RICHARD R. HORNER, PH.D.

BOX 551, 1752 NW MARKET STREET | TELEPHONE: (206) 782-7400
SEATTLE, WASHINGTON 98107 | E-MAIL: rrhorner@msn.com

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Everett DeLano, Esq.
DeLano & DeLano
220 West Grand Avenue
Escondido, California 92025

Dear Mr. DeLano:

At your request I reviewed documents submitted by the proponent of the Trails at Carmel Mountain Ranch development in the City of San Diego (the City). I focused principally on the proposed stormwater management system and the project's potential effects on the waters receiving its stormwater runoff (Chicarita Creek, Peñasquitos Creek, Peñasquitos Lagoon, and the adjacent Pacific Ocean shoreline). In forming my opinions, I reviewed and assessed a number of sections of the draft Environmental Impact Report (dEIR) and its Appendices E (Drainage Study), J (Geotechnical Report), and S (Stormwater Quality Management Plan, Parts 1 and 2), plus the hydromodification screening report prepared for the project.[1] This letter presents the opinions I reached.

In evaluating the Trails at Carmel Mountain Ranch documents, I applied the experience of my 43 years of work in the stormwater management field and 11 additional years of engineering practice. During this period, I have performed research, taught, and offered consulting services on all aspects of the subject, including investigating the sources of pollutants and other causes of aquatic ecological damage, impacts on organisms in waters receiving urban stormwater drainage, and the full range of methods of avoiding or reducing these impacts. Attachment A to this letter presents a more complete description of my background and experience. My full *curriculum vitae* are available upon request.

I. SUMMARY OF MY OPINIONS

The function of an Environmental Impact Report is to provide all of the information regulators and citizens need to make a full and confident evaluation of the proposal and its potential environmental effects. The Trails at Carmel Mountain Ranch project documents leave out details needed for this purpose. The final EIR should fill these gaps and also reevaluate some features of the selected stormwater management practices, specifically with respect to:

[1] Chang, W.W. 2020. Hydromodification Screening for the Trails at Carmel Mountain Ranch. Chang Consultants, Rancho Santa Fe, California.

- Going well beyond statements in the dEIR to the effect that applicable regulations will be followed and actually demonstrating that there will be no adverse impacts in the short-term construction and long-term operation phases of the project;

- Documenting any site conditions creating challenges for managing construction stormwater runoff and committing to a robust construction-phase stormwater management program prioritizing practices that avoid or greatly minimize soil loss or other pollutant releases;

- Performing water quality modeling to produce a quantitative accounting of pollutant mass loadings pre- and post-development and cumulatively within the watershed;

- Substantially upgrading the coverage of proposed pollutant source control practices to display where and how each practice will be utilized;

- Performing infiltration testing at each prospective biofiltration basin site to determine if local conditions will allow effective infiltration, even in the face of discouraging indications in the general soils data, since infiltrating biofiltration is superior for both water quality and hydromodification control compared to the proposed underdrained configuration;

- Clearing up the confusion existing in the dEIR and its appendices on the questions whether or not the full hydromodification analysis has been done for all biofiltration basins and what soil column depths were assumed for the analysis; and

- Employing 2020 County of San Diego BMP Design Manual recommendations to specify: (1) deeper biofiltration basin soil columns for improved water quality treatment, (2) nutrient sensitive media design to alleviate nitrogen transport to the receiving water impaired for that pollutant, and (3) flow spreading features to promote even flow distribution.

The remainder of my letter elaborates on these points.

II. INSUFFICIENT DETAIL FOR FINAL DECISION-MAKING

A. The dEIR's Deficiencies

The Notice of Availability of the dEIR issued by the City requests comments regarding the adequacy of the document to be included in the final EIR that will be considered by the decision-making authorities. In my opinion, the dEIR is inadequate in several respects under my purview as a basis for final decision making.

The dEIR's section 5.18 (Water Quality) is a key reference point for my considerations. It covers both short-term construction and long-term operation impacts on the receiving waters of stormwater runoff from the project. However, in both cases it merely relies on statements to the effect that applicable regulations will be followed; and hence there will be no adverse impacts.

