moffatt & nichol

Qualifications to Provide Professional Services for Phase II, Grays Harbor and Willapa Bay Sedimentation Dynamics and Mitigation Measures

Submitted to
Grays Harbor Conservation District

July 19, 2019

P190473

1. Qualifications and Relevant Experience

1.a. Overall Experience of the Team

Moffatt & Nichol

VALUE TO GHCD

- Extensive knowledge of estuarine processes and restoration measures.
- Built-in efficiencies for open coast modeling.

Moffatt & Nichol (M&N), a family-owned firm established in 1945, is known for providing coastal engineering and estuarine restoration services to coastal communities. M&N has a successful track record of working on the most challenging estuarine and waterfront projects in the Pacific Northwest and nationwide. We bring in-depth understanding of the physics of estuarine processes and unmatched experience in numerical modeling of these processes in estuaries and coastal environments. Our cohesive Seattle team of 25 engineers and environmental scientists has remained focused on our core area of expertise. Our ability to seamlessly share knowledge across our coastal offices allows us to supplement our local team with key expertise from across the country.

Pacific Shellfish Institute

VALUE TO GHCD

- Extensive knowledge of Grays Harbor and Willapa Bay estuarine habitat and restoration design as a result of their research and field work.

The Pacific Shellfish Institute (PSI), a Section 501(c)(3) private nonprofit organization established in 1995, develops and disseminates shellfish-related scientific and technical information of value to the general public, shellfish farmers, and public officials. PSI focuses on publicly-funded research projects to evaluate the ecology, health, and diseases of shellfish. Current work in Willapa Bay focuses on real time water quality monitoring at three locations in the bay, assessing of off bottom oyster production and evaluating oyster aquaculture and native eelgrass benefits and interactions with the marine ecosystem. Recent work in Quilcene Bay included in a literature review of oyster and clam tolerances to physical and water parameters, including sedimentation. The firm's vision is healthy ecosystems and sustainable coastal communities that understand the ecological, economic, and social contributions of shellfish and shellfish aquaculture to the region.

Lead To Results

VALUE TO GHCD

- Proven record for effective stakeholder engagement/ outreach.

Lead To Results (LTR), established in 2002, engages with organizations and constituent stakeholders to help clients hone their business or organizational focus, strategic planning, and media communications. LTR regularly volunteers its services to non-profit and community organizations, including recent engagements in planning and board development with the Pacific County Visitors' Bureau, South Pacific County Humane Society, South Pacific County Community Foundation, DePaul Industries, the Willapa Erosion Community Action Network, and the Pacific County Planning Commission.

David Evans & Associates

VALUE TO GHCD

- Extensive experience with coastal and estuarine data collection, including drone mapping.

Established in 1989, the marine services division of David Evans & Associates (DEA) with 17 staff is headquartered in Vancouver, Washington, and specializes in marine data collection and analysis, including bathymetric surveys, as well as development of digital elevation models combining information from various sources. DEA owns and operates numerous cost-effective vessels for daylight operations in shallower waters. DEA routinely acquires high-resolution, high-precision acoustic bathymetric, backscatter, subbottom, water column, and imagery data along with surface and core sediment samples to characterize the seafloor, subbottom, water column, and current velocity data.

Additional Team Members

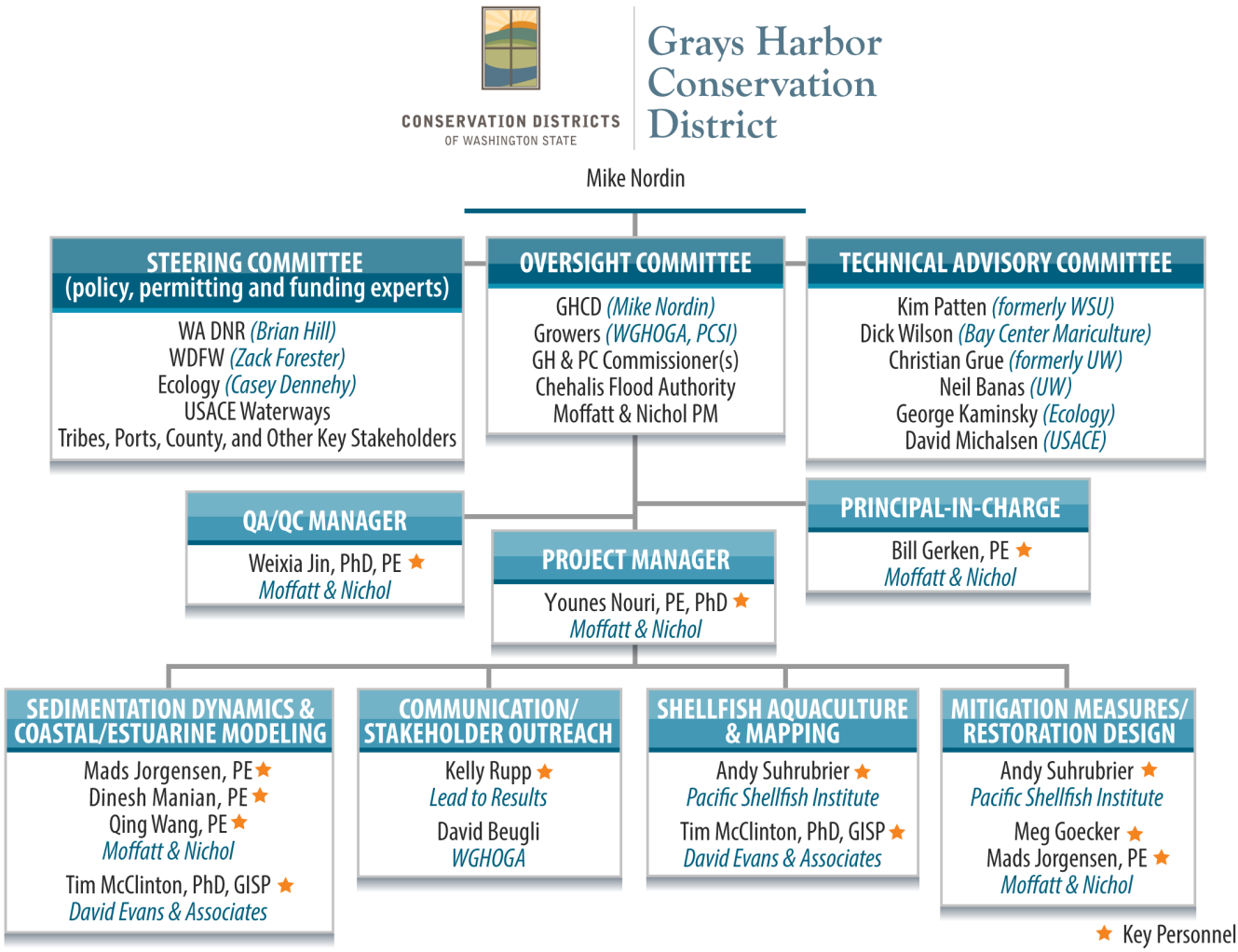
We understand the value of existing body of knowledge in conducting this work efficiently. We have reached out to several experts who have expressed interest to collaborate with us on this project: Dave Michalsen and Zeki Demirbilek (U.S. Army Corps of Engineers (USACE)), Kim Patten (Washington State University), and Dick Wilson (Bay Center Mariculture). We also recognize that availability of resources during remaining daylight tides can constrain the mapping effort. Therefore, we have reached out to Natural Resource Consultants (NRC) to provide additional survey crew if needed.

