Assessment of the

PRELIMINARY DRAFT STATE TECHNICAL SUPPORT DOCUMENT FOR PCB VARIANCES ON THE SPOKANE RIVER

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INTRODUCTION

While the Technical Support Document (TSD) establishes an adequate general outline for the variance process, in my view it has three major deficiencies:

- The best prospects for PCB reduction in the Spokane River and its biota in the relatively short and medium terms lie in source control actions, but the TSD does not cover that subject in sufficient breadth and depth.

- There are inefficiencies in the Pollutant Minimization Plans (PMPs) that could be corrected by cooperative actions by the dischargers.

- Some of the scheduling specified by the PMPs is too extended in my opinion.

These defects compromise what I believe should be the overarching goal of the process: to achieve the greatest possible reduction of PCBs in the Spokane River ecosystem in the shortest practically feasible time. I elaborate on each point in the following discussion.

INSUFFICIENT ATTENTION TO SOURCE CONTROL

Rationale for Increasing Emphasis on Source Control

The TSD, of course, deals directly with the five dischargers seeking variances. A study performed in 2003-2004 found that those five municipal and industrial plants accounted for only 20 percent of the PCB loading to the Spokane River within Washington, with 44 percent from municipal stormwater and 30 percent entering from Idaho. While the specific numbers may not apply today, the relative positions of the three dominating loading sources probably do. With treatment improvements recently completed at the Spokane County, Liberty Lake, and Inland Empire plants, quite possibly the dischargers' share is now below 20 percent. Moreover, it will probably fall further when treatment improvements are finished at the City of Spokane plant, seemingly soon, and, eventually, at Kaiser.

These circumstances suggest that the next round of PCB reduction can best be accomplished by addressing stormwater and the inflow from Idaho. In both instances, PCBs are surely widely distributed in the contributing drainages, but also have distinct sources that could be identified and mitigated. Admittedly, working interstate with a jurisdiction not suffering the consequences of chemicals originating there would have its difficulties. Putting that issue aside for the

moment, substantial progress could be made by tracing and excising sources of PCBs contributing to stormwater runoff in the urban portions of Washington's Spokane River watershed.

I recognize that these environmental sources of the pollutant are outside the direct areas of responsibility of the municipal and industrial wastewater plant operators. Yet, they are the entities that are seeking variances. At this point in time they do not have readily available technologies to upgrade treatment above the levels already installed at three plants, underway at a fourth, and recommended by Ecology for Kaiser. Even with these treatment improvements, the river is left in a condition unable to support its designated beneficial uses. Without additional actions, it will remain in that condition for the indefinite future. Consequently, Ecology should require the discharges to cooperate in and fund a comprehensive, goal-oriented program to identify the greatest sources of PCBs distributed in the regional environment and mitigate them in priority order.

Below, under the topic Pollutant Minimization Plan Inefficiencies, I recommend two additional cooperative efforts among the discharges to promote efficiency. At the end of this memorandum I suggest a mechanism for equitably allocating the responsibilities and costs of these joint programs.

Potential Sources for Remediation

The TSD identifies many of the sources that should be sought out in a comprehensive program to find and remove or reduce PCBs of environmental origin. TSD Table 10 provides a useful compilation, with particularly prevalent exposed PCB sources being aged electrical equipment; caulks; and paints, especially yellow applications for high visibility. Therefore, equipment graveyards, pavement and concrete structure joint caulks, road markings, and bollards are prime places to look for remediable PCBs.

One key source not identified by the TSD is automobile and other equipment dismantling operations and subsequent storage, handling, and disposal locations. Despite the ban on their use in manufacturing of these items four decades ago, PCBs are still commonly found in the non-metallic residues of these processes, which often are highly exposed to the outdoor environment. Therefore, substantial progress could be made in isolating these operations and materials from contact with rainfall and runoff at dismantlers, salvage yards, waste transfer stations, and landfills. There are no auto shredders in Spokane and its vicinity,[1] but the area does have 14 auto salvage yards;[2] three transfer stations;[3] and two landfills, one publicly owned facility for municipal solid waste, and one limited-purpose private landfill.[4]

In addition to the environmentally distributed PCB sources that could be addressed by targeted mitigation, a source specific to Inland Empire Paper is print ink contained in some recycled paper handled at the plant. The TSD does include this source for attention in that company's

[1] http://giecdn.blob.core.windows.net/fileuploads/file/rt_auto_shredder_poster.pdf (accessed July 9, 2020).
[2] https://www.salvage-parts.com/junk-yards/spokane-wa (accessed July 9, 2020).
[3] https://www.spokanecounty.org/2013/Regional-Disposal-Locations-Hours-Fees (accessed July 9, 2020).
[4] https://www.spokanecounty.org/DocumentCenter/View/4871/Final-2015Plan-PDF?bidId= (accessed July 9, 2020).

PMP, but it should more explicitly direct the company to investigate the extent of PCB-containing material in its recycled paper feedstock and its origins. That information should be used to determine what action should be taken to balance the competing interests of protecting the Spokane River on the one hand and saving resources through recycling on the other.

Regarding the PCB loading stemming from Idaho, the dischargers' cooperative program that I suggested above should reach out to the neighboring state to establish a relationship focused on the issue. As information accumulates from the source tracing and mitigation work in Washington, the knowledge should be conveyed to Idaho colleagues. Most source types and their relative PCB releases are probably common to the two states. Having been identified by intensive investigative work in Washington, they could be addressed in Idaho without that state having to do the preliminary work. The dischargers should assist in that work in all ways their legal, regulatory, and financial positions allow.

POLLUTANT MINIMIZATION PLAN INEFFICIENCIES

Literature Review Provisions

The TSD's Table 25 specifies Pollutant Minimization Program Actions to be taken by each discharger. A common action for the three municipal dischargers and Inland Empire is, "Conduct periodic literature review to identify emerging treatment technologies." That action is not specified for Kaiser, presumably because it is just now getting into the process of selecting advanced treatment. As I comment later, I believe that the PMP scheduling allows Kaiser too much time to complete installation of new treatment. That schedule should be tightened, and Kaiser too should be included in the periodic literature review directive.

As the TSD demonstrates on pages 34-38, there are numerous potential treatment technologies that could serve to reduce PCBs in municipal and industrial wastewater plant discharges. PCBs have a strong tendency to associate with solid particulate material in water, instead of in the dissolved state. Many other synthetic organic chemicals share this characteristic and can be captured by the same processes. With the combination of numerous chemicals and methods to remove them from wastewater, the potential volume of literature on the international scale is rich. That literature should be thoroughly reviewed within the first year of the variance period to define the present state of the technology. New reports should then be added at least biannually to stay current with developments.

Bench and Pilot Testing Provisions

Table 25 follows with the specification for the municipal dischargers and Inland Empire to, "Conduct bench scale/pilot studies on emerging PCB treatment technologies, as identified in periodic literature reviews." For the three municipal plants it goes on to state, "Conduct periodic review of alternative actions and implement feasible actions to reduce PCBs loading to the environment." That provision requires, among other identified feasible actions, the installation of additional treatment meeting the criteria. That statement is missing for Inland Empire, but must apply to that discharger too. Both actions quoted in this paragraph are missing in Kaiser's

case, again probably because of the lag in providing advanced treatment, but must be required of Kaiser too.

Conclusion

It is not efficient for three, four, or five entities, close to one another and having essentially the same problems and requirements, to perform literature reviews and bench and pilot testing separately. Ecology should require all to join in a cooperative effort to perform these tasks. Later, under the topic A Structure for a Cooperative Program, I give my recommendations for constituting such a program.

OVER-EXTENDED SCHEDULING

PMP Reevaluation Schedule

In accordance with the operative federal regulation, a water quality variance with a term greater than five years is reevaluated at least [emphasis added] every five years, meaning that a more compressed schedule can be specified. I believe that reevaluation should occur sooner than five years at the outset of the variance term and be adjusted according to the performance of the variance recipients. For example, with an initial reevaluation at the three-year point showing a high-performance level, the second reevaluation could be extended to five years later. On the other hand, inadequate performance would justify scheduling the next reevaluation once again in another three years, or even within two years. This strategy would be consistent with, and an addition to, the general adaptive management framework embedded in the state regulation governing variances and underlying the TSD overall. It would give the dischargers a strong incentive to elevate their performance.

Scheduling of Specific PMP Actions

There a number of instances where the frequencies and schedules in Tables 24 and 25 give more time than needed and should be allowed. I believe this leniency compromises what I stated earlier is my conception of the overarching goal of the TSD process: to achieve the greatest possible reduction of PCBs in the Spokane River ecosystem in the shortest practically feasible time. I give my alternative recommendations in Table 1.

As my Table 1 indicates, I take particular exception to the actions assigned to Kaiser in TSD Table 25. First, the firm is allowed far too long to select, design, and install a new treatment system. All of the other dischargers already have upgraded, or soon will, to the level of treatment Kaiser is just now beginning to consider. I believe that it is entirely feasible for Kaiser to complete the upgrade in half of the time allowed by the TSD. Second, Table 25 fails to assign Kaiser actions required of the other dischargers, namely literature review and bench or pilot testing of emerging technologies and actions to reduce PCBs loading to the environment. My recommended revisions to Table 25 correct these shortcomings.