Regarding the construction phase, several statements of this type appear, boiling down to the ultimate conclusion, "*With implementation of a SWPPP*[2] *and compliance with applicable water quality requirements, runoff from the project site during construction would not adversely affect surface waters or water quality.*" Similarly for long-term operations, the evaluation of impact significance is not justified beyond the extremely general assertion that, "*Through implementation of project-specific site design, source control, treatment control BMPs,*[3] *Low Impact Development practices, project design measures, related maintenance efforts, and conformance with City storm water standards and associated requirements … potential pollutant discharge and water quality impacts associated with construction and operation of the project would result in* ***less than significant*** *impacts.*"

Whereas the dEIR and its appendices give no more information on construction-phase stormwater management, Appendices E and S do provide data on the biofiltration basins planned to manage potential hydromodification and water quality impacts of the project. Later in this letter I assess those plans.

However, the documents nowhere actually demonstrate that the intended short-term construction and long-term operation management measures will result in less than significant negative receiving water impacts. There is no guarantee that even the most faithful adherence to specific regulatory points will not aggravate Clean Water Act (CWA) section 303(d) water quality impairments or compromise achievement of a total maximum daily load (TMDL), both of which apply in the Peñasquitos Creek and Lagoon system. The ultimate requirement, according to the San Diego MS4 permit[4] (at paragraph 2.a), is that, "*Discharges … must not cause or contribute to the violation of water quality standards in any receiving waters* …" The final EIR must give full assurance, with justification, that this standard will be attained.

It is entirely feasible to perform a quantitative assessment of the impact potential of a proposed land use modification, and below I outline how. This exercise should be required in the course of preparing the final EIR. Without it, regulators and interested citizens do not have sufficient information for a well-informed judgment of the ability of the proposed management practices to avoid significant impacts.

The dEIR is no more helpful when it turns in section 6.1 to cumulative effects of the Carmel Mountain Ranch project additive to those from other land use changes occurring in the same watershed. Section 6.1.10 asserts, "… *with implementation of storm drain facilities for each related project* [referring to other development in the watershed], *if applicable, the proposed project would not result in a cumulative impact to hydrology. Therefore, the proposed project's contribution to a cumulative hydrology impact would* ***not be cumulatively***

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[2] Stormwater pollution prevention plan.
[3] Best management practices.
[4] National Pollutant Discharge Elimination System (NPDES) Permit and Waste Discharge Requirements for Discharges from the Municipal Separate Storm Sewers Draining the Watersheds within the San Diego Region.

considerable." Section 6.1.18 sums up in the same vein: "*All cumulative projects would be required to demonstrate compliance with state and local water quality regulations. If projects are not compliant, mitigation measures would be required in order to ensure water quality impacts do not occur. Water quality impacts would* ***not be cumulatively considerable***."

The characterization of impacts being "not cumulatively considerable" is meaningless in any objective scientific sense. Just as with gauging the potential impacts of the Carmel Mountain Ranch development individually, the cumulative burden can also be analyzed using the same method that I present later.

B. Recommendations for Correcting Deficiencies in the Final EIR

Above I described how, in my opinion, the dEIR fails to provide convincing demonstrations that the short-term construction and long-term operation phases of the Carmel Mountain Ranch development will not cause significant negative receiving water impacts. Here, I outline what I believe to constitute convincing demonstrations and advocate that they be assembled for the final EIR.

1. Construction Phase

a. Importance of Effective Construction-Phase Stormwater Management

It is important that agency and citizen reviewers of the development proposal have confidence that the proponent understands the elevated potential for construction-phase impacts and is capable of managing them well. Construction zones cleared of vegetation and not otherwise stabilized yield much more sediment compared to the original area well covered with plants and to the same area restablized with vegetative cover following construction. Measurements and estimates using a mathematical model (Revised Universal Soil Loss Equation Version 2, RUSLE2) indicate 30 to more than 1000 times as much soil loss after compared to before clearing, the margin depending on site topographical, geological, and hydrological factors. Therefore, one year of construction with no or inferior erosion controls can release into the environment as much sediment loading as occurred over decades or even centuries before land clearing.