1.b/c. Moffatt & Nichol Team

POINT OF CONTACT
Younes Nouri, PhD, PE
ynouri@moffattnichol.com
206.622.0222

The specific individuals comprising the M&N team are intentionally selected for their personal experience with similar projects. For this assignment, we have assembled an exceptional team of personnel who collectively offer many decades of direct first-hand experience. Younes Nouri, proposed project manager, will serve as the main point of contact for this project. The organizational chart below illustrates how the individuals proposed for this project will be assembled to meet Grays Harbor Conservation District's (GHCD) needs. Experience profiles for each key team member follows. We have proposed three stakeholder committees, including steering, oversight, and technical advisory. Frequent communication with these committees will keep project objective in focus, facilitates use of existing body of knowledge, and ensures project outcomes are feasible.

Organizational Structure



Team Coherence

M&N's estuarine modeling team selected to work on this project have been working collaboratively on the coastal engineering portions of two large projects in the Coos Bay Estuary for 5 years. Proposal project manager, Younes Nouri, and principal-in-charge, Bill Gerken, have been collaborating on more than ten projects in the Pacific Northwest just in the last three years.

M&N's Seattle office has enjoyed a long-standing working relationship with DEA on projects in the Pacific Northwest's marine environment for almost 20 years. We routinely work with their marine surveys group on projects where our coastal modelers rely on DEA to provide the bathymetric surfaces, current profiles, and wave climate as input to our hydrodynamic and sediment transport models.

Younes Nouri, PhD, PE | Project Manager | Moffatt & Nichol

Younes will be the project manager and main point of contact for this project. He has 14 years of experience in coastal engineering with more than 30 projects in the Pacific Northwest just in the last five years. He offers his clients responsiveness, in-depth knowledge of coastal processes, and the ability to guide the team across the finish line within budget and schedule. Younes has a talent for effectively communicating complex coastal and estuarine processes in layman's terms.

Younes is extremely familiar with regional coastal processes because of his recent experience working on multiple projects in Grays Harbor estuary through his former employer. These projects have included Port of Grays Harbor Terminals 1 to 4 maintenance dredging analysis and design, Westport Marina maintenance dredging design, tsunami modeling for Imperium biodiesel facility, and technical review for the Satsop River riprap removal restoration project. Younes specializing at managing multidisciplinary projects with restoration objectives where coastal processes are the primary driver of the change in the system. His relevant experience includes leading estuarine dynamics for Coos Bay projects, as well as leading a numerical modeling team working on the Capitol Lake and Lower Deschutes estuary restoration environmental impact statement.

Bill Gerken, PE | Principal-in-Charge | Moffatt & Nichol

Bill has 30 years of experience in coastal analysis, design, and construction. His experience, gained through both the consultant and contractor perspectives, has given him a unique practical understanding of marine and coastal conditions, along with the experience of interacting with clients, government agencies, and the public planning process. Bill's recent relevant experience includes providing management and technical services for the Coos Bay project, which includes numerical simulation of waves, hydrodynamics, sediment transport, project impacts to navigation, and material transport for mitigation site(s).

Weixia Jin, PhD, PE | QA/QC Manager | Moffatt & Nichol

Weixia has 22 years of experience with a wide range of wetlands, marina, coastal, estuary, and riverine projects. Her experience includes engineering designs of tidal control structures, revetments, tidal inlets, jetties, and shore protection structures; numerical modeling of wave/tsunami, hydrodynamics, water quality, and sedimentation; engineering studies of estuary flood/ebb shoal development, as well as estuary erosion analyses and shore protection design. Weixia's recent relevant experience includes senior quality control for the Coos Bay project's hydrodynamic and sediment transport modeling and the technical lead of hydrodynamic, water quality, flood/ebb shoal modeling, and inlet stability analysis for the San Elijo Lagoon Restoration project.

Mads Jorgensen, PE | Lead Modeler and Mitigation Measures Specialist | Moffatt & Nichol

Mads has 25 years of experience with coastal engineering analysis, modeling, and design for marine structures and habitat. He has 9 years of experience of modeling with modeling hydrodynamics and sediment transport Coastal Modeling System (CMS)-Wave and CMS-Flow over a wide range of applications. Mads specializes in habitat enhancement and restoration projects, including analysis and design for wetland and marsh habitat, submerged aquatic vegetation, shellfish and oyster beds, and fish passage systems. He has used Particle Tracking Modeling (PTM) to emulate sediment suspension, plume characteristics, transport and settlement of materials affected by waves, tidal currents, and hydraulic/mechanical dredging operations. His experience with sediment mitigation includes sediment traps, use of flow-deflecting structures, and vegetation to improve flow conditions and prevent or promote sedimentation.

