DEMONSTRATION PROJECTS

DEMONSTRATION PROJECTS

Project Number	Project Proposals
DEMO-01	Living Blanket
DEMO-02	Shoreline Protection Utilizing Engineered In-Situ Native Material
DEMO-03	Crescent Stabilization System
DEMO-04	CWPPRA Project Monitoring & Assessment with Unmanned Aircraft Systems (UAS)
DEMO-05	Marine Gardens/Marsh Armor

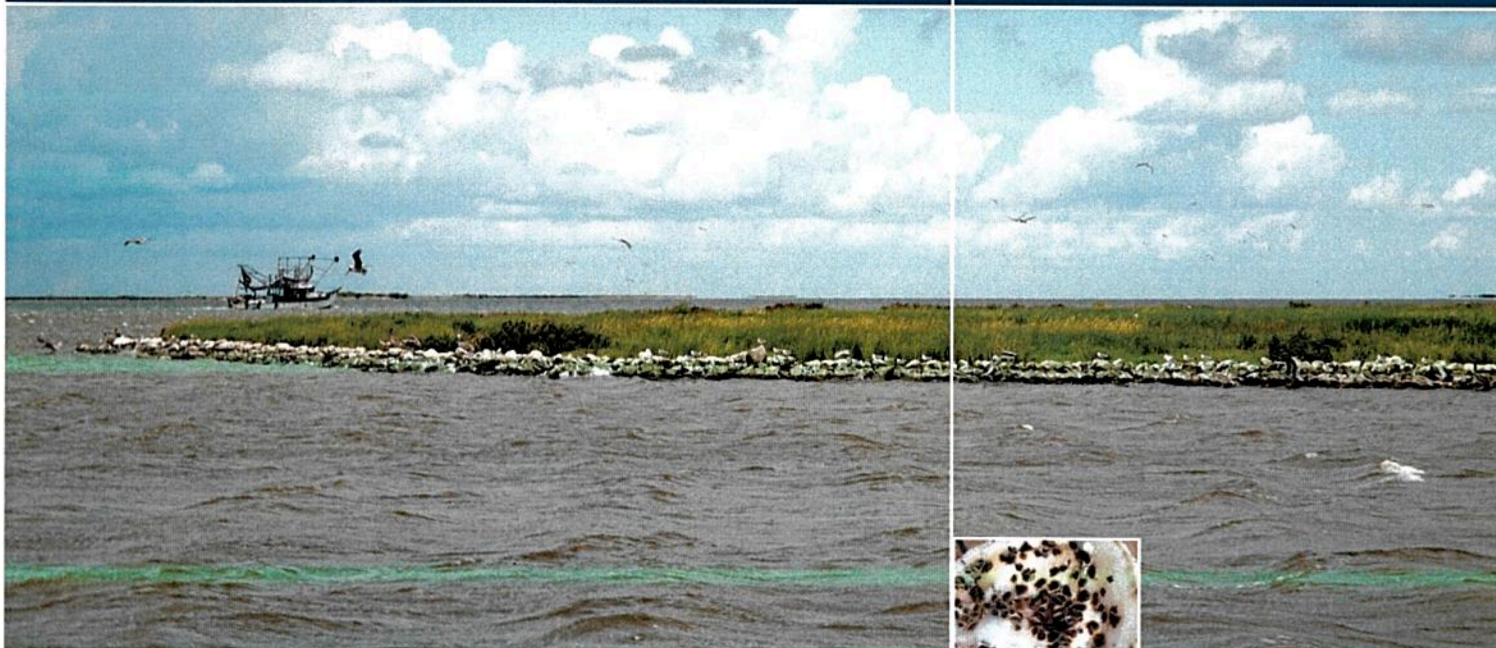
DEMO-01

LIVING BLANKET

Demo 1

the true living shoreline

LIVING BLANKET LLC™



The True Living Shorelines for...