Table 1. Recommended Alterations to the Frequencies and Schedules Prescribed in the TSD's Tables 24 and 25

Table 24					
Line	**Action**	**TSD Frequency**	**TSD Schedule**	**Recommended Frequency**	**Recommended Schedule**
1	Establish team	Once	By end of Year 1	Once	By end of Month 1
2	Identify procedures and methods for PMP effectiveness tracking	Once	By end of Year 1	Once	By end of Month 2
3	Submit proposed schedule for performing and completing PMP actions	Once	By end of Year 1	Once	By end of Month 3
4	Submit a Quality Assurance Project Plan (QAPP) for PMP PCB Sampling	Once	By end of Year 1 or as needed	By end of Month 6 and as needed with revision of the monitoring program	
10	Conduct periodic review of procurement policies	Ongoing	Review every 4 years	Ongoing	Review annually
11	Evaluate and optimize the solids dewatering and storage processes	Ongoing	By end of Year 10	By end of Year 3 and ongoing every 3 years	
13-14, 20-22	See Table 24	See Table 24	By Year 4 and every 5 years thereafter (prior to each mandatory interim review)	Same as Table 24	By the year preceding each mandatory interim review
Table 25					
1	Evaluate infiltration and inflow(I/I) to collection systems	Ongoing	Years 1-5 and implementation Years 6-15	Ongoing	Years 1-3 and implementation Years 4-15
3, 8	Conduct periodic literature review to identify emerging treatment technologies[a]	Ongoing	First report due by Year 4 and every 5 years thereafter	Ongoing	First report due by Year 1 and every 2 years thereafter
6, 15	Conduct periodic review of alternative actions and implement feasible actions to reduce PCBs loading to the environment[a, b]	Ongoing	Years 1-20	Ongoing	Years 1-20
16	Clean out north sewer	Ongoing	By Year 5, and as needed thereafter	Ongoing	By Year 1, and as needed thereafter

Table 1 continued

Line	Action	TSD Frequency	TSD Schedule	Recommended Frequency	Recommended Schedule
17	Refurbish PCB containing electrical equipment[c]	Ongoing	By Year 1 and as needed thereafter	Once	By Year 1
21	Identify and evaluate treatment technologies[d]	As necessary	Years 1-8	Once	By Year 1
22	Conduct bench/pilot scale testing of candidate technologies[d]	As necessary	By Year 8	Once	By Year 3
23	Submit final engineering design documents for selected treatment technology	Once	By Year 9	Once	By Year 4
24	Install and optimize selected treatment technology	Once	By Year 10	Once	By Year 5

[a] Kaiser should also be required to support and perform these actions in cooperation with the other dischargers. Furthermore, Kaiser, cooperating with the other dischargers, should also be required to support and conduct the actions, "Submit Scope of Work for conducting bench scale/pilot studies on emerging PCB treatment technologies, as identified during periodic literature reviews" and "Conduct bench scale/pilot studies on emerging PCB treatment technologies according to Ecology approved Scope of Work." These actions should be added to Kaiser's section of Table 25.

[b] In this concept, as discussed above, this action would be substantially upgraded to form a cooperative arrangement among the dischargers to conduct a comprehensive, goal-oriented program to identify the greatest sources of PCBs distributed in the regional environment and mitigate them in priority order.

[c] The goal for this action, as it appears to be stated in Table 25, is inadequate. All PCB-containing equipment should be identified and replaced with equipment not containing PCBs within the first year of the variance period.

[d] These specific actions pertain to Kaiser's selection and testing of its new stage of treatment. As indicated in note a above, Kaiser should also be required to support and perform such actions in cooperation with the other dischargers on an ongoing basis to keep abreast of treatment developments that further improve PCB capture.

A STRUCTURE FOR A COOPERATIVE PROGRAM

In passages above I recommended three actions on which the five dischargers should cooperate instead of pursuing separately: (1) environmental PCB source tracing and remediation; (2) treatment technology literature review; and (3) treatment technology bench and pilot testing. The variance recipients should form a consortium operated by a technical board representative of the participants. The board should hire a well-qualified consultant or consultants to perform the tasks under its direction.

Two issues associated with such an arrangement are allocation of funding support and representation on the board. In my opinion, a fair way to decide these issues would be allocation according to relative discharge of PCB mass loading to the river. The TSD presents PCB effluent data for each discharger that either directly cite mass loadings (mg/day) or give PCB concentrations (pg/L) that, along with flow data, can be applied to calculate loadings. These data appear in Tables 12-15 and 17. The years represented are not fully consistent among the

dischargers, starting as early as 2008 and as late as 2018 and terminating in either 2018 or 2019. Three of the dischargers completed advanced treatment projects during this period, events that most likely changed their discharge characteristics. Therefore, the tabulated data are not a perfect basis to make allocations.

A better basis would be to use data only from the time when the first advanced treatment system went on-line for an initial allocation of funding assessments. As data accumulate year by year, the relative mass loading releases should be recalculated and the assessments adjusted for the following year. A refinement would be to give some extra credit for those who installed advanced treatment at an early point, with a decrease in assessment in relation to the timing of installation. This arrangement would give all dischargers incentive to elevate their performance, particularly to encourage Kaiser to accelerate advanced treatment.

As an illustration for how the system would work, I used the TSD tabulated data, calculating mass loadings from concentration and flow information as necessary. Among the statistical reports for concentrations or loadings given in the tables, I used the medians. Table 2 summarizes the results. Hence, as the circumstances stood at the release of the TSD, Inland Empire would be assessed about one-third of the cost of the cooperative activities and the City slightly less and Kaiser slightly more than one-third.

Table 2. Relative Mass Loading Discharges by the Variance Applicants Based on Data Tabulated in the TSD

Discharger	Median PCB Mass Loading (mg/day)	Share of Total Mass Loading
Spokane County	3.67	2.0%
City of Spokane	52.1	27.9%
Liberty Lake	0.28	0.1%
Inland Empire	62.5	33.4%
Kaiser	68.3	36.6%
TOTAL	186.9	100.0%

Representation on the technical board could be decided similarly, with each participant having at least one member and otherwise membership in proportion to the funding assessment. Under this formula and based on the Table 2 data, a 20-member board would have one member each from Spokane County and Liberty Lake and the remaining 18 allocated five to the City, six to Inland Empire, and seven to Kaiser.

I intend these illustrations only as examples. Other workable and fair arrangements are surely possible. The important point to me is that certain actions under the variance structure could be conducted considerably more cost-effectively in a cooperative framework than under the individualized approach laid out in the TSD.

Curriculum Vitae

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EDUCATION

1976 - 1978 University of Washington, Seattle, Washington; Ph.D. (Civil Engineering)

1965 - 1966 University of Pennsylvania, Philadelphia, Pennsylvania; M.S. (Mechanical Engineering)

1961 - 1965 University of Pennsylvania, Philadelphia, Pennsylvania; B.S. *Cum Laude* (Mechanical Engineering)

HONORS AND AWARDS

Augustus Trask Ashton Scholarship, University of Pennsylvania, 1961 - 65
Annual Academic Honors, University of Pennsylvania, 1961 - 65
Tau Beta Pi National Engineering Honor Society
National Science Foundation Traineeship, University of Pennsylvania, 1965 - 66

EMPLOYMENT

1986 - Present Richard R. Horner, Sole Proprietor (offering services in environmental engineering and science)

2011 - Present University of Washington, Seattle, Washington
Emeritus Research Associate Professor

1981 - 2011 University of Washington, Seattle, Washington
Research Associate Professor

1986 - 1990 King County, Seattle, Washington
Coordinator of Puget Sound Wetland and Stormwater Management Research Program (part-time; continued under contract to University of Washington)

1969 - 1981 Northampton Community College, Bethlehem, Pennsylvania
Engineering Department (Coordinator, 1971 - 73 and 1978 - 79)
Environmental Studies Department (Co-coordinator, 1973 - 76 and 1978 - 1981)
Professor, 1978 - 1981; Associate Professor, 1973 - 78;
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1977 - 1978 University of Washington, Seattle, Washington
Department of Civil Engineering
Research Engineer, Highway Runoff Water Quality Project

1976 - 1977	University of Washington, Seattle, Washington Department of Civil Engineering and Institute for Environmental Studies Research Assistant and Teaching Assistant
1966 - 1969	Exxon Research and Engineering Company, Florham Park, New Jersey; Project Engineer
1965 - 1966	University of Pennsylvania, Philadelphia Pennsylvania Department of Mechanical Engineering; Research Assistant

NATIONAL COMMITTEES

National Academy of Sciences Panel on Reducing Stormwater Discharge Contributions to Water Pollution, 2007-2008.

Technical Advisory Panel for Water Environment Federation projects on Decentralized Stormwater Controls for Urban Retrofit and Combined Sewer Overflow Reduction, 2005-2007.

Co-chair, Engineering Foundation Conference on Effects of Watershed Development and Management on Aquatic Ecosystems, 1996.

National Academy of Sciences Panel on Costs of Damage by Highway Ice Control, 1990-91.

U.S. Environmental Protection Agency National Wetland Research Planning Panel, 1988, 1991.

RESEARCH PROJECTS

* Principal Investigator.
** Co-Principal Investigator. (Where undesignated, I was a member of the faculty investigation team without principal investigator status).

Effects of Waterfront Stormwater Solutions Prototypes on Water Quality Runoff in Puget Sound near Pomeroy Park - Manchester Beach; Washington Sea Grant; $148,838; 2015-17.

Development of a Stormwater Retrofit Plan for Water Resources Inventory Area (WRIA) 9 and Estimation of Costs for Retrofitting all Developed Lands of Puget Sound; U.S. Environmental Protection Agency and King County (WA); $243,619; 2010-13.

Ultra-Urban Stormwater Management; Seattle Public Utilities; $1,130,000; 1999-2008.*

Roadside Vegetation Management Study; Washington State Department of Transportation; $50,000; 2004-05.

The Ecological Response of Small Streams to Stormwater and Stormwater Controls; U. S. Environmental Protection Agency, cooperating with Watershed Management Institute (Crawfordsville, FL); $579,117; 1995-2003.*

Vegetated Stormwater Facility Maintenance; Washington State Department of Transportation; $86,000; 1998-2000.*

Roadside Drainage System Management for Water Quality Improvement; King and Snohomish (WA) Counties; $70,000; 1997-2000.*

Standardization of Wet Weather Protocols for Stream Impact and Treatment Technology Performance Assessments; Water Environment Research Foundation, cooperating with Water Research Center (Huntington Valley, Pennsylvania) and University of Illinois; $125,000; 1996-97.

Road Shoulder Treatments for Water Quality Protection; Washington State Department of Transportation and King County Roads Division; $90,000; 1995-96.**

Control of Nuisance Filamentous Algae in Streams by Invertebrate Grazing; National Science Foundation; $193,691; 1994-96.

Criteria for Protection of Urban Stream Ecosystems; Washington Department of Ecology; $230,000; 1994-96.

Region-Specific Time-Scale Toxicity in Aquatic Ecosystems; Water Environment Research Foundation, cooperating with Water Research Center (Huntington Valley, Pennsylvania) and University of Illinois; $670,000; 1994-96.

Establishing Reference Conditions for Freshwater Wetlands Restoration; U. S. Environmental Protection Agency; $75,000; 1993-97.