Dinesh Manian, PE | Coastal Modeler | Moffatt & Nichol

Dinesh has 10 years of experience in numerical modeling and analysis of waves, hydrodynamics, sediment transport, water quality, and particle tracking in coasts, rivers, and estuaries. He specializes in modeling of cohesive and non-cohesive sediment transport and morphology for projects involving understanding of complex sediment dynamics in estuaries, and sedimentation in ports and harbors. He has worked with several state-of-the-art numerical models, including CMS-Flow, CMS-Wave, DHI-MIKE, Delft3D, and XBEACH. Dinesh's recent relevant experience includes modeling waves, hydrodynamics, and sediment transport with CMS-FLOW and CMS-WAVE for the Port of Coos Bay project to provide maintenance-dredging estimates for channel modifications at the inlet, as well as to understand long-term fate of sediments from offshore dredge disposal.

Qing Wang, PE | Coastal Modeler | Moffatt & Nichol

Qing has 10 years of experience in coastal modeling with more than five PTM projects just in the last three years. She has modeled numerous coastal/estuarine processes: wave transformation and propagation in ports and harbors, beach nourishment and particle tracking, offshore sedimentation and dredging plume modeling, Federal Emergency Management Agency coastal floodplain mapping, and coastal estuarine study and restoration. Her recent relevant project experience includes PTM for Croatan Beach Nourishment Coastal Modeling and Analysis in Virginia Beach, Virginia; and PTM for Huntington Beach Desalination in Huntington Beach, California to quantify the potential for larval fish entrainment.

Tim McClinton, PhD, GISP | Marine Geoscientist | David Evans and Associates

Tim has 10 years of experience conducting a wide range of geophysical and hydrographic surveys and has designed specialized remote sensing analysis workflows to image and interpret seafloor and subsurface geology, characterize benthic habitats, identify hazardous materials on the seafloor, and detect physical processes within the water column. Tim's recent relevant project experience includes geologic mapping of offshore dredge disposal sites, for the Environmental Protection Agency, offshore Oregon; and benthic habitat mapping for the National Oceanic and Atmospheric Administration (NOAA) Office for Coastal Management and the National Park Service, Great Lakes.

Kelly Rupp | Stakeholder Outreach Specialist | Lead To Results

Kelly has nearly 40 years of experience building and leading project teams and workgroups for both private-sector businesses and public-sector agencies and commissions. He has proven effectiveness as facilitator and team leader in business development initiatives, public engagement and planning programs, and community development activities. Kelly is an accomplished author and organizer of business and strategic plans that lead to results. His recent relevant experience includes Willapa Bay shoreline erosion demonstration project facilitation; countywide economic development plan; and voluntary stewardship workgroup facilitation.

Andrew Suhrbier | Senior Marine Biologist | Pacific Shellfish Institute

Andy has 22 years of experience providing marine benthic/water quality sampling and analysis and mapping of marine habitats, including eelgrass and aquaculture, project development and management. His current projects include interactions of shellfish culture with the natural environment; the potential of polyculture systems (*P. californicus*); the impact of pollutants and bacterial contaminants on bivalve shellfish and human health; salmon restoration project interactions with shellfish; and shellfish bed population estimates and mapping. Andy's recent relevant experience includes interacting with shellfish producers regarding growing areas and methods along the West Coast, and work on shellfish certification standards for "The Food Alliance." He maintains water quality monitoring stations related to ocean acidification, a part of the Northwest Association of Networked Ocean Observing Systems. As part of this work, he is charged with the maintenance, deployment, retrieval and data analysis of current meters, multi and single parameter dataloggers, a pCO2 sensor package and PSI-developed dataloggers.

Meg Goecker, MS | Mitigation Measures Specialist | Moffatt & Nichol

Meg has 18 years of experience in applied coastal ecology with an emphasis in oyster, marsh, and seagrass restoration ecology. She was the technical scientific lead contracted by Mississippi Department of Environmental Quality to assist in scope and concept development for restoration plans for large scale oyster restoration projects associated with Deepwater Horizon oil spill. Meg's previous experience included being a marine habitat restoration specialist for the NOAA Restoration Center in Mississippi, Alabama, and the Florida panhandle. Meg's relevant project experience includes development of the restoration plan for 1,200 acres of subtidal oyster reefs in the Mississippi Sound; support and design project manager of over 5 miles of living shoreline projects for oyster habitat goals; and numerous monitoring events of restored oyster habitat.

Why the M&N Team?

We enter Phase II without any preconceived notion of cause(s) of excessive sedimentation and erosion in both bays, and we offer a toolbox to evaluate all possible influential parameters.

Unlike most estuaries in the Pacific Northwest, Grays Harbor and Willapa Bay are dominated by open ocean environmental forcing. M&N offers unmatched depth of expertise and recent experience with Coos Bay studying wave, hydrodynamics, sedimentation, and water quality processes.

2. Description of Project Experience

Estuarine restoration—from conceptual layouts, optimization, stability, and environmental impact assessment to detailed design—requires a thorough understanding of coastal processes, including water levels, waves, currents, sediment transport, and morphological evolution. The M&N team has extensive experience investigating these physical processes with the aid of state-of-the-art numerical tools to deliver valid, accurate, and usable solutions. This practical experience has been obtained through a focused effort over many years and projects and is one of the greatest advantages our team offers. Purely theoretical, mathematical, or academic understanding of the inner workings of numerical models cannot substitute for the practical, design-oriented experience that we bring to our clients' projects. The following projects have been completed by the M&N team and demonstrate our thorough knowledge of sediment survey design and analysis and estuarine habitat requirements.

Coos Bay Federal Navigation Channel Modification, Coos Bay, OR

M&N has provided engineering and coastal and analysis from feasibility through final design for a proposed wider and deeper federal navigation channel. The project represents a partnership between the Oregon International Port of Coos Bay and the USACE through a Section 204(f)/408 process.

