Appendix to FY23 Request for Proposals

The U.S. Army Engineer Research and Development Center's Coastal and Hydraulics Laboratory 2D Wave Flumes and Directional Spectra Wave Generator (DSWG)

U.S. Engineer Research and Development Center (ERDC), Coastal and Hydraulics Laboratory (CHL) has two directional-spectra wave generator basins and three wave flumes of different scales.

The two wave basins have the capability to conduct sediment studies and longshore currents.
- Basin 1 measures 100 x 100 ft by 3.3 ft deep
- Basin 2 measures 100 x 160 ft by 3.3 ft deep and is equipped with an instrumentation bridge to allow for cross-shore measurements

The directional spectra wave generator is moveable and can be set up in either basin. The directional spectra wave generator is composed of 56 individual paddles for a total length of 96-ft.

The three wave flumes are designed to accommodate a range of scales:
- Flume 1: The 3-ft flume measures 3-ft wide, 150-ft long, and 3-ft deep. The entire flume is glass. This flume can be used for laser-based velocity measurements like PIV.
- Flume 2: The 5-ft flume measures 5-ft wide, 200-ft long, and 5-ft deep. There is a 50-ft long, flat testing area. This flume is also capable of generating both opposing and following currents.
- Flume 3: The 10-ft flume measures 10-ft wide, 200-ft long, and 5-ft. There is a 50-ft long, flat testing area.

All wave machines make use of the latest wave generation technology and include active wave absorption.

Example projects that have used the U.S. Army Engineer Research and Development Center's Coastal and Hydraulics Laboratory facilities include:

Note: The below reference examples that mention wave making capabilities have since received an upgrade to the facility. Please reference the fact sheets for current accurate facility information.

- 5 ft Flume:
  - Wave attenuation by flexible, idealized salt marsh vegetation: https://doi.org/10.1016/j.coastaleng.2013.10.004
  - The response of vegetated dunes to wave attack: https://doi.org/10.1016/j.coastaleng.2019.103506
  - The Role of Belowground Biomass on Short Term Dune Evolution: https://doi.org/10.1142/9789811204487_0105
  - Walter Marine and Atlantic Reef maker wave Attenuator: wave transmission testing results: https://hdl.handle.net/11681/43303;

- 10 ft Flume:
  - Wave attenuation of coastal mangroves at a near-prototype scale: https://hdl.handle.net/11681/45565
- Large-Scale Sediment Transport Facility (LSTF):
  - Capabilities of the Large-Scale Sediment Transport Facility: https://apps.dtic.mil/sti/pdfs/AD1007544.pdf

Current instrumentation available for proposers to apply in their experiment includes 80 capacitance wave gauges, 12 ADVs, PIV system, Qualisys motion tracking (both above and below water), Faro Focus terrestrial LiDAR, and various other instruments (IMUs, force transducers, flow meters, etc.). LabVIEW is primarily used for data acquisition.

There is a fully functional sediment properties laboratory on-site including sieve analysis, laser diffraction for fine grains, wave-current boundary layer simulator, and a SEDFLUME. Specialized shop capability includes custom model bathymetry; 5-axis CNC machining for plastics, wood, metal; 3D printing; acrylic molding; in addition to common needs like carpentry, welding, and plumbing. Also, heavy machinery like forklifts and telehandlers are available.

U.S. Army Engineer Research and Development Center's Coastal and Hydraulics Laboratory General Sediment Testing Guidance:
- In house sediment available for use by awardees is well sorted, 0.15 mm. Other sizes would need to be sourced independently by the participants including material costs and costs associated with transport to the U.S. Army Engineer Research and Development Center's Coastal and Hydraulics Laboratory facility.

- Transporting material in/out of flumes/basins can add significant time to a project
  - 5ft and 10 ft flume: ~1-2 weeks
  - 3ft flume: ~1 week
  - Wave Basins: ~ 3-4 weeks (for material other than the in place 0.15mm sediment)
  - Larger flumes and basins will require more material and labor, so scaling to the 5ft or 3ft flume, if possible, within design would be advisable

- Materials that will **NOT** be allowed in the flumes/basins:
  - Salt water and salt
  - Cohesive sediment
  - Any sharp edged, mobile material that may permanently damage viewing glass during testing (flumes)
  - Any hazardous materials that cannot be safely drained from the facility

WAVE FLUMES

The U.S. Army Engineer Research and Development Center (ERDC) Coastal and Hydraulics Laboratory (CHL) houses three state-of-the-art wave flumes that are ideally suited for addressing a wide range of applications across a broad range of geometric scales. These flumes support research and site-specific studies of both government organizations and non-government organizations, including academia and the public sector.

APPLICATIONS

All 2D flumes are for coastal applications, ranging from fundamental research of water wave propagation physics, wave interaction with natural and nature-based features, and sediment transport in wave-current environments to designing and testing military infrastructure and coastal structures to include armor stability, wave runup, reflection, transmission, and overtopping.