Increased sediment transport into streams and estuaries has numerous ecological consequences, including:

- Covering and seeping into the gravels where fish spawn and eggs develop; in filling the pore spaces, sediments restrict the flow of water carrying dissolved oxygen, resulting in asphyxiation of the young;
- Covering the stones serving as habitat for fish food sources (e.g., insects, algae);
- Filling pools where fish rest and feed;

- Reducing visibility, making it harder for fish to find food and avoid predators;
- Reducing light penetration to underwater plants and algae;
- Abrading the soft tissues of fish, especially gills; and
- Transporting other pollutants present in the soil or picked up in transport.

Soils generally contain nutrients such as phosphorus and nitrogen that fertilize plants and algae. These nutrients are transported along with eroded soil. When they enter natural water bodies and raise the amounts of these substances present in the water, they can stimulate increased growths of algae and aquatic plants, a process known as eutrophication. In these circumstances the forms of algae tend to change from single-celled organisms to filamentous forms, which are less desirable for several reasons. They are generally an inferior food source for wildlife; clog water intakes, conveyances, and boat motors; and foul beaches when they wash up on them. When the increased masses of algae die, bacteria decomposing them exert a large demand on the oxygen dissolved in the water and reduce the amount available for fish. It is not unusual for a eutrophic lake or estuary to have little or no oxygen in the colder waters at the bottom and reduced oxygen even near the surface.

Selenium is a naturally occurring element present in various earthen materials, including soils. It is a nutritionally essential element for animals in small amounts but toxic at higher concentrations. Selenium bioaccumulates in the aquatic food chain, and chronic exposure in fish and aquatic invertebrates can cause reproductive impairments (e.g., larval deformity or mortality). The element can also adversely affect juvenile growth and mortality. Selenium is toxic to water fowl and other birds that consume aquatic organisms containing excessive levels of selenium.[5] While it is fairly well sequestered when soils are intact, it is mobilized with erosion and transported with the sediments.

Additional pollutant generation considerations at a construction site involve the materials used, wastes produced, and vehicles and other equipment and their fueling and maintenance. They can release metals, petroleum products, and synthetic organic chemicals potentially toxic to aquatic life.

Peñasquitos Lagoon is listed under CWA Section 303(d) as impaired for sedimentation and siltation and has a TMDL to address that problem. Peñasquitos Creek is listed for total nitrogen, selenium, and toxicity, among other pollutants, under the same authority. Poorly controlled erosion and toxics associated with construction materials, wastes, and equipment will aggravate those conditions if the Trails at Carmel Mountain Ranch construction site is not very well controlled.

[5] https://www.epa.gov/wqc/aquatic-life-criterion-selenium (accessed February 1, 2021).

b. Recommended Improvements in the Final EIR

While I recognize that preparing a specific, complete construction-phase stormwater pollution prevention plan may not be productive before final project design, I believe that the proponent should take two steps in that direction for the final EIR: (1) document any site conditions creating challenges for managing construction stormwater runoff, and (2) commit to a robust management program tailored to the conditions identified in the first step. Doing so would provide a convincing demonstration of non-significant construction-phase impacts in my view.

The principal conditions governing erosion and sediment control are construction schedule relative to the climatological pattern, existing land cover, topography, soils erosivity, flow quantities, and drainage pathways. The wide variation in these factors from site-to-site accounts for the broad range in soil loss cited above. The challenges increase when construction is coincident with precipitation, vegetation is non-existent or removed, topography steepens, soils are relatively erosive, and runoff flows are concentrated instead of dispersed. The dEIR and its attachments do not examine these matters in any systematic way related to planning for construction-phase stormwater management. Any such conditions should be identified and given attention in conducting the second recommended step.

For the second step I recommend that the proponent commit to a regime with the goal of release no sediments or other pollutants to receiving waters. I have found that accomplishing or at least coming very close to that goal is possible with a hierarchical approach, selecting first those practices that guarantee no soil loss or other pollutant releases and moving to less effective methods only when the applying the first set cannot fully control the site. Attachment B outlines this approach.