Stormwater Management Technical Assistance to Local Governments; Washington Department of Ecology; $115,000; 1992-93.*

Center for Urban Water Resources Management; Washington Department of Ecology; $336,490; plus $157,400 matching support from seven local governments; 1990-93.*

University of Washington Cooperative Unit for Wetlands and Water Quality Research; King County, Washington; amount varied by year; 1987-95.*

Assessment of Portage Bay Combined Sewer Overflows; City of Seattle; $132,676; 1990-91.*

Velocity-Related Critical Phosphorus Concentrations in Flowing Water, Phase 3; National Science Foundation; $108,332; 1988-90.**

Design of Monitoring Programs for Determining Shellfish Bed Bacterial Contamination Problems; Washington Department of Ecology; $12,000; 1988-89.*

Puget Sound Protocols Development; Tetra Tech, Inc. and Puget Sound Estuary Program; $10,144; 1988.*

Improving the Cost Effectiveness of Highway Construction Site Erosion/ Pollution Control, Phase 2; Washington State Department of Transportation; $97,000; 1987-89.*

Wetland Mitigation Project Analysis; Washington State Department of Transportation; $74,985; 1987-89.*

Lake Chelan Water Quality Assessment; Harper-Owes, consultant to Washington State Department of Ecology; $42,977; 1986-88.

Quality of Management of Silver Lake; City of Everett; $67,463; 1986-88.

Effectiveness of WSDOT Wetlands Creation Projects; Washington State Department of Transportation; $42,308; 1986-87.*

Improving the Cost Effectiveness of Highway Construction Site Erosion/Pollution Control; Washington State Department of Transportation; $41,608; 1986-87.*

Management Significance of Bioavailable Phosphorus in Urban Runoff; State of Washington Water Research Center and Municipality of Metropolitan Seattle; $32,738; 1986-87.**

Environmental Monitoring and Evaluation of Calcium Magnesium Acetate (CMA); Transportation Research Board of National Academy of Sciences; $199,943; 1985-87.*

Conceptual Design of Monitoring Programs for Determination of Water Quality and Ecological Change Resulting from Nonpoint Source Discharges; Washington State Department of Ecology; $49,994; 1985-86.**

Development of an Integrated Land Treatment Approach for Improving the Quality of Metalliferous Mining Wastewaters; Washington Mining and Mineral Resources Research Institute; $4,000; 1985-86.*

Preliminary Investigation of Sewage Sludge Utilization on Roadsides; Washington State Department of Transportation; $6,664; 1984-85.*

Source Control of Transit Base Runoff Pollutants; Municipality of Metropolitan Seattle; $26,867; 1984-85.**

Lake Sammamish Future Water Quality; Municipality of Metropolitan Seattle; $28,500; 1984-85.

Implementation of Highway Runoff Water Quality Research Results; Washington State Department of Transportation; $13,998; 1984-85.*

Performance Evaluation of a Detention Basin and Coalescing Plate Oil Separator for Treating Urban stormwater Runoff; Washington State Water Research Center; 1984-85; $11,724.**

Velocity-Related Critical Phosphorus Concentrations in Flowing Water, Phase 2; National Science Foundation; $99,088; 1983-85.**

Development of a Biological Overland Flow System for Treating Mining Wastewaters; Washington Mining and Mineral Resources Research Institute; $6,030; 1983-84.*

Nutrient Contributions of Agricultural Sites to the Moses Lake System; Moses Lake Conservation District; $15,039; 1982-84.*

Planning Implementation of Runoff Water Quality Research Findings; Washington State Department of Transportation; $12,735; 1982-83.**

Transport of Agricultural Nutrients to Moses Lake; Brown and Caldwell Engineers; $22,725; 1982-83.**

Investigation of Toxicant Concentration and Loading Effects on Aquatic Macroinvertebrates; University of Washington Graduate School Research Fund; $3,788; 1982.*

Sampling Design for Aquatic Ecological Monitoring; Electric Power Research Institute; $542,008; 1981-86.

Velocity-Related Critical Phosphorus Concentrations in Flowing Water; National Science Foundation; $70,310; 1980-82.

Highway Runoff Water Quality; Washington State Department of Transportation; $461,176; 1977-82.

BOOKS

Shaver, E., R. Horner, J. Skupien, C. May, and G. Ridley. *Fundamentals of Urban Runoff Management: Technical and Institutional Issues*, 2nd Edition. U.S. Environmental Protection Agency, Washington, D.C., 2007.

Azous, A. L. and R. R. Horner. *Wetlands and Urbanization: Implications for the Future*. Lewis Publishers, Boca Raton, FL, 2000.

Horner, R. R., J. J. Skupien, E. H. Livingston, and H. E. Shaver. *Fundamentals of Urban Runoff Management: Technical and Institutional Issues*. Terrene Institute, Washington, D. C., 1994.

REFEREED JOURNAL PUBLICATIONS AND BOOK CHAPTERS

Wright, O.M., E. Istanbulluoglu, R.R. Horner, C.L. DeGasperi, and J. Simmonds. 2018. Is There a Limit to Bioretention Effectiveness? Evaluation of Stormwater Bioretention Treatment Using a Lumped Ecohydrologic Watershed Model and Ecologically-Based Design Criteria. *Hydrological Processes* 2018:1-17.

Chapman, C. and R.R. Horner. Performance Assessment of a Street-Drainage Bioretention System. *Water Environment Research* 82(2): 109-119, 2010.

Horner, R. R. et al. Structural and Non-Structural Best Management Practices (BMPs) for Protecting Streams. In *Linking Stormwater BMP Designs and Performance to Receiving Water Impact Mitigation*, B. K. Urbonas (ed.), American Society of Civil Engineers, New York, pp. 60-77, 2002.

Comings, K. J., D. B. Booth, and R. R. Horner. Storm Water Pollutant Removal by Two Wet Ponds in Bellevue, Washington. *Journal of Environmental Engineering* 126(4):321-330, 2000.

Anderson, E. L., E. B. Welch, J. M. Jacoby, G. M. Schimek, and R. R. Horner. Periphyton Removal Related to Phosphorus and Grazer Biomass Level. *Freshwater Biology* 41:633-651, 1999.

Horner, R. R., D. B. Booth, A. Azous, and C. W. May. Watershed Determinants of Ecosystem Functioning. In *Effects of Watershed Development and Management on Aquatic Ecosystems*, L. A. Roesner (ed.), American Society of Civil Engineers, New York, pp. 251-274, 1997.

Horner, R.R. Toward Ecologically Based Urban Runoff Management. In *Urban Runoff and Receiving Systems*, E.E. Herricks (ed.), Lewis Publishers, Boca Raton, Florida, pp. 365-378, 1995.

Walton, S. P., E. B. Welch, and R. R. Horner. Stream Periphyton Response to Grazing and Changes in Phosphorus Concentration. *Hydrobiologia* 302:31-46, 1994.

Reinelt, L. E. and R. R. Horner. Pollutant Removal from Stormwater Runoff by Palustrine Wetlands Based on a Comprehensive Budget. *Ecological Engineering* 4:77-97, 1995.

Horner, R.R. and M.V. Brenner. Environmental Evaluation of Calcium Magnesium Acetate for Highway Deicing Applications. *Resources, Conservation and Recycling* 7:213-237, 1992.

Brenner, M.V. and R.R. Horner. Effects of Calcium Magnesium Acetate on Dissolved Oxygen in Water. *Resources, Conservation and Recycling* 7:239-265, 1992.

Reinelt, L.E., R.R. Horner, and R. Castensson. Nonpoint Source Water Quality Management: Improving Decision-Making Information through Water Quality Monitoring. *Journal of Environmental Management* 34:15-30, 1992.

Horner, R.R., M.V. Brenner, R.B. Walker, and R.H. Wagner. Environmental Evaluation of Calcium Magnesium Acetate. In *Calcium Magnesium Acetate (CMA): An Emerging Bulk Chemical for Multi-purpose Environmental Applications*, D.L. Wise, Y.A. Lavendis, and M. Metghalchi (eds.), Elsevier Science Publishers B.V., The Netherlands, pp. 57-102, 1991.

Horner, R.R., E.B. Welch, M.R. Seeley, and J.M. Jacoby. Responses of Periphyton to Changes in Current Velocity, Suspended Sediments and Phosphorus Concentration. *Freshwater Biology* 24:215-232, 1990.

Horner, R.R. Long-Term Effects of Urban Stormwater on Wetlands. In *Design of Urban Runoff Quality Controls*, L.A. Roesner, B. Urbonas, and M.B. Sonnen (eds.), American Society of Civil Engineers, New York, pp. 451-466, 1989.

Welch, E.B., R.R. Horner, and C.R. Patmont. Phosphorus Levels That Cause Nuisance Periphyton: A Management Approach. *Water Research* 23(4):401-405, 1989.

Butkus, S.R., E.B. Welch, R.R. Horner, and D.E. Spyridakis. Lake Response Modeling Using Biologically Available Phosphorus. *Journal of the Water Pollution Control Federation* 60(9):1663-1669, 1988.

Reinelt, L.E., R.R. Horner, and B.W. Mar. Nonpoint Source Pollution Monitoring Program Design. *Journal of Water Resources Planning and Management* 114(3):335-352, 1988.

Welch, E.B., J.M. Jacoby, R.R. Horner, and M.R. Seeley. Nuisance Biomass Levels of Periphytic Algae in Streams. *Hydrobiologia*, 157:161-168, 1988.

Reinelt, L.E., R. Castensson, and R.R. Horner. Modification of an Existing Monitoring Program to Address Nonpoint Source Pollution, A Case Study of the Svarta River Basin, Sweden. *Vatten* 43:199-208, 1987.

Mar, B.W., R.R. Horner, J.S. Richey, D.P. Lettenmaier, and R.N. Palmer. Data Acquisition, Cost-Effective Methods for Obtaining Data on Water Quality. *Environmental Science and Technology* 20(6):545-551, 1986.

Horner, R.R., J.S. Richey, and G.L. Thomas. A Conceptual Framework to Guide Aquatic Monitoring Program Design for Thermal Electric Power Plants. *Rationale for Sampling and Interpretation of Ecological Data in the Assessment of Freshwater Ecosystems*, Special Technical Publication 894 of the American Society for Testing and Materials, Philadelphia, Pennsylvania, pp. 86-100, 1986.

Welch, E.B., D.E. Spyridakis, J.I. Shuster, and R.R. Horner. Declining Lake Sediment Phosphorus Release and Oxygen Deficit Following Wastewater Diversion. *Journal of the Water Pollution Control Federation* 58(1):92-96, 1986.