- Erosion Control
- Estuary Enhancement
- Restoration
- Wildlife & Fishery Enhancement
- Stock Replenishment
- Reef Construction
- Recreational Habitats
- Mitigation

www.livingblanket.com

Saving Our Coasts, Through Viable and Dynamic Living Shorelines.

Living Blanket, LLC™ is transforming our coastline by building reefs and living shorelines using patent pending products and processes.

This is the only product that is seeded with oysters, so that it is a true living shoreline upon placement. The oysters continue to grow and spawn naturally so that the reef sees dynamic growth as it matures. Other products depend on natural recruitment of oysters so they are at the mercy of the vagaries of tides, current, and water conditions.

Colorado State University has tested our articulated blankets and are built on proven technology. Over 30 million square feet have been sold spanning the last 35 years. The properties of the blankets have been tested by Dr. Christopher Thornton, Ph.D. for behavior in wave action and all results are available.

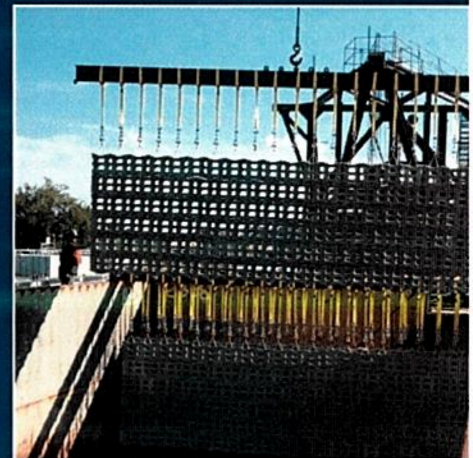
Our specialty manufactured blankets are infused with calcium that acts as catalyst to attract oysters in a natural way. Oysters are then seeded onto the blankets utilizing hopper barges as an integral part of this patent pending mobile setting system. Our sparge system roils the water column, allowing an even set of motile larvae throughout the barge.

To ensure success, larvae is seeded directly onto the blankets, using our patent pending process. Before emplacement, the blankets with oysters attached are then allowed to grow in a protected environment, feeding naturally. An optional biodegradable predat shield can be added to the blankets for certain environments.

Three Step Process:

- **Living Blankets, LLC are loaded into a dockside barge**
- **Hopper barge is flooded and blankets are seeded with pediveliger larvae**
- **Oyster spat laden blankets are emplaced according to project specifications**

The Only Product Delivering Oysters To Your Project.

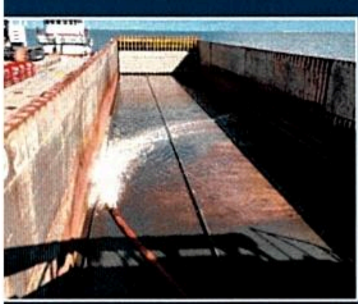


Living Blanket, LLC™ technology has created a patent pending mobile setting process that allows us to bring our oysters to any job, no matter of the location. Our setting team and equipment travels to your project and our process can truly be set up in any environment that is friendly to the development of oysters. These blankets are fully modular so any size or configuration can be used, and they can be placed in sub-tidal or tidal environments.

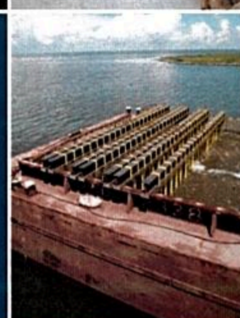
Each barge can produce 3,000 linear feet or 23,000 square feet of our "living blankets". After placement, if the oysters die off due to environmental reasons, the blankets can be reseeded for continued growth.

We use proprietary decadal salinity data to evaluate each project location for suitability and the potential for success.

The oysters of this living shoreline will settle in leases and beds where they can be commercially and recreationally harvested. The blankets will break the kinetic energy of waves, stop erosion, and clean the water. The restorative properties of adult oysters include the ability to filter up to 65 gallons of water a day. Each oyster will spawn naturally after six months of blanket emplacement which leads to dynamic growth of the reef. Upon placement in the wild, this is a living growing shoreline providing a habitat and full ecosystem to marine life and birds.



four week old spat on shell



Living Blanket, LLC™ utilizes wild brood stock from multiple locations so that we can return our oysters back to their natural habitat.