The highest priority for erosion and sediment control in the Appendix B outline is to use construction management practices such as: (1) performing all ground-disturbing work in the dry periods, stabilizing disturbed surfaces, and then working off the ground in wet intervals; (2) greatly limiting the area disturbed at any one time; and (3) self-containing disturbed areas so that they cannot possibly flow out. The latter strategy can be applied at different space and time scales. For example, on the large scale, an entire area can be channeled to a large depression for evaporation and infiltration of runoff. On the small scale, a short slope above a completed curb can drain to a recess below the curb level. On the medium level, soil stockpiles can be placed within a recess sufficient to contain drainage from them. These measures can be established briefly, until an area is stabilized, or for a longer period while extensive work occurs in the contributing drainage area. Appropriate hydrologic analysis is needed to be sure that containment areas are large enough not to drain out during foreseeable conditions.

The second priority practices are means of slope stabilization that are highly effective but do not fully prevent soil loss, such as bonded fiber matrix and straw blanket slope covers. Following in the third priority are ways of recapturing sediments already entrained in runoff. These practices are never 100 percent effective, although active treatments like polymer-assisted filtration and electrocoagulation can come close and have been used extensively in construction and other applications in the Pacific Northwest. While the first-priority construction management practices are very economical, these treatment techniques do have higher costs.

For pollutants associated with construction materials, wastes, and equipment, the priority practices are source controls that isolate them to the maximum possible extent from contract with rainfall or runoff. They are straightforward techniques like enclosures, covers, and containments for storage, as well as berming to prevent flow into or away from contaminated areas.

I recommend that the final EIR make a general commitment to use the hierarchical approach to construction-phase stormwater management that I have outlined. I further recommend that any particular potential problem areas found in my recommended first step be highlighted and related to particular BMPs from the hierarchy intended to be used to manage them.

2. Long-Term Operation Phase

a. Importance of Effective Operation-Phase Stormwater Management

Peñasquitos Creek has CWA section 303(d) impairment listings for total dissolved solids and the bacteria indicators enterococcus and fecal coliforms, in addition to total nitrogen, selenium, and toxicity. As pointed out earlier, Peñasquitos Lagoon has an impairment listing and a TMDL for sedimentation and siltation. Stormwater runoff from urban developments is associated with all of these water quality problems, as well as others in the categories of metals, petroleum products, pesticides and other synthetic organic chemicals, and oxygen-demanding substances. The Trails at Carmel Mountain Ranch will have more human presence and activity and higher vehicular traffic than the preceding golf course land use. Accordingly, it presents the potential to release more types of pollutants and larger quantities of most of them than in the golf course state.

A true impact assessment would make a quantitative accounting of the mass loadings of key pollutants, particularly for those responsible for 303(d) listings and the TMDL, for the finished development in comparison to the pre-existing land use. It would extend that analysis to the cumulative pollutant loading burdens associated all land use changes occurring or expected in the Peñasquitos Creek and Lagoon watershed.

b. Recommended Improvements in the Final EIR

In my opinion, a convincing demonstration of non-significant long-term operation-phase impact would be water quality modeling to produce the quantitative account of pollutant mass loadings pre- and post-development and cumulatively within the watershed. Water quality modeling is well developed and routine; and numerous models, at varying levels of complexity and capability, are available in the public domain.[6] The relatively sophisticated models most

[6] See, for example, https://stormwater.pca.state.mn.us/index.php/Available_stormwater_models_and_selecting_a_model (accessed February 1, 2021)

used in Southern California are SWMM (Storm Water Management Model) and LSPC (Loading Simulation Program in C++) for modeling pollutant generation and transport and SUSTAIN (System for Urban Stormwater Treatment and Analysis IntegratioN) for BMP performance.

At the other end of the scale, relatively simple spreadsheet models taken from the general marketplace or user-developed can be employed productively to evaluate relative pollutant loadings with different land use scenarios. These models divide the site into drainage subcatchments, each representing a land surface with pollutant sources, and a BMP to collect and treat its stormwater runoff. This step has already been completed for Carmel Mountain Ranch. Pollutant mass loadings (*e.g.*, kg/year) associated with the land use are found from the voluminous literature on this subject and adjusted relative to the efficiency of the BMP in reducing them. Efficiency data are also abundant in the literature of the stormwater management field for common BMPs, like the underdrained biofiltration units proposed for the subject development. The adjusted mass loadings from the various subcatchments are added to determine the totals at the ultimate site discharge point to the receiving water. This exercise is also performed for the pre-development land use and compared to the results for the development. For cumulative assessment purposes, the same exercise can be conducted for nearby parcels also draining to the receiving water, with its totals added to those from the subject development.

