Risk Assess.* 2(3):570–579.

Miller, C.B., and R.D. Nielsen. 1988. Development and growth of large, Calanid copepods in the Ocean Subarctic Pacific, May 1984. *Progr. Oceanogr.* 20:275–292.

INVITED PRESENTATIONS/POSTERS/PANELS/PEER REVIEWS

02/09—Fifth International Conference on Remediation of Contaminated Sediments. Graphic visualization of correlation and similarity. D. Nielsen, M. Aldea, and G. Palushock (presented by M. Aldea). Jacksonville, FL.

02/09—Fifth International Conference on Remediation of Contaminated Sediments: A multinomial exact test for interpretation of sediment profile image data. D. Nielsen and J.D. Germano (poster). Jacksonville, FL.

01/06—Workshop on U.S. Seawater Vaporization: Getting to Resolution. An evaluation of the approaches used to predict potential impacts of open loop LNG vaporization systems on fishery resources of the Gulf of Mexico. Houston, TX.

10/05—Environmental Technologies Panel Meeting. Sediment assessments for remedial investigations. National Shipbuilding Research Program. Seattle, WA.

07/04—Society of Wetland Scientists 25th Annual Conference. Restoration of the Mesopotamian marshlands: Applications of hydrodynamic models. Seattle, WA.

09/04—Sediment Management Workgroup Members Meeting. Use and extension of the sediment quality triad approach at working shipyards. Seattle, WA.