Richey, J.S., B.W. Mar, and R.R. Horner. The Delphi Technique in Environmental Assessment, Part 1: Implementation and Effectiveness. *Journal of Environmental Management* 21:135-146, 1985.

Richey, J.S., R.R. Horner, and B.W. Mar. The Delphi Technique in Environmental Assessment, Part 2: Consensus on Critical Issues in Environmental Monitoring Program Design. *Journal of Environmental Management* 21:147-159, 1985.

Horner, R.R. and B.W. Mar. Assessing Impacts of Operating Highways on Aquatic Ecosystems. *Transportation Research Record* 1017:47-55, 1985.

Horner, R.R., E.B. Welch, and R.B. Veenstra. Development of Nuisance Periphytic Algae in Laboratory Streams in Relation to Enrichment and Velocity. In *Periphyton of Freshwater Ecosystems*, R.G. Wetzel (ed.), Dr. W. Junk BV, the Hague, The Netherlands, pp. 121-134, 1983.

Horner, R.R. and B.W. Mar. A Guide for Assessing Water Quality Impacts of Highway Operations and Maintenance. *Transportation Research Record* 948:31-40, 1983.

Chui, T.W., B.W. Mar, and R.R. Horner. A Pollutant Loading Model for Highway Runoff. *Journal of Environmental Engineering Division*, ASCE 108:1193-1120, 1982.

Horner, R.R. and E.B. Welch. Stream Periphyton Development in Relation to Current Velocity and Nutrients. *Canadian Journal of Fisheries and Aquatic Sciences* 38:449-457, 1981.

REVIEWED PROCEEDINGS PUBLICATIONS

Horner, R. R. Stormwater Runoff Flow Control Benefits of Urban Drainage System Reconstruction According to Natural Principles. Presentation at Puget Sound—Strait of Georgia Research Conference, Vancouver, B. C., 2003.

May, C.W. and R.R. Horner. 2002. The Limitations of Mitigation-Based Stormwater Management in the Pacific Northwest and the Potential of a Conservation Strategy Based on Low-Impact Development Principles. Proc. 2002 ASCE Stormwater Conference, Portland, OR.

Horner, R. R. and C. R. Horner. Performance of a Perimeter ("Delaware") Sand Filter in Treating Stormwater Runoff from a Barge Loading Terminal. Proc. Comprehensive Stormwater and Aquatic Ecosystem Management Conf.; Auckland, New Zealand; February 1999, pp. 183-192, 1999.

Horner, R. R. and C. W. May. Regional Study Supports Natural Land Cover Protection as Leading Best Management Practice for Maintaining Stream Ecological Integrity. Proc. Comprehensive Stormwater and Aquatic Ecosystem Management Conf.; Auckland, New Zealand; February 1999, pp. 233-248, 1999.

Horner, R. R. Constructed Wetlands for Urban Runoff Water Quality Control. Proc. National Conf. on Urban Runoff Management; Chicago, Illinois; March 1993, pp. 327-340, 1995.

Horner, R. R. Training for Construction Site Erosion Control and Stormwater Facility Inspection. Proc. National Conf. on Urban Runoff Management; Chicago, Illinois; March 1993, pp. 426-450, 1995.

Horner, R. R. Overview of the Puget Sound Wetlands and Stormwater Management Research Program. Proc. Puget Sound Water Quality Authority Research Meeting; Seattle, Washington; January 1995, pp. 141-145, 1995.

Horner, R. R. and L. E. Reinelt. Guidelines for Managing Urban Wetlands. Proc. Puget Sound Water Quality Authority Research Meeting; Seattle, Washington; January 1995, pp. 171-178, 1995.

Taylor, B. K. Ludwa, and R. R. Horner. Urbanization Effects on Wetland Hydrology and Water Quality. Proc. Puget Sound Water Quality Authority Research Meeting; Seattle, Washington; January 1995, pp. 146-154, 1995.

Reinelt, L.E. and R.R. Horner. Urban Stormwater Impacts on the Hydrology and Water Quality of Palustrine Wetlands in the Puget Sound Region. Proc. Puget Sound Water Quality Authority Research Meeting; Seattle, Washington; January 1991; pp. 33-42.

Horner, R.R. Environmental Effects of Calcium Magnesium Acetate, Emphasizing Aquatic Ecosystem Effects. Proc. Conf. on Environmental Impacts of Highway Deicing, Institute of Ecology Publication No. 33, University of California, Davis; 1990; pp. 97-119.

Stockdale, E.C. and R.R. Horner. Using Freshwater Wetlands for Stormwater Management: A Progress Report. Proc. Wetlands 1988: Urban Wetlands and Riparian Habitat Symposium; Oakland, California, June 1988.

Horner, R.R. Highway Construction Site Erosion and Pollution Control: Recent Research Results. Proc. 39th Annual Road Builders' Clinic; Moscow, Idaho; March 1988; pp. 37-54.

Horner, R.R., F.B. Gutermuth, L.L. Conquest, and A.W. Johnson. Urban Stormwater and Puget Trough Wetlands. Proc. 1st Annual Meeting on Puget Sound Research; Seattle, Washington; March 1988; pp. 723-746.

Weiner, R.F., R.R. Horner, and J. Kettman. Preliminary Comparative Risk Assessment for Hanford Waste Sites. Proc. Waste Management 88; Tucson, Arizona; February 1988.

Stockdale, E.C. and R.R. Horner. Prospects for Wetlands Use in Stormwater Management. Proc. Coastal Zone 87 Conf.; Seattle, Washington; May 1987; pp. 3701-3714.

Horner, R.R. A Review of Wetland Water Quality Functions, Proc. Conf. on Wetland Functions, Rehabilitation, and Creation in the Pacific Northwest: The State of Our Understanding; Port Townsend, Washington; May 1986; pp. 33-50.

Bain, R.C., Jr., R.R. Horner, and L. Nelson. Nonpoint Pollution Control Strategies for Moses Lake, Washington. Proc. Fifth Annual Conf. North American Lake Management Society; Lake Geneva, Wisconsin; November 1985; pp. 170-176.

Shuster, J.I., E.B. Welch, R.R. Horner, and D.E. Spyridakis. Response of Lake Sammamish to Urban Runoff Control. Proc. Fifth Annual Conf. North American Lake Management Society; Lake Geneva, Wisconsin; November 1985; pp. 229-234.

Horner, R.R., J.S. Richey, and B.W. Mar. A General Approach to Designing Environmental Monitoring Programs. Proc. Pacific Section AAAS Sym. on Biomonitors, Bioindicators and Bioassays of Environmental Quality; Missoula, Montana; June 1985.

Horner, R.R. Improvement of Environmental Impact Assessment of Nonpoint Sources of Water Pollution. Proc. Non-point Pollution Abatement Sym.; Milwaukee, Wisconsin; April 1985.

Horner, R.R., E.B. Welch, M.M. Wineman, M.J. Adolfson, and R.C. Bain, Jr. Nutrient Transport Processes in an Agricultural Watershed. Proc. Fourth Annual Conf. North American Lake Management Society; McAfee, New Jersey; October 1984; pp. 221-228.

Horner, R.R. and B.W. Mar. A Predictive Model for Highway Runoff Pollutant Concentrations and Loadings. Proc. Stormwater and Water Quality Management Model Users' Group Meeting. EPA 600/9-82-015; Alexandria, Virginia; March 1982; pp. 210-224.

TECHNICAL REPORTS

Horner, R.R. Development of a Stormwater Retrofit Plan for Water Resources Inventory Area 9: Flow and Water Quality Indicators and Targets. King County Water and Land Resources Division, Seattle, Washington, 2013.

Horner, R.R. and J. Gretz. Investigation of the Feasibility and Benefits of Low-Impact Site Design Practices Applied to Meet Various Potential Stormwater Runoff Regulatory Standards. Report to U.S. Environmental Protection Agency by Natural Resources Defense Council, 2011.

Horner, R.R. Section 4-2, Protection and Restoration Strategies for Watersheds and Tributaries; Chapter 4: A Science-Based Review of Ecosystem Protection and Restoration Strategies for Puget Sound and Its Watersheds; Puget Sound Science Update. Puget Sound Partnership, Tacoma, WA, 2010.

Garrison, N., R.C. Wilkinson, and R. Horner. How Greening California Cities Can Address Water Resources and Climate Challenges in the 21st Century. Natural Resources Defense Council, 2009.

Horner, R. R. Supplementary Investigation of the Feasibility and Benefits of Low-Impact Site Design Practices ("LID") for the San Francisco Bay Area. Natural Resources Defense Council, 2009.

Horner, R. R. Initial Investigation of the Feasibility and Benefits of Low-Impact Site Design Practices ("LID") for the San Francisco Bay Area. Natural Resources Defense Council, 2009.

Horner, R. R. Investigation of the Feasibility and Benefits of Low-Impact Site Design Practices ("LID") for Ventura County. Natural Resources Defense Council, 2008.

Horner, R. R. and C. Chapman. NW 110th Street Natural Drainage System Performance Monitoring, With Summary of Viewlands and 2nd Avenue NW SEA Streets Monitoring. Report to City of Seattle Public Utilities, 2007.

Horner, R. R. Investigation of the Feasibility and Benefits of Low-Impact Site Design Practices ("LID") for the San Diego Region. Natural Resources Defense Council, 2006.

Horner, R. R. SPU Drainage Rate Analysis Options: Recommendations on Certain Technical Issues. Report to City of Seattle Public Utilities, 2005.

Hill, K. and R. Horner. Assessment Of Alternatives In Roadside Vegetation Management. Report to Washington State Department of Transportation, 2005.

Horner, R. R. and Entranco, Inc. Regional Detention Facilities Retrofit Project: Evaluation of Regional Stormwater Ponds for Water Quality Improvements. Report to City of Bellevue Utilities Department, 2005.

Horner, R. R. and T. Osborn. Removal of Fecal Coliforms from Stormwater Runoff: A Literature Review. Report to City of Blaine, 2005.

Horner, R.R., H. Lim, and S.J. Burges. Hydrologic Monitoring of the Seattle Ultra-Urban Stormwater Management Projects: Summary of the 2000-2003 Water Years, Water Resources Series Technical Report Number 181. Department of Civil and Environmental Engineering, University of Washington, Seattle, WA. Report to City of Seattle Public Utilities, 2004.