The best analysis to prepare the final EIR would be to run SMMM or LSPC plus SUSTAIN to determine the relative pollutant loadings pre- and post-development and cumulatively for all land use changes discharging stormwater runoff to the Peñasquitos Creek and Lagoon watershed. Even the spreadsheet exercise described above would provide valuable information to determine objectively if the land use changes projected to occur in the watershed will aggravate existing water quality problems. The reality is that all models, even the most advanced in algorithm development and input data population, present simplified versions of complex environmental processes. Therefore, they are most useful in making relative comparisons (*e.g.*, between pre-and post-development pollutant generation), a situation that tends to annul their imperfections. My opinion is that a quantitative, objective assessment of prospective water quality modification associated with the proposed development should be required for the final EIR.

III. SPECIFIC ASSESSMENT OF PROPOSED BEST MANAGEMENT PRACTICES

Section 5.18.3 of the dEIR lists the proposed general stormwater management practices: "*Site-specific source control BMPs include prevention of illicit discharges, storm drain stenciling, integrated pest management principles, and efficient landscape and irrigation design. Treatment BMPs selected for the proposed project include multiple lined biofiltration basins.*" The source control BMPs are not further elaborated. Appendix S does give substantial additional detail on the biofiltration basins.

A. Source Control BMPs

The vague source control list is highly inadequate. First, it is incomplete in relation to the

San Diego MS4 permit's directive regarding source control [at paragraph E.3.a(2)]. Furthermore, a mere listing is insufficient for any thoughtful determination of extent and quality of implementation that may result. The final EIR should augment the list and substantially amplify where and how each practice will be utilized.

B. Treatment and Hydromodification Control BMPs

1. Scope of the Management Plan

The Trails at Carmel Mountain Ranch site is divided into 15 drainage management areas (DMAs). Ten are to be served with biofiltration basins. The remaining five are "self-mitigating" according to Appendix S,[7] which presumably means that all runoff is retained within the DMA and does not discharge from it on the surface; at least I can imagine no other interpretation. There is no further discussion of these areas, and it is unclear why they can function as such and others cannot. Based on the data presented, the self-mitigated areas are similar in size and soil characteristics to other DMAs. The final EIR should clarify this issue. If I am correct that self-mitigation means on-site retention, this is the best BMP there is, since no runoff discharges to create hydromodification or water quality problems in the receiving waters. The final EIR should further examine if other DMAs could, at least partially, use this practice.

The 10 biofiltration basins are to provide both hydromodification control and water quality treatment. They are designed to have impermeable liners and underdrains because of the supposed unsuitability of the site to infiltrate water adequately for proper functioning. The underdrains convey water percolating through the soil column to a surface discharge point. I accept that the general soil conditions, as reported in the Geotechnical Report (Appendix J), are not promising for infiltration. However, there has been no infiltration testing at the exact intended sites for the basins, and soils can vary extensively around a site. I believe that, in preparation of the final EIR, such testing should be performed at each prospective basin site. I hold that position because infiltrating biofiltration is superior to the underdrained configuration by entirely preventing the surface discharge of runoff that can be retained from creating hydromodification and water quality problems. Because of potential variability even within a basin, a common recommendation is to perform three tests spread around at each basin location.[8]

2. Biofiltration Basin Design Aspects

The Stormwater Quality Management Plan (Part 1) in Appendix S gives specifications for the biofiltration basins. The dimensions supposedly are adequate to serve requirements for both hydromodification control and water quality treatment. However, there is some confusion on this point. The Preliminary Hydromodification Management Study attached to Part 1 indicates that the basins were modeled for hydromodification control purposes with the SWMM model. Table 7 gives some resulting data for the basins. The soil depths cited in the table are 27 inches for all basins, whereas the specifications in tables within the core of Part 1 show that eight