M&N performed extensive numerical modeling to address physical changes to the Coos Bay estuary system due to the proposed channel modifications. Numerical modeling studies included hydrodynamics, waves, sediment transport and estuarine morphology, tsunami waves, turbidity plume dispersion, disposal plume, and salinity modeling. For each physical process, M&N developed the model to represent 'baseline' conditions and then evaluated alternatives in comparison with baseline conditions. M&N used a variety of state-of-the-art software packages, including CMS (Flow and Wave modules), MIKE-21 (FMHD, SW, ST, BW, and PT modules), MIKE3-FM, DREDGE, STFATE, and Delft3D.

KEY RELEVANT FEATURES

- Wave numerical modeling using CMS Wave
- Hydrodynamic modeling using CMS Flow, MIKE2D, MIKE3D, and Delft3D
- Sediment transport modeling using CMS, Delft3D, MIKE2D, and MIKE3D
- Suspended sediment dispersion modeling using PTM
- Evaluation of alternatives with respect to baseline conditions
- Habitat (eelgrass) impact assessment
- Flood shoal and sediment management analyses

Reference: Rod (Hans R.) Moritz | USACE, Portland District | 503.808.5150 | hans.r.moritz@usace.army.mil

San Elijo Lagoon Restoration, San Diego County, CA

San Elijo Lagoon, one of the few remaining coastal wetlands in San Diego County, provides vital habitats for resident and migratory wildlife and sensitive, threatened, and endangered plants. The urbanization of the lagoon's watershed introduced sediment, nutrients, and bacteria to be introduced into the lagoon; it also demanded the addition of transportation infrastructure, and disposal of sewage sludge.

The San Elijo Lagoon restoration project was completed to return the lagoon to more stable tidal conditions through a large-scale restoration effort. The project consisted of dredging approximately 450,000 cubic yards of sand from the lagoon and beneficial reuse of the material as sand on the local beaches.

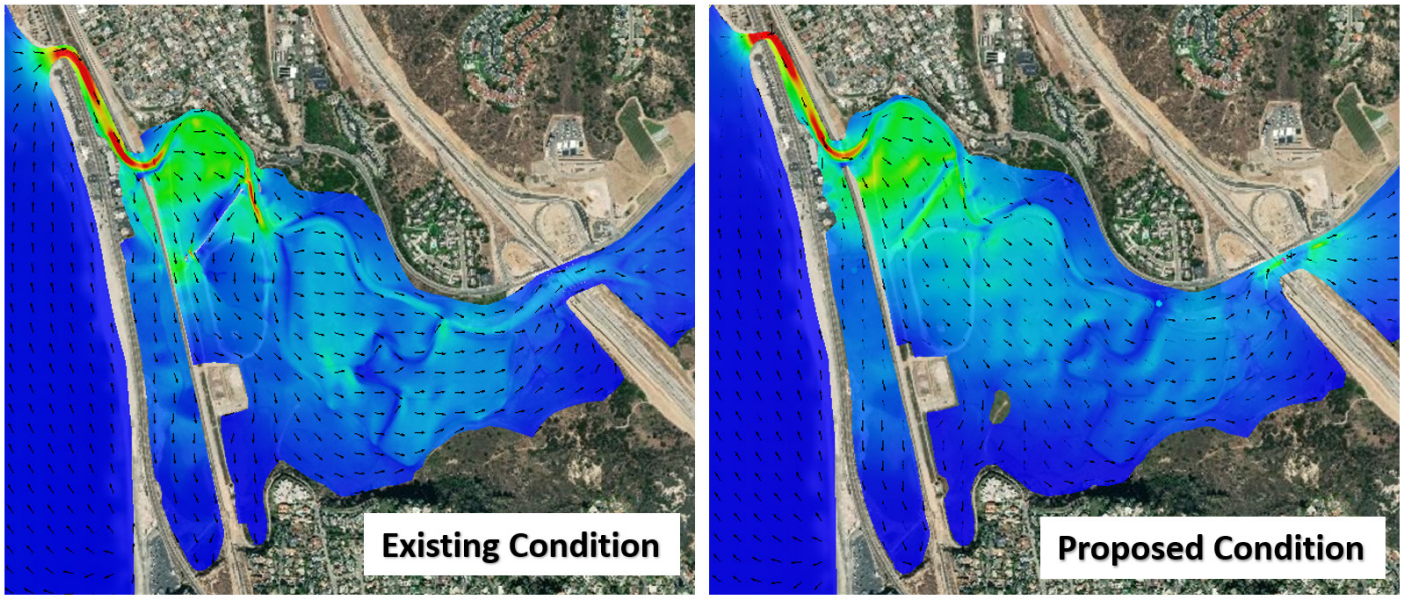
KEY RELEVANT FEATURES

- Wave and Hydrodynamic numerical modeling
- Evaluation of alternatives with respect to baseline conditions
- Habitat (eelgrass) impact assessment
- Multidisiplinary restoration design

M&N led an interdisciplinary team of wetland biologists, marine biologists, avian scientists, geomorphologists, coastal, civil, geotechnical, and structural engineers, landscape architects, and surveyors to assess the site and define problems and solutions. The work involved determining goals and objectives for improving physical, chemical, and biological conditions for salt marsh habitat (subtidal, mudflat, low marsh, mid- and high-marsh) and marine life. Design occurred through a collaborative and iterative process with the client, stakeholders, and the team to develop an optimized design for enhancement/restoration of the target habitat. The project design was completed, permits were secured, and the site has been under construction for 1.5 years with completion within the next year.

Resiliency was incorporated into the project by accommodating sea level rise into the design and analyses. Examples of resilient project components included two higher-elevation fill areas to act as transitional habitat in the short-term and wetland habitat in the long-term as sea levels rise.