LIVING BLANKET LLC™

Corporate
7 River Road
Jefferson, LA 70121
504 432 7004

Research & Development Facility
381 Old Highway 26
Perkinston, MS 39573
601 528 2400

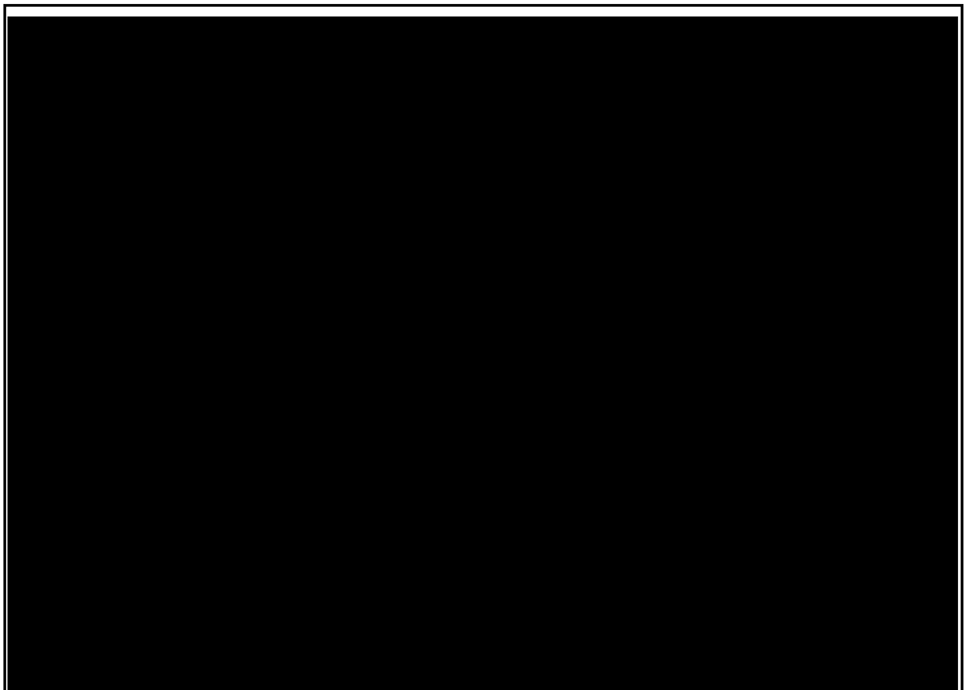
LIVING BLANKET LLC

WHAT IS LIVING BLANKET TM

- A unique, patent pending product that delivers a **TRUE LIVING SHORELINE.**
- Articulated concrete blankets **SEEDED** with oyster larvae.
  - Process does not depend on natural recruitment
- Living Blanket utilizes exclusive process of infusing fossilized oyster shell into concrete
  - Attracts eyed larvae for setting and encourages natural recruitment
- A modular system that can be put in almost any environment that is conducive to oyster growth.

WHY LIVING BLANKET TM

- Living Blanket expands CWPPRAs' restoration capabilities by building on existing restoration tools to provide a unique opportunity to incorporate oyster culture capabilities into a living shoreline.
  - Shoretec Block Mats
  - Enhances/Expands shoreline coastal protection features
- Introduces a process utilizing live seeded oysters into a restoration features for the first time.
- Only product that delivers live oysters and utilizes innovative process to enhance recruitment that can sustain reef development.