[7] Attachment 1.B: Worksheet B-2.1: DCV (pdf page 87).
[8] California Stormwater Quality Association. 2003. California Stormwater BMP Handbook, New Development and Redevelopment (BMP TC-11, page 4). California Stormwater Quality Association, Menlo Park, CA.

of the ten basins actually have soil depths of 21 inches. Detention volume, and the associated hydromodification control, would be underestimated if the basins have soil columns only 21 inches deep and the modeling assumed 27 inches. This error must be corrected for the final EIR.

To further confuse the issue, the Drainage Study (Appendix E) presents detention modeling for two basins (9 and 11) conducted using the Rational Method as the hydrologic model. The document then states, "*During final engineering, calculations will be prepared for all basins to show final detained flow rates out of the detention basins*." Whether or not all basins have been fully specified must be settled in the final EIR. In any event, the Rational Method is highly inferior in comparison to SWMM and other continuous hydrologic simulation models and should not be used.

To return to the issue of basin soil depth, 21 inches in most of the basins places some limits on their probable effectiveness. One obvious benefit of a deeper soil column is more contact time between pollutants in percolating water and the medium that extracts those pollutants and prevents their discharge. Furthermore, vegetation larger than grasses and other low-growing herbaceous plants, offers treatment and hydromodification control advantages but requires deeper soil for rooting. Bushes and trees provide several beneficial hydrologic services. Their leaves intercept falling raindrops and evaporate some back to the atmosphere. Roots take in percolating water to nourish above-ground tissue, where the leaves transpire some back to the atmosphere. If infiltrating biofilters can be used, tree roots form channels through the soil and promote effective percolation. Since the development will drain to waters with water quality impairments and a TMDL, all treatment advantages should be pursued, including deepening the biofiltration basin soils well beyond the 18-inch minimum prescribed by the 2020 County of San Diego BMP Design Manual (the BMP Manual). Soil column depths of 36 inches would increase treatment residence time by 71 percent, compared to 21 inches, and would support a vegetation canopy including trees and bushes as well as herbaceous plants.

As pointed out earlier, Peñasquitos Creek is on the CWA 303(d) list as impaired for total nitrogen, a nutrient that, when in excess supply relative to physiological needs, leads to excessive growth of algae, a process known as eutrophication. There is not only increased algal abundance but also a tendency to change the community from single-celled organisms to filamentous forms, which are less desirable for several reasons. They are generally an inferior food source for wildlife; clog water intakes, conveyances, and boat motors; and foul beaches when they wash up on them. Some filamentous blue-green algae produce toxins that can kill an animal that drinks directly from the water and must be removed before distributing to humans. When the increased masses of algae die, bacteria decomposing them exert a large demand on the oxygen dissolved in the water and reduce the amount available for aquatic life. Rooted and floating aquatic plant growth is also over-stimulated in a eutrophic condition, with further negative impacts.

Underdrained biofilters, while generally relatively effective in capturing most pollutants, actually have often been seen to release more nutrients like nitrogen than enter. One source of net nutrient export is the organic compost that often constitutes the biofiltration soil medium and serves well in capturing pollutants other than nutrients. Another source is nutrient release during plant scenescence and decomposition. The BMP Manual has recognized this problem and specified: "*Where receiving waters are impaired or have a TMDL for nutrients, the system is designed with nutrient sensitive media design (see fact sheet BF-2)*." The fact sheet, located in Appendix E.15 of the manual gives instructions regarding the soil medium composition, plant selection and establishment, and a water retention zone below the underdrain in aggregate (crushed rock and gravel). The dEIR does not address this issue, but the final EIR should commit to using nutrient sensitive media design.

The BMP Manual specifies that the area contributing runoff to biofiltration basins like proposed for Carmel Mountain Ranch is to be ≤ 5 acres, with ≤ 1 acre preferred. The reason is that high flows generated in larger areas tend not to disperse evenly over the surface and thus are not treated uniformly. The BMP Manual would allow a larger contributing area, with agency approval, if the basin incorporates design features (*e.g.*, flow spreaders) to promote even distribution. Of the 10 proposed Carmel Mountain Ranch biofiltration basins, eight have contributing areas larger than 5 acres, as much as 14.9 acres. The final EIR should spell out how the basins will comply with the BMP Manual specifications.