Reference: Doug Gibson | The Nature Collective | 858.704.4552 | doug@thenaturecollective.org



South Arm Jetty Tidal Marsh Habitat Enhancement, Sturgeon Bank, BC

The Port Metro Vancouver Habitat Enhancement Program proposes to construct habitat creation and restoration projects within the greater Vancouver area as a multi-phased effort. M&N conducted numerical modeling to assess possible changes to the current patterns and wave environment as a result of the project and informed the design of a tidal marsh. M&N also modeled tidal and river hydraulics to evaluate various alternatives based on the performance of a cobble berm protecting the tidal marsh and water exchange related to tidal variation and river inflow using MIKE 21-FM module. Analysis considered water exchange over a tidal cycle for determining the balance of inflow and outflow and associated flow velocities over the crest of the cobble berm, an existing jetty, and the entrance sill to the marsh.

KEY RELEVANT FEATURES

- Wave and Hydrodynamic modeling using MIKE2D
- Evaluation of alternatives with respect to baseline conditions
- Habitat (eelgrass) impact assessment

Reference: Gord Ruffo | Port of Vancouver | 604.665.9018 | Port of Vancouver

Seawater Desalination, Huntington Beach, CA

To support Poseidon Water in obtaining a coastal development permit for the Huntington Beach Seawater Desalination project. M&N was tasked with evaluating potential fish entrainment at the proposed project intake. First, M&N conducted coupled wave and hydrodynamic simulations using the MIKE21 FM modeling suite along the nearshore zone and embayments in proximity to the proposed project and alternative site intakes. Then, the hydrodynamic currents and water levels were used to drive the PTM and the PTM model was used to simulate transport of conservative tracer (assuming the fish larvae will be transported as conservative tracers). Potential entrainment at the project intake was quantified.

KEY RELEVANT FEATURES

- Wave and hydrodynamic numerical modeling
- Larvae fish transport and dispersion modeling using PTM
- Evaluation of alternatives with respect to baseline conditions

Reference: Scott Maloni | Poseidon Water | 760.655.3996 | smaloni@poseidon1.com

Croatan Beach Nourishment, Virginia Beach, VA

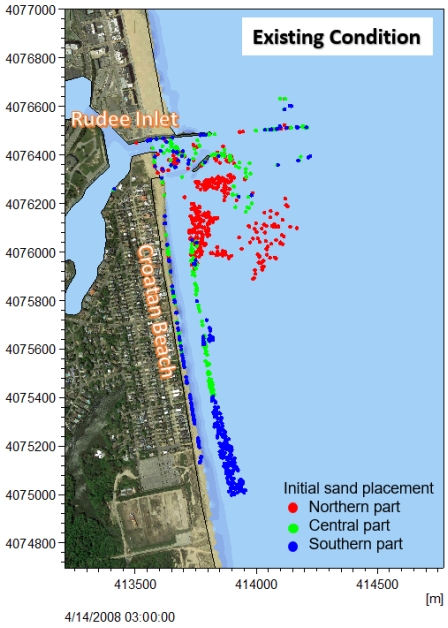
The purpose of this coastal study was to support the design and permitting of the proposed Croatan Beach Nourishment for the City of Virginia Beach. Benefits to the local community include enhanced storm protection and a wider recreational beach for residents and visitors.

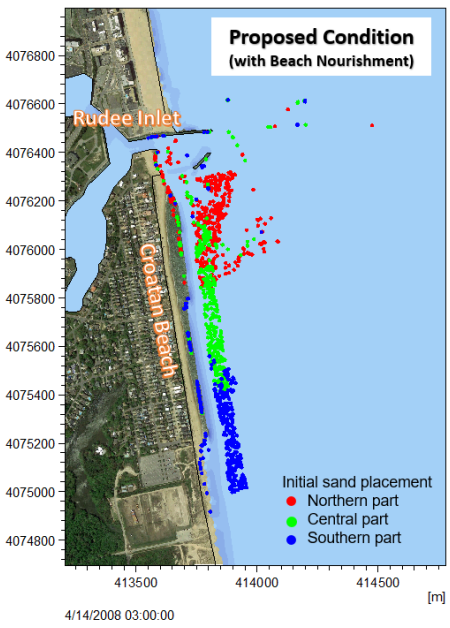
M&N conducted numerical modeling to compare alternatives in support of beach nourishment. Numerical modeling studies included simulation of waves to transform offshore waves to nearshore, hydrodynamics coupled with wave inputs to simulate current fields, and sediment tracking modeling to simulate sand movement under combined wave and hydrodynamic forces. Model results provided understanding of effect of hydrodynamic and wave forces on placed sand along the shoreline. Alternatives were evaluated based on distribution of sand particles and quantified volumes of sand transported to the entrance channel.

Reference: Dan Adams | City of Virginia Beach | 757.385.4783 | dadams@vbgov.com

KEY RELEVANT FEATURES

- Wave and Hydrodynamic numerical modeling
- Sediment transport analysis using particle tracking under wave and hydrodynamic forces
- Evaluation of alternatives with respect to baseline conditions





Willapa Bay Shoreline Erosion Demonstration Project Facilitation, Pacific County, WA

LTR organized and led meetings of the technical and steering committees, as well as all public outreach and the community meeting to develop a long-term solution to shoreline erosion in the North Cove area. LTR ensured that committee and community stakeholders were engaged, informed, and contributed to consensus decisions on erosion protection investments for the future.

Reference: Kathy Spoor | Pacific County | 360.875.9334 | kspoor@co.pacific.wa.us

Countywide Economic Development Plan, Pacific County, WA

LTR organized, promoted, and led over ten workshops and dozens of stakeholder interviews across six sub-regions of Pacific County to collect perspectives on priority business issues, community strengths and needs, socioeconomic diversity, and entrepreneurial opportunities. LTR compiled data from hundreds of surveys and research inquiries to ensure a comprehensive situational assessment and broad public inputs.