Horner, R.R., C.W. May, and E.H. Livingston. Linkages Between Watershed and Stream Ecosystem Conditions in Three Regions of the United States. Report to U.S. Environmental Protection Agency by Watershed Management Institute, Inc., Crawfordville, FL, 2003.

Karr, J. R., R. R. Horner, and C R. Horner. EPA's Review of Washington's Water Quality Criteria: An Evaluation of Whether Washington's Criteria Proposal Protects Stream Health and Designated Uses. Report to National Wildlife Federation, 2003.

Horner, R.R., H. Lim, and S.J. Burges. Hydrologic Monitoring of the Seattle Ultra-Urban Stormwater Management Projects, Water Resources Series Technical Report Number 170. Department of Civil and Environmental Engineering, University of Washington, Seattle, WA. Report to City of Seattle Public Utilities, 2002.

Miller, A.V., S.B. Burges, and R.R. Horner. Hydrologic Monitoring of the Seattle Ultra-Urban Stormwater Management Projects, Water Resources Series Technical Report Number 166. Department of Civil and Environmental Engineering, University of Washington, Seattle, WA. Report to City of Seattle Public Utilities, 2001.

Mills, M. and R. R. Horner. Comprehensive Ditch and Culvert Program. Report to City of Seattle Public Utilities, 2001.

Colwell, S., R. R. Horner, D. B. Booth, and D. Gilvydis. A Survey of Ditches Along County Roads for Their Potential to Affect Storm Runoff Water Quality. Report to Snohomish County Surface Water Management Division, Snohomish County Road Maintenance, King County Land and Water Resources Division, King County Department of Transportation Road Maintenance, 2000.

Cammermayer, J. W. and R. R. Horner. Vegetated Stormwater Facility Maintenance. Report to Washington State Department of Transportation, WA-RD-495.1, 2000.

Azous, A. L. and R. R. Horner (eds.). Wetlands and Urbanization: Implications for the Future. Report to Washington Department of Ecology, 1997.

May, C. W., E. B. Welch, R. R. Horner, J. R. Karr, and B. W. Mar. Quality Indices for Urbanization Effects in Puget Sound Lowland Streams. Report to Washington Department of Ecology, 1997.

Livingston, E. H., H. E. Shaver, J. J. Skupien, and R. R. Horner. Operation, Maintenance, and Management of Stormwater Management Systems. Report to U. S. Environmental Protection Agency, 1997.

Livingston, E. H., H. E. Shaver, R. R. Horner, and J. J. Skupien,. Watershed Management Institute. Institutional Aspects of Urban Runoff Management: A Guide for Program Development and Implementation. Report to U. S. Environmental Protection Agency, 1997.

St. John, M. S. and R. R. Horner. Effect of Road Shoulder Treatments on Highway Runoff Quality and Quantity. Report to Washington State Department of Transportation, WA-RD-429.1, 1997.

Horner, R.R. Storm Drainage Water Quality Rate Basis Recommendations. Report to City of Bellevue Utilities Department, 1996.

Horner, R. R. and C. R. Horner. Impacts on Aquatic Ecosystems and Organisms of Airplane and Airport Runway Deicing Chemicals. Report to Port of Seattle, Seattle, Washington, 1996.

Horner, R. R. Constituents and Sources of Water Pollutants in Urban Stormwater Runoff. Report to Natural Resources Defense Council, Los Angeles, California, 1995.

Horner, R. R. Program Recommendations and Review of Submittals for Los Angeles County Stormwater NPDES Compliance. Report to Natural Resources Defense Council, Los Angeles, California, 1995.

Horner, R. R. and C. R. Horner. Design, Construction, and Evaluation of a Sand Filter Stormwater Treatment System, Part II, Performance Monitoring. Report to Alaska Marine Lines, Seattle, Washington, 1995.

Horner, R. R. Review of Draft Design Memorandum, Lakemont Boulevard Extension. Report to City of Bellevue, Washington, 1995.

Economic and Engineering Services, Inc. and R. R. Horner. Wetpond Restoration for Water Quality Enhancement. Report to City of Bellevue, Washington and Washington Department of Ecology, 1995.

City of Bellevue Utilities Department (R. R. Horner contributing author). Characterization and Source Control of Urban Stormwater Quality. Report to Washington Department of Ecology, 1995.

Horner, R. R. Constituents and Sources of Water Pollutants in Highway Stormwater Runoff. Report to Natural Resources Defense Council, Los Angeles, California, 1994.

Horner, R. R. Program Recommendations and Review of California Department of Transportation Submittals for Santa Monica Bay Watershed Stormwater NPDES Compliance, Support Materials. Report to Natural Resources Defense Council, Los Angeles, California, 1994.

Horner, R. R. Peer Review of Assessment of Potential Impacts from Sediment and Phosphorus Loading to Lewis Creek and Lake Sammamish - Lakemont Boulevard Extension Project. Report to City of Bellevue, Washington, 1994.

Horner, R. R. Review of the Literature on Constructed Wetlands for Municipal Wastewater Treatment. Report to Kramer, Chin and Mayo, Inc., Seattle, Washington, 1994.

Engineering Technologies Associates, Inc. and R. R. Horner. Conceptual Framework for Hydrograph Classification. Report to Water Research Center, Huntington Valley, Pennsylvania, 1994.

Horner, R. R. Phantom Lake Stormwater Controls Evaluation, Review of Water Quality Data and Literature. Report to CH2M-Hill, City of Bellevue Storm and Surface Water Utility, and Boeing Computer Services Corporation, Bellevue, Washington, 1993.

Horner, R. R. Boeing Customer Service Training Center Stormwater Quality Monitoring and Assessment Program. Report to Boeing Commercial Airplane Company, Sverdrup Corporation, and City of Renton, Washington, 1992.

Welch, E.B., R.J. Totorica and R.R. Horner. Approach to Developing Nutrient Loading Criteria for Franklin D. Roosevelt Lake. Report to Washington Department of Ecology, Olympia, 1992.

Municipality of Metropolitan Seattle (R. R. Horner contributing author). Biofiltration Swale Performance, Recommendations, and Design Considerations. Report to Washington Department of Ecology, Olympia, 1992.

Horner, R.R. and P. Kalina. Water Quality Assessment of Portage Bay. Report to City of Seattle, 1991.

Horner, R.R. and C.R. Horner. Transport and Fate of Metal and Organic Toxicants in Arid-Region Wetlands. Report to U.S. Environmental Protection Agency, Corvallis Laboratory, 1991.

King County Resource Planning Section (R. R. Horner contributing author). Development of Guidance for Managing Urban Wetlands and Stormwater. Report to Washington Department of Ecology, Olympia, 1991.

Horner, R.R. and C.R. Horner. Use of Underdrain Filter Systems for the Reduction of Stormwater Runoff Pollutants: A Literature Review. Report to Kramer, Chin and Mayo, Inc., 1990.

Reinelt, L.E. and R.R. Horner. Characterization of the Hydrology and Water Quality of Palustrine Wetlands Affected by Urban Stormwater. Report prepared for the Puget Sound Wetlands and Stormwater Management Research Program, Seattle, WA, 1990.

Horner, R. R. Analysis of Proposed Surface Water Source Control Requirements for the Commencement Bay Nearshore/Tideflats Superfund Area. Report to Port of Tacoma, Washington, 1989.

Horner, R.R. and K.J. Raedeke. Guide for Wetland Mitigation Project Monitoring. Report to Washington State Department of Transportation, 1989.

Horner, R.R., J. Guedry, and M.H. Kortenhof. Improving the Cost-Effectiveness of Highway Construction Site Erosion and Pollution Control. Report to Washington State Department of Transportation, 1989.

Horner, R.R., J. Guedry, and M.H. Kortenhof. Highway Construction Site Erosion and Pollution Control Manual. Report to Washington State Department of Transportation, 1989.

Horner, R.R., M.V. Brenner, and C.A. Jones. Design of Monitoring Programs for Determining Sources of Shellfish Bed Bacterial Contamination Problems. Report to Washington Department of Ecology, 1989.

Horner, R. R. and C. R. Horner. A Technical Review of the Sediment/Toxicant Retention and Nutrient Removal Transformation Functions of WET 2.0. Report to AScI Corporation and U. S. Environmental Protection Agency, Duluth, Minnesota, 1989.

Horner, R. R. and M. Benjamin. Washington State Pulp and Paper Plant Water Treatment Effluent Limitations. Report to Technical Resources, Inc., Rockville, Maryland, 1988.

Tetra Tech, Inc., University of Washington (R.R. Horner), and Battelle Pacific Northwest Laboratories. Recommended Protocols for Measuring Conventional Water Quality Variables and Metals in Fresh Waters of the Puget Sound Region. Report to Puget Sound Estuary Program, U.S. Environmental Protection Agency, Region 10, Seattle, 1988.

Horner, R.R. Biofiltration Systems for Storm Runoff Water Quality Control. Report to Municipality of Metropolitan Seattle, Seattle, 1988.

URS Consultants, R.R. Horner, Matrix Management Group, Weston/Northwest Cartography, and Water Resources Associates. City of Puyallup Stormwater Management Program. Report to City of Puyallup, 1988.

Welch, E.B., J. Oppenheimer, R.R. Horner, and D.E. Spyridakis. Silver Lake Water Quality Nutrient Loading and Management. Report to City of Everett, 1988.

Horner, R.R. Environmental Monitoring and Evaluation of Calcium Magnesium Acetate (CMA)--Final Report. Report to National Research Council, National Academy of Sciences, 1988.

Horner, R.R., E.B. Welch, S.R. Butkus, and D.E. Spyridakis. Management Significance of Bioavailable Phosphorus. Report to Municipality of Metropolitan Seattle and State of Washington Water Research Center, 1987.

Horner, R.R. and S.E. Cassatt. Effectiveness of Wetlands Creation in Mitigating Highway Impacts. Report to Washington State Department of Transportation, 1987.

Horner, R.R. and M.H. Kortenhof. Improving the Cost-Effectiveness of Highway Construction Site Erosion/Pollution Control, Phase 1. Report to Washington State Department of Transportation, 1987.

Horner, R.R., B.W. Mar, L.E. Reinelt, and J.S. Richey. Design of Monitoring Programs for Determination of Ecological Change Resulting from Nonpoint Source Water Pollution in Washington State. Report to Washington State Department of Ecology, 1986.