I would be pleased to answer any questions you or others to whom the letter is distributed may have.

Sincerely,

Richard R. Horner

Attachments: A. Background and Experience; Richard R. Horner, Ph.D.
B. Model Construction Stormwater Management Program

Attachment A. Richard R. Horner, Ph.D.

BACKGROUND AND EXPERIENCE

I have 54 years of professional experience, 44 teaching and performing research at the college and university level. For the last 43 years I have specialized in research, teaching, and consulting in the area of stormwater runoff and surface water management.

I received a Ph.D. in Civil and Environmental Engineering from the University of Washington in 1978, following two Mechanical Engineering degrees from the University of Pennsylvania in 1965 and 1966. Although my degrees are all in engineering, I have had substantial course work and practical experience in aquatic biology and chemistry.

For 12 years beginning in 1981, I was a full-time research professor in the University of Washington's Department of Civil and Environmental Engineering. From 1993 until 2011, I served half time in that position and had adjunct appointments in two additional departments (Landscape Architecture and the College of the Environment's Center for Urban Horticulture). I spent the remainder of my time in private consulting through a sole proprietorship. My appointment became emeritus in late 2011, but I continue university research and teaching at a reduced level while maintaining my consulting practice.

My research, teaching, and consulting embrace all aspects of stormwater management, including determination of pollutant sources; their transport and fate in the environment; physical, chemical, and ecological impacts; and solutions to these problems through better structural and non-structural management practices.

I have conducted numerous research investigations and consulting projects on these subjects. Serving as a principal or co-principal investigator on more than 40 research studies, my work has produced three books, approximately 30 papers in the peer-reviewed literature, and over 20 reviewed papers in conference proceedings. I have also authored or co-authored more than 80 scientific or technical reports.

In addition to graduate and undergraduate teaching, I have taught many continuing education short courses to professionals in practice. My consulting clients include federal, state, and local government agencies; citizens' environmental groups; and private firms that work for these entities, primarily on the West Coast of the United States and Canada but in some instances elsewhere in the nation.

Over a 17-year period beginning in 1986 I spent a major share of my time as the principal investigator on two extended research projects concerning the ecological responses of freshwater resources to urban conditions and the urbanization process. I led an interdisciplinary team for 11 years in studying the effects of human activities on freshwater wetlands of the Puget Sound lowlands. This work led to a comprehensive set of management guidelines to reduce negative effects and a published book detailing the study and its results. The second effort involved an analogous investigation over 10 years of human effects on Puget Sound's salmon spawning and rearing streams. These two research programs have had broad sponsorship, including the U.S. Environmental Protection Agency, the Washington Department of Ecology, and a number of local governments.

I have helped to develop stormwater management programs in Washington State, California, and British Columbia and studied such programs around the nation. I was one of four principal participants in a U.S. Environmental Protection Agency-sponsored assessment of 32 state, regional, and local programs spread among 14 states in arid, semi-arid, and humid areas of the West and Southwest, as well as the Midwest, Northeast, and Southeast. This evaluation led to the 1997 publication of "Institutional Aspects of Urban Runoff Management: A Guide for Program Development and Implementation" (subtitled "A Comprehensive Review of the Institutional Framework of Successful Urban Runoff Management Programs").

My background includes 26 years of work in California, where I have been a federal court-appointed overseer of stormwater program development and implementation at the city and county level and for two California Department of Transportation districts. I was directly involved in the process of developing the 13 volumes of Los Angeles County's Stormwater Program Implementation Manual, working under the terms of a settlement agreement in federal court as the plaintiffs' technical representative. My role was to provide quality-control review of multiple drafts of each volume and contribute to bringing the program and all of its elements to an adequate level. I have also evaluated the stormwater programs in San Diego, Orange, Riverside, San Bernardino, Ventura, Santa Barbara, San Luis Obispo, and Monterey Counties, as well as a regional program for the San Francisco Bay Area. At the recommendation of San Diego Baykeeper, I have been a consultant on stormwater issues to the City of San Diego, the San Diego Unified Port District, and the San Diego County Regional Airport Authority.