Reference: Jim Sayce | Pacific County Economic Development Council | 360.875.9330 | saycej@pacificedc.org

Quilcene River Dike Removal, Quilcene, WA

PCI studied the potential impact of the Quilcene River dike removal, for salmon restoration efforts, on shellfish resources in Quilcene Bay. PCI engaged with stakeholders in personal and group settings, mapped shellfish resources, and evaluated the tolerances of species in the bay to salinity and sediment. The team provided expert evaluation of multiple restoration scenarios.

Reference: Mendy Harlow | Hood Canal Enhancement Group | 360.275.3575 | mendy@pnwsalmoncenter.org

3. Methodology and Background

We propose a slightly modified structure for the tasks identified in the request for qualifications, which fall into four key areas: 1. Sedimentation Dynamics; 2. Shellfish Aquaculture and Mapping; 3. Communication/Stakeholder Outreach; and 4. Mitigation Measures. Work on all four lead tasks will begin following notice to proceed and occur in parallel where possible to maintain project efficiencies. Frequent communication within the team and with stakeholder committees (shown in organizational chart) will assure a collaborative approach that keeps the goals of the project in clear focus.

Our proposed technical approach for the project is described below and will be further refined in collaboration with GHCD. We propose to use as much of Phase I data and knowledge as possible, while also incorporating fresh expertise to meet the project goals. We understand that USACE is currently working on a sedimentation analysis of Port of Grays Harbor terminals. We will collaborate closely with USACE to increase efficiency in our work by building upon USACE and University of Washington (UW) modeling studies and field measurements.

Sedimentation Dynamics (Task Nos. 1 through 8)

Drastic changes in morphology (e.g. reported accelerated migration of Whitcomb Flats) are an indication of an imbalance in the sediment budget possibly caused by changes in the system (e.g. federal navigation channel realignment) or environmental forces (e.g. climate change). Modeling can at times be completed in isolation from empirical data and observations and this can lead to potential misunderstandings and mischaracterizing processes. The M&N team will conduct a desktop morphologic analysis to understand and quantify the physical processes before starting any modeling. This will include the following steps:

Data Review/Analysis: Compile and review publicly available records of tides and water levels, wind, offshore waves, river and creek discharge and sediment load, topography and bathymetry survey data (i.e., NOAA and USACE), historical and recent dredge records and associated rates of sedimentation, oblique, and ortho-aerial imagery to identify trends of shoreline change. Review of previous studies of hydrodynamics and sediment transport (e.g. PIE 2003 and USACE 2010). Acquire modeling setup files developed by USACE ERDC.

Desktop Morphologic and Sediment Budget Analysis: Investigate sand transport patterns by fluvial and estuarine processes. Investigate inlet processes and migration/stability of ebb/flood shoals. Establish timeline of sediment sources (river flow and sediment load) with sediment sinks (dredge records, erosion events) with morphologic changes for specific events (e.g., 2015 flooding) and long-term periods.

Wave and Hydrodynamics Modeling – Baseline Conditions: Develop a modeling methodology (basis of analysis) to establish all input data and assumptions, and analysis scenarios. Assemble the model, which includes updating bathymetry and boundary conditions. Perform model calibration/validation. Run the coupled hydrodynamic and wave spectrum model to provide hydrodynamic modeling results (waves, water levels and currents). Estimate radiation stresses from waves and tidal/river flows and investigate deposition and erosion patterns.

Technical Advisory Committee Review: Review of preliminary wave and hydrodynamics model results by a Technical Advisory Committee and respond to comments/concerns.

Wave and Hydrodynamics Modeling – Proposed Alternatives: Compare results with results of baseline. Comparison of model between baseline and proposed conditions will inform evaluation of alternatives.

Sediment Transport Modeling or PTM (optional): A PTM model can be used to simulate the transport of conservative tracer (sand) for baseline and proposed conditions. Comparison of results will inform evaluation of alternatives.

Proposed Deliverables: Digital elevation model in GIS format, section of report on sediment budget analysis; section of report on modeling methodology (basis of analysis), sections of report on describing modeling results, appendix to the technical report, including comments by technical advisory committee and responses.

Shellfish Aquaculture and Mapping (Task Nos. 1 and 8)

There is the pragmatic need to understand, from the growers' perspective, conditions that are optimal for shellfish culturing, and to acknowledge the fact that culturing practices could influence channeling, water flows, and micronutrients available to shellfish. Creating a shellfish culturing map – identifying seasonality of bed-use – is an important contribution to this study. It is likely that much of this mapping exists or can be constructed by engaging with the growers.

Stakeholder outreach: Stakeholder outreach to understand and document ground observations and areas of existing concerns. M&N will collaborate with steering committee to identify stakeholder groups and the most efficient way to engage them. The M&N team will interview shellfish farmers (e.g. Coast Seafoods Co., Minterbrook Seafoods, Cedar River Seafoods, Brady's Oysters, etc.), resource agency staff (e.g. Washington Department of Fish and Wildlife [WDFW], Washington Department of Natural Resources, USACE, etc.), tribal representatives and community members either by individual contact or as part of a forum setting. Focus areas will be identified for this effort.

Data Review/Analysis: Review of existing information will supplement a literature review completed in 2016 for the Quilcene River project where PSI staff: 1) reviewed available literature relevant to the physical and water quality conditions in the study area and other comparable examples; 2) reviewed literature describing the physical and water quality tolerances of the shellfish species grown in the area.

Shellfish Bedding Mapping: Assess selected shellfish culture and harvest sites in the project area using available maps and aerial and ground surveys. There are some minimal fall tides that could be worked but they do not allow for maximum beach exposure. Winter tides are at night, which could increase site safety issues and operational expenses due to poor field of view and the need for spring verification. Survey specifics will include average bed height, substrate, species, and grow-out method. Distance to historical, current, and predicted dredging locations will also be noted. Areas that are not presently being cultivated will also be included in the survey noting the site potential for shellfish, bed height, bed substrate, and historical shellfish cultivation (gathered from prior interviews).

Proposed Deliverables: Shellfish culturing GIS map in Google or ESRI format with layers describing the details noted above and section of report to summarize the review and input from stakeholders.