Horner, R.R., E.B. Welch, M.R. Seeley, and J.M. Jacoby. Velocity-Related Critical Phosphorus Concentrations in Flowing Water, Phase II. Report to National Science Foundation, 1986.

Horner, R.R., J.S. Richey, and D.P. Lettenmaier. Source Control of Transit Base Runoff Pollutants--Final Report. Report to Municipality of Metropolitan Seattle, 1985.

Welch, E.B., R.R. Horner, D.E. Spyridakis, and J.I. Shuster. Response of Lake Sammamish to Past and Future Phosphorus Loading. Report to Municipality of Metropolitan Seattle, 1985.

Horner, R.R. and S.R. Wonacott. Performance Evaluation of a Detention Basin and Coalescing Plate Oil Separator for Treating Urban Stormwater Runoff. Report to State of Washington Water Research Center and U.S. Geological Survey, 1985.

Cahn, D.C. and R.R. Horner. Preliminary Investigation of Sewage Sludge Utilization in Roadside Development. Report to Washington State Department of Transportation, 1985.

Horner, R.R. Highway Runoff Water Quality Research Implementation Manual, Vol. 1-2, FHWA WA-RD 72.1,2. Report to Washington State Department of Transportation, 1985.

Horner, R.R. Suggested Revisions to WSDOT Manuals for Implementing Washington State Highway Runoff Water Quality Research Results, FHWA WA-RD 72.3. Report to Washington State Department of Transportation, 1985.

Mar, B.W., D.P Lettenmaier, R.R. Horner, J.S. Richey, R.N. Palmer, S.P. Millard, and M.C. MacKenzie. Sampling Design for Aquatic Ecological Monitoring, Vol. 1-5. Final Report on Electric Power Research Institute, Project RP1729-1, 1985.

Horner, R.R., J.S. Richey, D.P. Lettenmaier, and J.F. Ferguson. Source Control of Transit Base Runoff Pollutants, Task 1--Interim Report. Report to Municipality of Metropolitan Seattle, 1984.

Brown and Caldwell Engineers and R.R. Horner. Moses Lake Clean Lake Project, Phase I. Report to Moses Lake Irrigation and Rehabilitation District, 1984.

Mar, B.W., D.P. Lettenmaier, J.S. Richey, R.R. Horner, R.N. Palmer, S.P. Millard, and G.L. Thomas. Sampling Design for Aquatic Ecological Monitoring, Phase II--Methods Development, Vol. 1-2. Report to Electric Power Research Institute, 1984.

Horner, R.R. Highway Runoff Water Quality Technology Transfer Workshop Handbook. Prepared for Washington State Department of Transportation, 1983.

Pedersen, E.R., R.R. Horner, and G.L. Portele. SR 528 - 4th Street Extension, Marysville, Snohomish County, Washington: Draft Environmental Impact Statement. Prepared for City of Marysville, 1983.

Horner, R.R., B.W. Mar, B. Chaplin, and F. Conroy. Implementation Plan for Highway Runoff Water Quality Research Results. Report to Washington State Department of Transportation, 1983.

Little, L.M., R.R. Horner, and B.W. Mar. Assessment of Pollutant Loadings and Concentrations in Highway Stormwater Runoff, FHWA WA-RD-39.17. Report to Washington State Department of Transportation, 1983.

Horner, R.R., and E.B. Welch. Velocity-Related Critical Phosphorus Concentrations in Flowing Water. Final Report to National Science Foundation for award number (CME) 79-18514, 1982.

Horner, R.R., and E.B. Welch. Impacts of Channel Reconstruction on the Pilchuck River, FHWA WA-RD-39.15. Report to Washington State Department of Transportation, 1982.

Mar, B.W., R.R. Horner, J.F. Ferguson, D.E. Spyridakis, and E.B. Welch. Summary - Highway Runoff Water Quality, 1977-1982, FHWA WA-RD-39.16. Report to Washington State Department of Transportation, 1982.

Horner, R.R. and B.W. Mar. Guide for Water Quality Assessment of Highway Operations and Maintenance, FHWA WA-RD-39.14. Report to Washington State Department of Transportation, 1982.

Mar, B.W., D.P. Lettenmaier, R.R. Horner, D.M. Eggers, R.N. Palmer, G.J. Portele, J.S. Richey, E.B. Welch, G. Wiens, and J. Yearsley. Sampling Design for Aquatic Ecological Monitoring, Phase 1. Report to Electric Power Research Institute, 1982.

Portele, G.J., B.W. Mar, R.R. Horner, and E.B. Welch. Effects of Seattle, Area Highway Stormwater Runoff on Aquatic Biota, FHWA WA-RD-39.11. Report to Washington State Department of Transportation, 1982.

Wang, T.S., D.E. Spyridakis, B.W. Mar, and R.R. Horner. Transport, Deposition, and Control of Heavy Metals in Highway Runoff, FHWA WA-RD-39.10. Report to Washington State Department of Transportation, 1982.

Chui, T.W., B.W. Mar, and R.R. Horner. Highway Runoff in Washington State: Model Validation and Statistical Analysis, FHWA WA-RD-39.12. Report to Washington State Department of Transportation, 1981.

Mar, B.W., J.F. Ferguson, D.E. Spyridakis, E.B. Welch, and R.R. Horner. Year 4, Runoff Water Quality, August 1980-August 1981, FHWA WA-RD-39.13. Report to Washington State Department of Transportation, 1981.

Horner, R.R. and S.M. Grason. An Ecological Study of the Monocacy Creek and its Groundwater Sources in the Vicinity of Camels Hump. Report to the Monocacy Creek Watershed Association, Bethlehem, Pennsylvania, 1981.

Horner, R.R. and E.B. Welch. Background Conditions in the Lower Pilchuck River Prior to SR-2 Construction. Report to Washington State Department of Transportation, 1979.

Horner, R.R. and B.W. Mar. Highway Runoff Monitoring: The Initial Year, FHWA WA-RD-39.3. Report to Washington State Department of Transportation, 1979.

Horner, R.R. and E.B. Welch. Effects of Velocity and Nutrient Alterations on Stream Primary Producers and Associated Organisms, FHWA WA-RD-39.2. Report to Washington State Department of Transportation, 1978.

Horner, R.R., T.J. Waddle, and S.J. Burges. Review of the Literature on Water Quality Impacts of Highway Operations and Maintenance. Report to Washington State Department of Transportation, 1977.

Horner, R.R. A Method of Defining Urban Ecosystem Relationships Through Consideration of Water Resources. U.S. Man and the Biosphere Project 11 Report, 1977.

Horner, R.R. and R. Gilliom. Bear Lake: Current Status and the Consequences of Residential Development. Report to Bear Lake Residents' Association, Kitsap County, Washington, 1977.

PRESENTATIONS AND DISCUSSIONS

*Presented by a co-author. In all other cases, I presented the paper.

Stormwater Runoff Flow Control Benefits of Urban Drainage System Reconstruction According to Natural Principles. Puget Sound/Georgia Strait Research Meeting; Vancouver, British Columbia; April 2003.

Structural and Non-Structural Best Management Practices (BMPs) for Protecting Streams. Invited presentation at the Engineering Foundation Conference on Linking Stormwater BMP Designs and Performance to Receiving Water Impact Mitigation; Snowmass, Colorado; August 2001.

Performance of a Perimeter ("Delaware") Sand Filter in Treating Stormwater Runoff from a Barge Loading Terminal. Invited presentation at the Comprehensive Stormwater and Aquatic Ecosystem Management Conf.; Auckland, New Zealand; February 1999.

Regional Study Supports Natural Land Cover Protection as Leading Best Management Practice for Maintaining Stream Ecological Integrity. Invited presentation at the Comprehensive Stormwater and Aquatic Ecosystem Management Conf.; Auckland, New Zealand; February 1999.

Watershed Determinants of Ecosystem Functioning. Invited presentation at the Engineering Foundation Conference on Effects of Watershed Development on Aquatic EcosystemsUrban Runoff and Receiving Systems; Snowbird, Utah; August 1996.

Overview of the Puget Sound Wetlands and Stormwater Management Research Program. Puget Sound Water Quality Authority Research Meeting; Seattle, Washington; January 1995.

Guidelines for Managing Urban Wetlands. Puget Sound Water Quality Authority Research Meeting; Seattle, Washington; January 1995.

Urbanization Effects on Wetland Hydrology and Water Quality. Puget Sound Water Quality Authority Research Meeting; Seattle, Washington; January 1995 (prepared with B. Taylor and K. Ludwa).*

Constructed Wetlands for Urban Runoff Water Quality Control. Invited presentation at National Conf. on Urban Runoff Management; Chicago, Illinois; March 1993.

Training for Construction Site Erosion Control and Stormwater Facility Inspection. Invited presentation at National Conf. on Urban Runoff Management; Chicago, Illinois; March 1993.

Toward Ecologically Based Urban Runoff Management. Invited presentation at The Engineering Foundation Conference on Urban Runoff and Receiving Systems; Crested Butte, Colorado; August 1991.

How Stormwater Harms Shellfish. Invited presentation at the Pacific Rim Shellfish Sanitation Conference; Seattle, Washington; May 1991.

Environmental Evaluation of Calcium Magnesium Acetate for Highway Deicing Applications. Invited presentation at Conference on Calcium Magnesium Acetate, An Emerging Chemical for Environmental Applications; Boston, Massachusetts; May 1991.

Issues in Stormwater Management. Statement to State Senate Environment and Natural Resources Committee; Olympia, Washington; January 1991.

Urban Stormwater Impacts on the Hydrology and Water Quality of Palustrine Wetlands in the Puget Sound Region. Invited presentation at Puget Sound Water Quality Authority Research Meeting; Seattle, Washington; January 1991 (prepared with L.E. Reinelt).

The Impact of Nonpoint Source Pollution on River Ecosystems. Invited presentation at the Northwest Rivers Conference; Seattle, Washington; November 1990.

Research Program Overview and Discussion of Hydrologic and Water Quality Studies. Presented at the Puget Sound Wetlands and Stormwater Management Research Program Workshop; Seattle, Washington; October 1990.

Control of Urban Runoff Water Quality. Invited presentations at American Society of Civil Engineers Urban Stormwater Short Courses; Bellevue, Washington; April, 1990; Portland, Oregon; July 1990.