I was a member of the National Academy of Sciences-National Research Council ("NAS-NRC") committee on Reducing Stormwater Discharge Contributions to Water Pollution. NAS-NRC committees bring together experts to address broad national issues and give unbiased advice to the federal government. The present panel was the first ever to be appointed on the subject of stormwater. Its broad goals were to understand better the links between stormwater discharges and impacts on water resources, to assess the state of the science of stormwater management, and to apply the findings to make policy recommendations to the U.S. Environmental Protection Agency relative to municipal, industrial, and construction stormwater permitting. My principal contribution to the committee's final report, issued in October 2008, was the chapter presenting the committee's recommendations for broadly revamping the nation's stormwater program.

Attachment B. Model Construction Stormwater Management Program

A. Erosion and sediment transport—Manage the construction site to avoid, or minimize to the maximum extent possible, the release of sediments and other pollutants from the site through the use of the following measures.

1. As the top priority emphasize construction management BMPs, such as:
    - Maintain existing vegetation cover, if it exists, as long as possible;
    - Perform ground-disturbing work in the season with smaller risk of erosion, and work off disturbed ground in the higher risk season.
    - Limit ground disturbance to the amount that can be effectively controlled temporarily in the event of rain.
    - Use natural depressions and planning excavation to drain runoff internally and isolate areas of potential sediment and other pollutant generation from draining off the site, so long as safe in large storms;
    - Schedule and coordinate rough grading, finish grading, and erosion control application to be completed in the shortest possible time overall and with the shortest possible lag between these work activities.

2. If construction management BMPs cannot fully prevent soil exposure, apply stabilization BMPs that provide cover appropriate to site conditions, season, and future work plans, e.g.:
    - Rapidly stabilize disturbed areas that could drain off the site, and that will not be worked again, with permanent vegetation supplemented with highly effective temporary erosion controls until achievement of at least 90 percent vegetative soil cover.
    - Rapidly stabilize disturbed areas that could drain off the site, and that will not be worked again for more than three days, with highly effective temporary erosion controls.
    - If at least 0.1 inch of rain is predicted with a probability of 40 percent or more, before rain falls stabilize or isolate disturbed areas that could drain off the site, and that are being actively worked or will be within three days, with measures that will prevent or minimize to the greatest extent possible the transport of sediment off the property.

3. As backup for cases where all of the above measures are used to the maximum extent possible but sediments still could be released from the site, consider the need for sediment collection BMPs including, but not limited to, conventional settling ponds and advanced sediment collection devices such as polymer-assisted sedimentation and advance sand filtration.

4. Specify emergency stabilization and/or runoff collection BMPs (e.g., using temporary depressions) procedures for areas of active work when rain is forecast.

5. If sediment-bearing runoff could still leave the site, use perimeter control BMPs (*e.g.*, silt fence) as backup where some soil exposure will still occur, even with the best possible erosion control (above measures) or when there is discharge to a sensitive water body.

6. Specify flow control BMPs to prevent or minimize to the extent possible:
    - Flow of relatively clean off-site water over bare soil or potentially contaminated areas;

- Flow of relatively clean intercepted groundwater over bare soil or potentially contaminated areas;
- High velocities of flow over relatively steep and/or long slopes, in excess of what erosion control coverings can withstand;
- Erosion of channels by concentrated flows either by using channel lining, velocity control, or both.

7. Specify construction entrance and exit area stabilization BMPs, provision of a nearby tire and chassis wash for dirty vehicles leaving the site with a wash water sediment trap, and a sweeping plan.

8. Specify construction road stabilization BMPs.

9. Specify wind erosion control BMPs.

B. Other pollutants—Manage the construction site to avoid the release of pollutants other than sediments by preventing contact between rainfall or runoff and potentially polluting construction materials, processes, wastes, and vehicle and equipment fluids by such source control BMPs as enclosures, covers, and containments, as well as berming to direct runoff.