Communication/Stakeholder Outreach (Task 9)

The breadth of this project, including the recommendation of future shellfish growing areas and optimal sedimentation mitigation measures, suggests multiple workgroups should be assembled to gather and focus various industry and technical expertise, as well as stakeholder perspectives.

Meeting format (face-to-face, web-enabled, or teleconference) and frequency (weekly or semi-weekly) will be determined by the GHCD and the M&N team, and workgroup/committee leaders. Appropriate advance communications (individual invitations, distribution of reference material, and clear expectations as to process or outcomes) will be committed. When complex technical data needs to be shared, the presentation content will be edited, formatted, and rehearsed as needed to maximize clarity for group understanding and decision making. A formal team website will be developed and populated with ongoing information and background materials as appropriate.

Proposed Deliverables: Meeting minutes, documentation of review comments and responses.

Mitigation Measures (Task 10)

Mitigation measures and recommendations will be developed from work completed as part of the other three task areas. This will include input from updated data collection, review, and modeling, and stakeholder input (including professional opinions and anecdotal observations). The M&N team will supplement our local findings with expertise collected from other applicable nationwide sources and examples. The design and installation of additional reef substrate, through increased profiles of natural (rock, shells) or artificial structures (racks, cages or artificial reefs) are a few examples. While each project is unique with site-specific challenges, the process by which our Team develops mitigation measures and recommendations is based on a similar strategy. Developed mitigation measures and recommendations will be both technically sound, practicable, and environmentally sustainable. They are developed in collaboration with our client and team to respond to the overall project objective and goals, and result in implementation efforts that are economically feasible and meet overall project schedule goals.

Mitigation Measure Development: Develop alternatives for mitigation measures based on model results and understanding of wave, hydrodynamics, and sediment transport process.

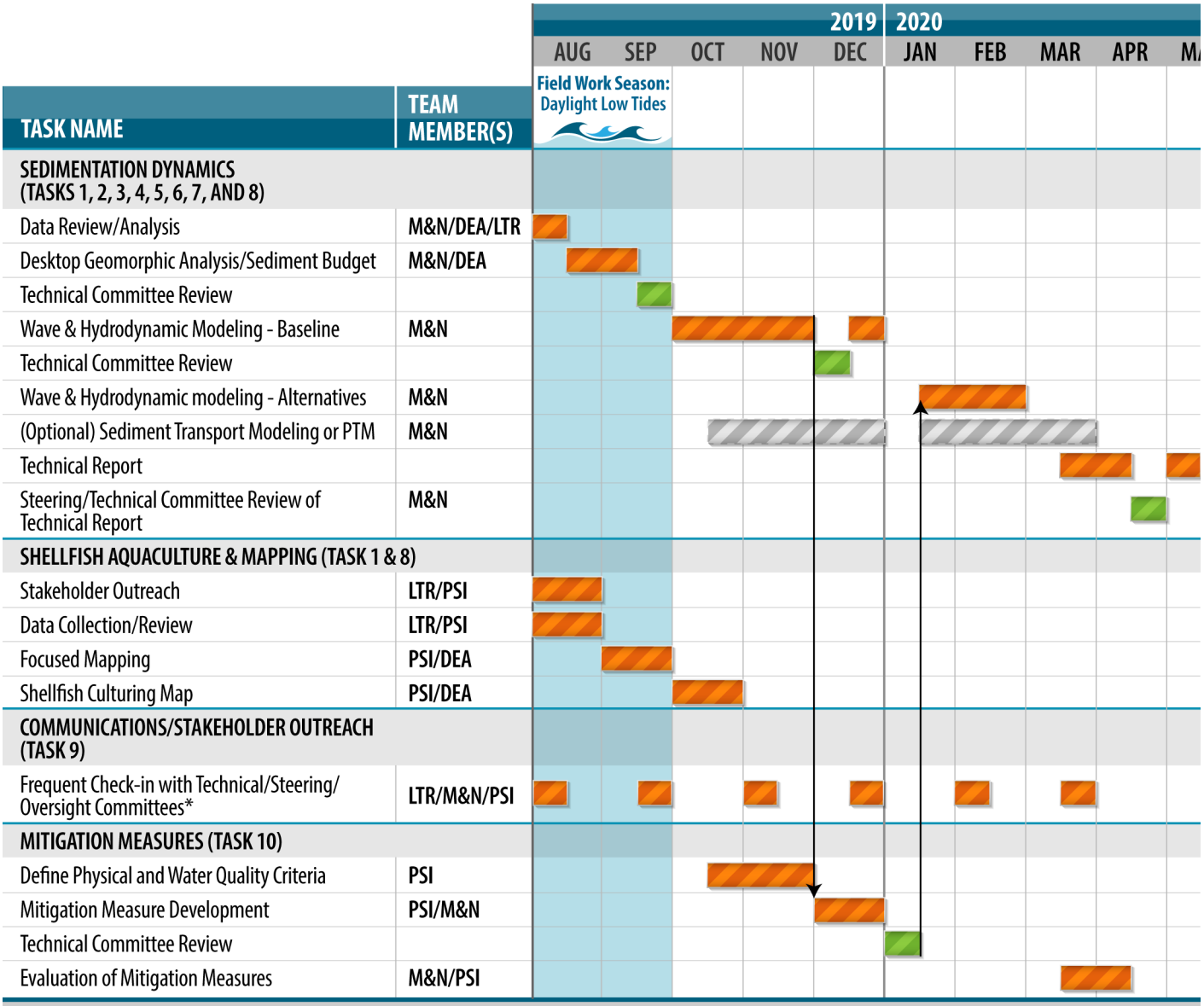
Technical Advisory and Steering Committee Review: Seek input from client/stakeholders on proposed alternatives

Proposed Deliverables: Section of technical report on mitigation measures.