Various Aspects of Erosion Prevention and Control. Invited presentations at University of Wisconsin Erosion Control Short Course; Seattle, Washington; July 1990.

Examination of the Hydrology and Water Quality of Wetlands Affected by Urban Stormwater. Presented at the Society of Wetland Scientists Annual Meeting; Breckenridge, Colorado, June 1990 (prepared with L.E. Reinelt).*

Analysis of Plant Communities of Wetlands Affected by Urban Stormwater. Presented at the Society of Wetland Scientists Annual Meeting; Breckenridge, Colorado; June 1990 (prepared with S.S. Cooke).*

Environmental Evaluation of Calcium Magnesium Acetate. Invited presentation at the Symposium on the Environmental Impact of Highway Deicing; Davis, California; October 1989.

Application of Wetland Science Principles in the Classroom and Community. Invited presentation at the Annual Meeting of the Association of Collegiate Schools of Planning; Portland, Oregon; October 1989.

Structural Controls for Urban Storm Runoff Water Quality. Invited presentation at the Northwest Regional Meeting of the North American Lake Management Society; Seattle, Washington; September 1989.

The Puget Sound Wetlands and Stormwater Management Research Program. Invited presentation at the U.S. Environmental Protection Agency Workshop on Wetlands and Stormwater; Seattle, Washington; September 1989.

An Overview of Storm Runoff Water Quality Control. Invited presentation at the American Water Resources Association Workshop on Forest Conversion; LaGrande, Washington; November 1988.

Progress in Wetlands Research. Invited presentation at the Pacific Northwest Pollution Control Association Annual Meeting; Coeur d'Alene, Idaho; October 1988.

Long-Term Effects of Urban Stormwater on Wetlands. Invited presentation at the Engineering Foundation Conference on Urban Stormwater; Potosi, Missouri; July 1988.

Highway Construction Site Erosion and Pollution Control: Recent Research Results. Invited presentation at the 39th Annual Road Builders' Clinic; Moscow, Idaho; March 1988.

Urban Stormwater and Puget Trough Wetlands. Presented at the 1st Annual Puget Sound Water Quality Authority Research Meeting; Seattle, Washington; March 1988 (prepared with F.B. Gutermuth, L.L. Conquest, and A.W. Johnson).

Preliminary Comparative Risk Assessment for Hanford Waste Sites. Presented at Waste Management 88; Tucson, Arizona; February 1988 (prepared with R.F. Weiner and J. Kettman).*

What Goes on at the Hanford Nuclear Reservation? Invited presentation at the Northwest Association for Environmental Studies Annual Meeting; Western Washington University, Bellingham, WA; November 1987.

The Puget Sound Wetlands and Stormwater Management Research Program. Invited presentation at the Pacific Northwest Pollution Control Association Annual Meeting; Spokane, Washington; October 1987.

Design of Cost-Effective Monitoring Programs for Nonpoint Source Water Pollution Problems. Invited presentation at the American Water Resources Association, Puget Sound Chapter, Annual Meeting; Bellevue, Washington; November 1986.

A Review of Wetland Water Quality Functions. Invited plenary presentation at the Conference on Wetland Functions, Rehabilitation, and Creation in the Pacific Northwest: The State of Our Understanding; Port Townsend, Washington; May 1986.

Nonpoint Discharge and Runoff session leader. American Society of Civil Engineers Spring Convention; Seattle, Washington; April 1986.

Prevention of Lake Sammamish Degradation from Future Development. Invited presentation at the American Society of Civil Engineers Spring Convention; Seattle, Washington; April 1986.

Design of Monitoring Programs for Nonpoint Source Water Pollution Problems. Invited presentation at the American Society of Civil Engineers Spring Convention; Seattle, Washington, April 1986 (prepared with L.E. Reinelt, B.W. Mar, and J.S. Richey).*

Nonpoint Pollution Control Strategies for Moses Lake, Washington. Presented at the Fifth Annual Meeting of the North American Lake Management Society; Lake Geneva, Wisconsin; November 1985 (prepared with R.C. Bain, Jr., and L. Nelson).

Response of Lake Sammamish to Urban Runoff Control. Presented at the Fifth Annual Meeting of the North American Lake Management Society; Lake Geneva, Wisconsin; November 1985 (prepared with J.I. Shuster, E.B. Welch, and D.E. Spyridakis).*

A General Approach to Designing Environmental Monitoring Programs. Invited presentation at the Pacific Section AAAS Symposium on Biomonitors, Bioindicators, and Bioassays of Environmental Quality; Missoula, Montana; June 1985 (prepared with J.S. Richey and B.W. Mar).

Panel Discussion on the Planning Process for Non-point Pollution Abatement Programs. Non-point Pollution Abatement Symposium; Milwaukee, Wisconsin; April 1985.

Nutrient Transport Processes in an Agricultural Watershed. Presented at the Fourth Annual Meeting of the North American Lake Management Society; McAfee, New Jersey; October 1984 (prepared with E.B. Welch, M.M. Wineman, M.J. Adolfson, and R.C. Bain Jr.).*

Nutrient Transport Processes in an Agricultural Watershed. Presented at the American Society of Limnology and Oceanography Annual Meeting; Vancouver, British Columbia; June 1984 (prepared with M.M. Wineman, M.J. Adolfson, and R.C. Bain, Jr.).

Factors Affecting Periphytic Algal Biomass in Six Swedish Streams. Presented at the American Society of Limnology and Oceanography Annual Meeting; Vancouver, British Columbia; June 1984 (prepared with J.M. Jacoby and E.B. Welch).*

A Conceptual Framework to Guide Aquatic Monitoring Program Design for Thermal Electric Power Plants. Presented at the American Society for Testing and Materials Symposium on Rationale for Sampling and Interpretation of Ecological Data in the Assessment of Freshwater Ecosystems; Philadelphia, Pennsylvania; November 1983 (prepared with J.S. Richey, and G.L. Thomas).

Panel Discussion. Public Forum: Perspectives on Cumulative Effects; Institute for Environmental Studies; University of Washington; Seattle, Washington; August 1983.

A Guide for Assessing the Water Quality Impacts of Highway Operations and Maintenance. Presented at the Transportation Research Board Annual Meeting; Washington, D.C.; January 1983 (prepared with B.W. Mar).

Assessment of Pollutant Loadings and Concentrations in Highway Stormwater Runoff. Presented at the Pacific Northwest Pollution Control Association Annual Meeting; Vancouver, British Columbia; November 1982 (prepared with B.W. Mar and L.M. Little).

Phosphorus and Velocity as Determinants of Nuisance Periphytic Biomass. Presented at the International Workshop on Freshwater Periphyton (SIL); Vaxjo, Sweden; September 1982 (prepared with E.B. Welch and R.B. Veenstra).*

The Development of Nuisance Periphytic Algae in Laboratory Streams in Relation to Enrichment and Velocity. Presented at the American Society of Limnology and Oceanography Annual Meeting; Raleigh, North Carolina; June 1982 (prepared with R.B. Veenstra and E.B. Welch).

A Predictive Model for Highway Runoff Pollutant Concentrations and Loadings. Presented at the Stormwater and Water Quality Model Users' Group Meeting; Alexandria, Virginia; March 1982 (prepared with B.W. Mar).

Stream Periphyton Development in Relation to Current Velocity and Nutrients. Presented at American Society of Limnology and Oceanography Winter Meeting; Corpus Christi, Texas; January 1979 (prepared with E.B. Welch).

A Comparison of Discrete Versus Composite Sampling of Storm Runoff. Presented at the Northwest Pollution Control Association Annual Meeting; Victoria, British Columbia; October 1978 (prepared with B.W. Mar and J.F. Ferguson).*

A Method of Defining Urban Ecosystem Relationships Through Consideration of Water Resources. Presented at UNESCO International Man and the Biosphere Project 11 Conference; Poznan, Poland; September 1977.

GRADUATE AND UNDERGRADUATE COURSES TAUGHT (University of Washington)

Civil and Environmental Engineering 552, Environmental Regulations; 8 quarters.

Landscape Architecture 590, Urban Water Resources Seminar; 3 quarters.

Landscape Architecture 522/523, Watershed Analysis and Design; 15 quarters.

Engineering 260, Thermodynamics; 1 quarter.

Engineering 210, Engineering Statics; 2 quarters.

Civil Engineering/Water and Air Resources 453, Water and Wastewater Treatment; 1 quarter.

Civil Engineering/Water and Air Resources 599, Analyzing Urbanizing Watersheds; 1 quarter.

CONTINUING EDUCATION SHORT COURSES TAUGHT (University of Washington; multiple offerings)

Infiltration Facilities for Stormwater Quality Control

Wetlands Ecology, Protection, and Restoration

Storm and Surface Water Monitoring

Fundamentals of Urban Surface Water Management

Applied Stormwater Pollution Prevention Planning Techniques

Construction Site Erosion and Pollution Control Problems and Planning

Construction Site Erosion and Pollution Control Practices

Construction Site Erosion and Sediment Control Inspector Training

Inspection and Maintenance of Permanent Stormwater Management Facilities

Biofiltration for Stormwater Runoff Quality Control

Constructed Wetlands for Stormwater Runoff Quality Control

LOCAL COMMITTEES

Stormwater Panel advising Puget Sound Partnership, 2007.

Technical Advisory Committee, City of Seattle Environmental Priorities Project, 1990-91.

Environmental Toxicology Graduate Program Planning Committee, University of Washington, 1990.

Habitat Modification Technical Work Group, Puget Sound Water Quality Authority, 1987.

Underground Injection Control of Stormwater Work Group, Washington State Department of Ecology, 1987.

Nonpoint Source Pollution Conference Advisory Committee, 1986-87.

Puget Sound Wetlands and Stormwater Management Research Committee, 1986-90.

Accreditation Review, University of Washington Department of Landscape Architecture, 1986.

Planning Committee for University of Washington Institute for Environmental Studies Forum on Perspectives on Cumulative Environmental Effects, 1983.

CONSULTING

Columbia Riverkeeper and Northwest Environmental Defense Center; Portland Oregon; Assessment of Oregon Department of Environmental Quality's actions regarding setting Water Quality-Based Effluent Limits; 2020.

Coast Law Group, Encinitas, California; Technical assistance in a Clean Water Act legal case and expert testimony; 2019-2020.