RECENT PROJECTS

- Measuring response of floating military causeway systems in the surf zone
- Assessing the effectiveness of proprietary wave attenuation technologies and systems
- Quantifying wave attenuation of natural and nature-based features including wetlands, mangroves, and reefs
- Dune breaching, overtopping, and erosion in the presence of vegetation
- Generalized breakwater deterioration and stability studies
- Testing of instrumentation under controlled conditions prior to field deployment

WAVE FLUME SPECIFICATIONS

	0.9-m Flume	1.5-m Flume	3.0-m Flume
Length (m)	45.7	63.0	63.0
Width (m)	0.9	1.5	3.0
Depth of test area (m)	0.9	1.5	1.5
Additional Features	glass walls along entire lengh of flume	15.2-m long, flat testing area with viewing glass / following and opposing currents	15.2-m long, flat testing area with viewing glass

WAVE GENERATORS

	0.9-m Flume	1.5-m Flume	3.0-m Flume
Max Stroke (m)	2.0	2.0	
Max Paddle Velocity (m/s)	–	0.6	
Period Range (s)	0.5 - 5.0	0.5 - 5.0	
Max Regular Wave Height	0.45 m between wave periods of 1.7 – 3.5 s [1]	0.6 m at a wave period of 2.0 s [2]	
Max Significant Wave Height	0.23 m between peak wave periods of 1.7 – 3.5 s [1]	0.3 m at a peak wave period of 2.0 s [2]	

[1] - water depth of 0.76 m
[2] - water depth of 1.6 m

All wave flumes are equipped with piston-type wavemakers with modern wave generation capability, including active wave absorption. These wavemakers can create regular waves, irregular waves for commonly used (e.g., JONSWAP, TMA, Pierson-Moskowitz) and user-specified spectra, and solitary waves.

SUPPORT

An extensive variety of precise instrumentation complements the state-of-the-art capability of the flumes. The instrumentation includes capacitance wave gauges, acoustic Doppler velocimeters (ADVs), particle image velocimetry systems (PIV), underwater and surface motion tracking systems, and terrestrial LiDAR. Shop capability includes custom model bathymetry; 5-axis CNC machining for plastics, wood, and metal; 3D printing; acrylic molding; and skilled trades like carpentry, welding, and plumbing.

Directional Spectra Wave Generator (DSWG)

The U.S. Army Engineer Research and Development Center's Coastal and Hydraulics Laboratory houses a state-of-the-art Directional Spectra Wave Generator (DSWG) that is ideally suited for simulating realistic nearshore, coastal environments. The DSWG supports research and site-specific studies of both government and non-government organizations, including academia and the public sector. The DSWG is uniquely suited for addressing needs in both civil and military programs by reproducing littoral processes and surf zone characteristics, such as soil type, beach slope, water depth, longshore currents, and sea states, that are critical to decision-making and infrastructure design, testing, and operation.

Applications and recent projects:
- Nearshore hydrodynamics and sediment transport research including nearshore placement
- Surf zone morphodynamics and change including channel infilling
- Testing of coastal structures (e.g., breakwaters, groins, geotextiles, jetties) to include armor stability, wave runup, reflection, transmission, overtopping, and harbor resonance
- Testing and certifying flood mitigation and barrier products
- Assessing engineering performance of natural and nature-based features
- Bathymetry inversion and indirect bathymetry estimation
- Testing amphibious and bottom crawling vehicles for surf zone operations such as autonomous bathymetry measurements and mine detection

DSWG specifications and capabilities:
Basin
- 30 m wide, 50 m long, and 1.4 m deep
- Variable water depth between 0.3 and 1.0 m
- Modifiable beach slope (existing 1:30)

Wave Generation System
- Comprised of 56 individual wave paddles
- Piston-type waveboards with modern wave generation capabilities, including active wave absorption and generation of regular waves, irregular waves, solitary waves, and multidirectional waves
- Wave period range: 1.0 to 10.0 seconds
- Max regular wave: 0.5 m between the wave periods of 2.0 – 3.0 seconds at 1.0 m water depth
- Max significant wave: 0.26 m between the wave periods of 2.0 – 3.0 seconds at 1.0 m water depth
- Max paddle stroke and velocity: 1.1 m and 0.7 m/s

Supporting Infrastructure
- Cross-shore instrumentation bridge
- Onsite sediment supply comprised of fine, well-sorted sand (d_{50} = 0.15 mm)
- Specialized instrumentation including acoustic Doppler velocimeters (ADVs), wave gauges, flow meters, variable speed pumps to supplement wave-driven currents, beach profiling LiDAR, underwater and surface motion tracking systems to measure six degrees of freedom (6DoF)

Payoff: The DSWG accurately reproduces surf zone processes found on natural beaches in a finite-length wave basin and offers controlled, systematic testing of civil and military infrastructure in known and anticipated coastal environments.