4. Schedule

We understand the need and purpose for completing this study in a timely manner and its importance to GHCD. We will collaborate with GHCD to develop a detailed scope of work and a realistic schedule to meet project objectives. All project constraints (e.g. limited daylight low tides in fall and its effect on survey method) will be incorporated into the schedule. The M&N team will use all resources at its disposal, including its existing database of shellfish beds, expansion of survey team as needed, and requesting USACE model setups to work with GHCD to minimize uncertainties and develop a sound workplan. We have developed a tentative schedule shown below that will be refined at the outset of the project in-line with the agreed upon scope of work.

Tentative Project Schedule



TASK NAME	TEAM MEMBER(S)
SEDIMENTATION DYNAMICS (TASKS 1, 2, 3, 4, 5, 6, 7, AND 8)	
Data Review/Analysis	M&N/DEA/LTR
Desktop Geomorphic Analysis/Sediment Budget	M&N/DEA
Technical Committee Review	
Wave & Hydrodynamic Modeling - Baseline	M&N
Technical Committee Review	
Wave & Hydrodynamic modeling - Alternatives	M&N
(Optional) Sediment Transport Modeling or PTM	M&N
Technical Report	
Steering/Technical Committee Review of Technical Report	M&N
SHELLFISH AQUACULTURE & MAPPING (TASK 1 & 8)	
Stakeholder Outreach	LTR/PSI
Data Collection/Review	LTR/PSI
Focused Mapping	PSI/DEA
Shellfish Culturing Map	PSI/DEA
COMMUNICATIONS/STAKEHOLDER OUTREACH (TASK 9)	
Frequent Check-in with Technical/Steering/ Oversight Committees*	LTR/M&N/PSI
MITIGATION MEASURES (TASK 10)	
Define Physical and Water Quality Criteria	PSI
Mitigation Measure Development	PSI/M&N
Technical Committee Review	
Evaluation of Mitigation Measures	M&N/PSI

Assumptions: *Schedule has to be refined to allow for November and December holidays.*

** Frequency of meetings will be determined in coordination with GHCD.*

4.a. Managing Risk and Uncertainties in the Schedule

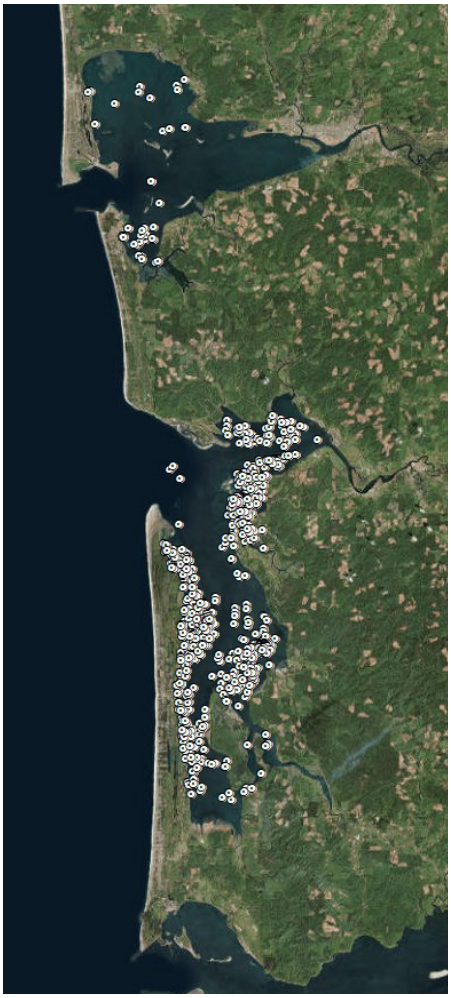
We will rely on our experience with similar projects and frequent communication with GHCD to efficiently manage resources and minimize uncertainties in schedule. The following are examples elements that can impact the schedule and measures we will take to address them.

Shellfish Mapping and Aquaculture/Stakeholder Outreach: We understand the importance of ground observations by the local community and invaluable insights of the commercial industry. We will supplement the Phase I survey results with stakeholder outreach at the outset of the project to understand and document ground observations and areas of existing concerns. Focus areas will be identified during this phase and will help the consultant team to efficiently identify data gaps and develop focused mapping efforts to minimize schedule as much as possible.

Shellfish Mapping and Aquaculture/Shellfish Bedding Mapping: There are different methods for surveying existing and identifying potential shellfish growing beds. The table below lists these methods and their corresponding advantages and disadvantages.

The M&N team will use a combination of these methods to efficiently map the existing beds and minimize schedule as much as possible. Our team member, PSI, has previously compiled a map of shellfish harvest sites for a different project and will supplement that with a literature review of physical and water quality tolerances of the shellfish species grown in the study area completed in 2016 for the Quilcene River project. We will use that information to project advantage and to minimize the schedule as much as possible.

SHELLFISH SURVEY METHOD	PROS	CONS
Desktop Analysis	*Least effort (schedule & budget)*	*Limited to available data & assumptions*
Ground Survey	*Most reliable, highest effort*	*Constrained by daylight low tides*
Drone Systems	*Time-saving, developing technology*	*Significant post-processing required, needs ground-truthing*
Satellite Imagery	*Cost effective, constrained by availability of high resolution aerials*	*Significant post-processing required, needs ground-truthing*



Shellfish harvest site locations in Grays Harbor and Willapa Bay (PSI 2016).

Sedimentation Dynamics/Modeling Methodology (Basis of Analysis): Sometimes the outcome of numerical modeling studies does not answer the project questions. This is usually because of an incomplete understanding of the system, physics of the related processes, and a model's capabilities to capture them. We will rely on our understanding of model capabilities to develop modeling methodology that will meet the project needs. The modeling methodology will be reviewed by the Technical Advisory Committee prior to start of modeling effort to ensure modeling serves its intended purpose and to avoid inefficiency and schedule slide.

Sedimentation Dynamics/Wave and Hydrodynamics Modeling for Proposed Alternatives: We will use our state-of-the-art in-house supercomputer (cluster) to run multiple scenarios and evaluate various mitigation measures (e.g., sediment control structures, changes in dredging, changing bathymetry) in parallel. M&N is the only company using a supercomputer to shorten the schedule as much as possible.