Monterey County District Attorney, Monterey, California; Assessment of pollution issues at two construction company yards; 2019-2020.

Seneca Lake Guardian, Seneca Falls, New York; Assessment of potential water quality problems associated with an industrial plant; 2019.

Endangered Habitats League, Los Angeles, California; Assessment of stormwater management systems proposed for a large residential development; 2018-2019.

Ziontz Chestnut Law Firm, Seattle, Washington; Assistance with implementation of a court order on a settled case.

U.S. Department of Justice; Technical assistance in a Clean Water Act legal case; 2017-2018.

Kampmeier & Knutsen PLLC, Portland, Oregon; Technical assistance in a Clean Water Act legal case; 2017.

Black Warrior Riverkeeper, Birmingham, Alabama; Review and comment on a total maximum daily load assessment for the Black Warrior River; 2017.

DeLano and DeLano, Escondido, California; Assessment of stormwater management systems proposed for residential and commercial developments; 2012-present.

Salmon-Safe, Inc.; assessment of sites for possible certification representing practices that protect salmon; 2004-present.

Puget Soundkeeper Alliance and Smith and Lowney, PLC, Seattle, Washington; Technical assistance in Clean Water Act legal cases and expert testimony; 1996, 2002-present.

Natural Resources Defense Council, Los Angeles, California; Technical and program analysis and expert testimony on legal cases involving municipal and industrial stormwater NPDES permit compliance and assistance in reacting to California municipal stormwater permits; 1993-present.

Santa Monica Baykeeper (now Los Angeles Waterkeeper); Technical and program analysis and expert testimony on legal cases involving municipal and industrial stormwater NPDES permit compliance; 1993-present.

Orange County Coastkeeper; Assistance with legal cases involving industrial and construction site pollution control and monitoring and expert testimony; 2001-present.

Lawyers for Clean Water; Assistance with legal cases involving stormwater discharges and expert testimony; 2004-2018.

Earthjustice; Report and testimony regarding Washington state municipal stormwater permit before Pollution Control Hearing Board; 2008, 2013; assessment of Washington, DC combined sewer overflow control plan; 2015.

Tulane Environmental Law Clinic; Assessment and declaration on a legal case involving discharge under an industrial stormwater permit and expert testimony; 2015.

San Diego Coastkeeper, San Diego, California; Technical and program analysis and expert testimony on potential legal cases involving municipal and industrial stormwater NPDES permit compliance; liaison with City of San Diego; 1996-2011 and 2019.

Stillwater Science and Washington Department of Ecology; Water quality modeling for Puget Sound Characterization, Phase 2; 2010-2011.

City of Seattle Public Utilities; Analysis of technical aspects of stormwater management program; 2000-2008.

Ventura Coastkeeper; Technical and program analysis and expert testimony on legal cases involving municipal and industrial stormwater NPDES permit compliance; 2010-2015.

San Diego Airport Authority; Peer review of consultant products, training; 2004-2006.

U. S. Federal Court, Central District of California; Special master in Clean Water Act case; 2001-2002.

Storm Water Pollution Prevention Program, City of San Diego; Advising on response to municipal stormwater NPDES program; 2001-2002.

Kerr Wood Leidel, North Vancouver, B.C.; subconsultant for Stanley Park (Vancouver, B.C.) Stormwater Constructed Wetland Design; 1997-1998.

Clean South Bay, Palo Alto, California; Technical and program analysis and expert testimony on potential legal cases involving municipal and industrial stormwater NPDES permit compliance; 1996.

Resource Planning Associates, Seattle, Washington; Assistance with various aspects of monitoring under Seattle-Tacoma International Airport's stormwater NPDES permit; 1995-1997.

Watershed Management Institute, Crawfordsville, Florida; Writing certain chapters of guides for stormwater program development and implementation and maintenance of stormwater facilities; 1995-2003.

King County Roads Division, Seattle, Washington; Teaching two courses on construction erosion and sediment control; 1995.

Snohomish County Roads Division, Seattle, Washington; Teaching a course on construction erosion and sediment control; 1995.

Alaska Marine Lines, Seattle, Washington; Performance test of a sand filter stormwater treatment system; 1994-95.

Economic and Engineering Services, Inc., Bellevue, Washington; Assessment of the potential for water quality benefits through modifying existing stormwater ponds; technical advice on remedying operating problems at infiltration ponds; 1994-96.

Washington State Department of Transportation, Olympia, Washington; Teaching courses on construction erosion and sediment control; 1994.

City of Bellevue, Washington; Peer review of documents on potential erosion associated with a road project; analysis of stormwater quality data; 1993-95.

City of Kelowna, B. C., Canada; Teaching short courses on constructed wetlands and erosion and sediment control; 1993.

Oregon Department of Environmental Quality, Portland, Oregon; Technical review of Willamette River Basin Water Quality Study reports; 1992-93.

Whatcom County, Bellingham, Washington; Mediation on lakeshore development moratorium among county, water district, and local community representatives; 1993.

Boeing Commercial Airplane Company, Renton, Washington and Sverdrup Corporation, Kirkland, Washington (at request of City of Renton); Review of stormwater control system design; design of performance monitoring study for system; 1992-94.

Golder Associates, Redmond, Washington; Technical advisor for study of stormwater infiltration; 1992.

Smith, Smart, Hancock, Tabler, and Schwensen Attorneys, Seattle, Washington; Technical advice on a legal case involving a stormwater detention pond; 1992.

PIPE, Inc., Tacoma, Washington; Teaching a course on the stormwater NPDES permit; 1992.

CH_2M-Hill, Inc., Bellevue, Washington and Portland, Oregon; Technical seminar on constructing wetlands for wastewater treatment; literature review on toxicant cycling in arid-region wetlands

constructed for waterwater treatment; literature and data review on lake nutrient input reduction; expert panel on TMDL analysis for Chehalis River; 1989-1995.

Kramer, Chin and Mayo, Inc., Seattle, Washington; Watershed analysis in Washington County and Lake Oswego, Oregon; literature review in preparation for stormwater infiltration system design; literature review and contribution to design of constructed wetland for municipal wastewater treatment; 1989-1995.

Woodward-Clyde Consultants, Portland, Oregon and Oakland, California; Analysis of wetland capabilities for receiving urban stormwater; design of a constructed wetland for urban stormwater treatment; technical advisor on Washington Department of Ecology and City of Portland stormwater manual updates; 1989-1995.

R.W. Beck and Associates, Seattle, Washington; Assessment of pollutant loadings and their reduction for one master drainage planning and two watershed planning efforts; 1989-92.

Boeing Computer Services Corporation, Bellevue, Washington; mediation among Boeing, citizens' group, and City of Bellevue on stormwater control system design; 1990.

Parametrix, Inc., Bellevue, Washington; Review of Kitsap County Drainage Ordinance; 1990.

U.S. Environmental Protection Agency, Duluth Laboratory; Review of certain provisions of WET 2.0 wetland functional assessment model; 1989.

King County Council, Seattle, Washington; Review of King County Surface Water Design Manual; 1989.

Port of Tacoma, Washington; Assessment of stormwater control strategies; 1989.

Municipality of Metropolitan Seattle, Seattle, Washington; Assessment of land treatment systems for controlling urban storm runoff water quality; 1988-1992.

Impact Assessment, Inc., La Jolla, California (contractor to Washington State Department of Ecology); Socioeconomic impact assessment of the proposed high-level nuclear waste repository at Hanford, Washington; 1987.

Technical Resources, Inc., Rockville, Maryland (contractor to U. S. Environmental Protection Agency); assessment of water treatment waste disposal at pulp and paper plants; 1987-88.

Dames and Moore, Seattle, Washington; analysis of the consequences of a development to Martha Lake; 1987.

Harper-Owes, Seattle, Washington; project oversight, data analysis, and review of limnological aspects for Lake Chelan Water Quality Assessment Study; 1986-88.

URS Corporation, Seattle, Washington and Columbus, Ohio; presentation of a workshop on nonpoint source water pollution monitoring program design; analysis of innovative and alternative wastewater treatment for Columbus; development of a stormwater utility for Puyallup, Washington; watershed analysis for Edmonds, Washington; 1986-88.

Entranco Engineers, Bellevue, Washington; environmental impact assessment of proposed highway construction; technical review of Lake Sammamish watershed management project; technical review of Capital Lake wetland development; 1981-82; 1987-88; 1990.

Washington State Department of Ecology, Olympia, Washington; review of literature on wetland water quality, preparation of conference plenary paper, and leading discussion group at conference; analysis in preparation for a Shoreline Hearing Board case; 1986-87.

Richard C. Bain, Jr., Engineering Consultant, Vashon Island, Washington; analysis of watershed data and development of a policy for septic tank usage near Moses Lake, Washington; 1984-87.

University of Washington Friday Harbor Laboratory; analysis of adjacent port development and preparation of testimony for Shoreline Hearing Board; 1986.

Washington State Department of Transportation and Morrison-Knudsen Company, Inc./H.W. Lochner, Inc., Joint Venture, Mercer Island, Washington; environmental assessment of disposal of excavated material by capping a marine dredge spoil dumping site; 1984.

Foster, Pepper, and Riviera Attorneys, Seattle, Washington; analysis and testimony on provisions to reduce pollutants in stormwater runoff from a site proposed for development; 1983.

Williams, Lanza, Kastner, and Gibbs Attorneys, Seattle, Washington; collection and analysis of water quality data to support a legal case and preparation of testimony; 1982.

Herrera Environmental Consultants, Seattle, Washington; lake data analysis and report preparation; 1982-83.

Brown and Caldwell Engineers, Seattle, Washington; data collection and analysis for watershed study; 1982-83.

City of Marysville, Washington; environmental impact assessment of proposed bridge construction; 1982-83.

F.X. Browne Associates, Inc., Lansdale, Pennsylvania; contributions to manual on lake restoration for U.S. Environmental Protection Agency; preparation of funding proposals and permits for lake restoration; lake data analysis; literature reviews and analysis of septic tank contributions to lake nutrient loading and availability of different forms of nutrients; 1980-83.

Reston Division of Prentice-Hall, Inc., Reston, Virginia; review of and contributions to texts on environmental technology; 1978-79.

Butterfield, Joachim, Brodt, and Hemphill Attorneys, Bethlehem, Pennsylvania; analysis of environmental impact statements; expert witness; 1973.