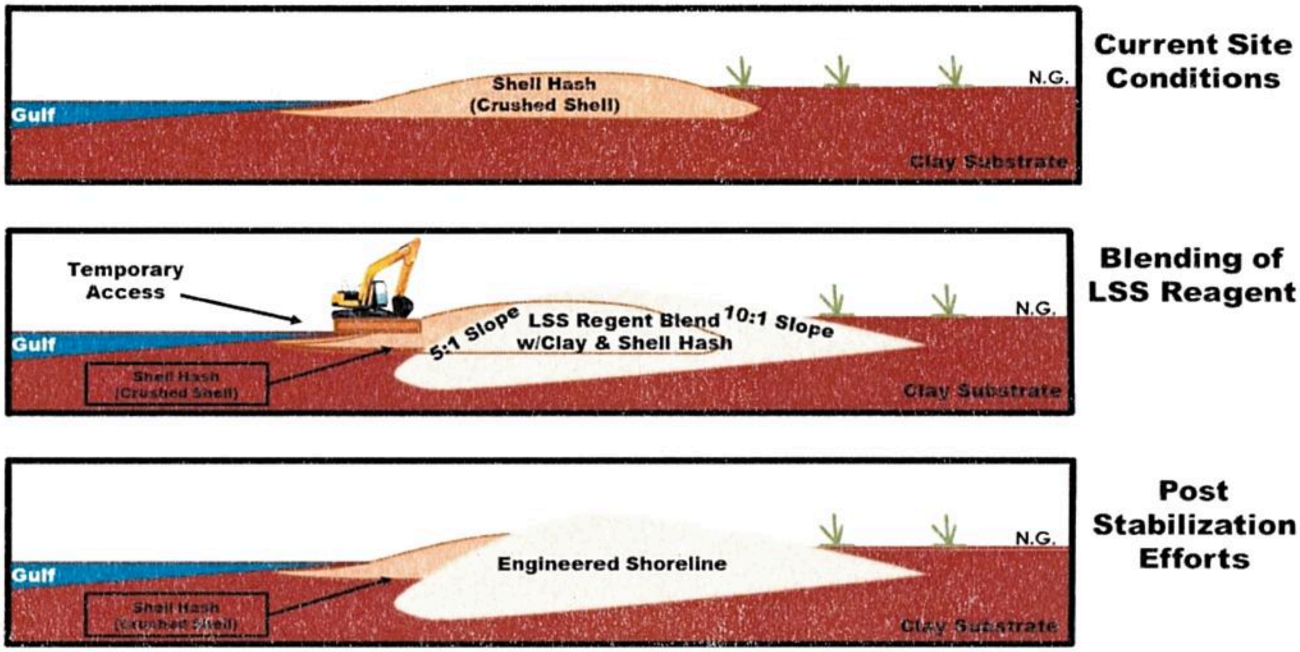


DEMO-02

Shoreline Protection Utilizing Engineered In-Situ Native Material

Demo-02

Conceptual Design: LSS Reagent Implementation



The resultant stabilized native material is designed to withstand the constant wave action forces and periodic storm surge much like the stabilized dikes that surround and protect a multi-billion dollar LNG facility.

The characteristics of Louisiana's coastline vary, which is why representative samples must be collected and tested with various reagent dosages to determine optimum strength conditions.

Project Benefits:
The proposed project would:

1. Be environmentally safe;
2. Provide immediate shoreline protection;
3. Appear like natural existing shorelines but less dense;
4. Cost less than riprap placement and man-made non-rock solutions;
5. Absorb and deflect wave energy and storm surges;
6. Protect and enhance existing marsh and future marsh creation projects;
7. Trap sediment behind the shoreline to build up marsh during storm surge events, without eroding away; and
8. Reduce interior marsh loss.

Project Costs:
The pre-designed cost to perform at least three (3) reaches of shoreline protection using in-situ stabilization techniques, pre-mixed native materials and a minimum of two reagent blends is $883,412 including mobilization, site access, staging and demobilization; approximately $476 per foot of stabilized shoreline not including upfront engineering design, mobilization, site access, staging and demobilization costs.

Preparer(s) of documents:

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PPL27 DEMONSTRATION PROJECT
January 31, 2017

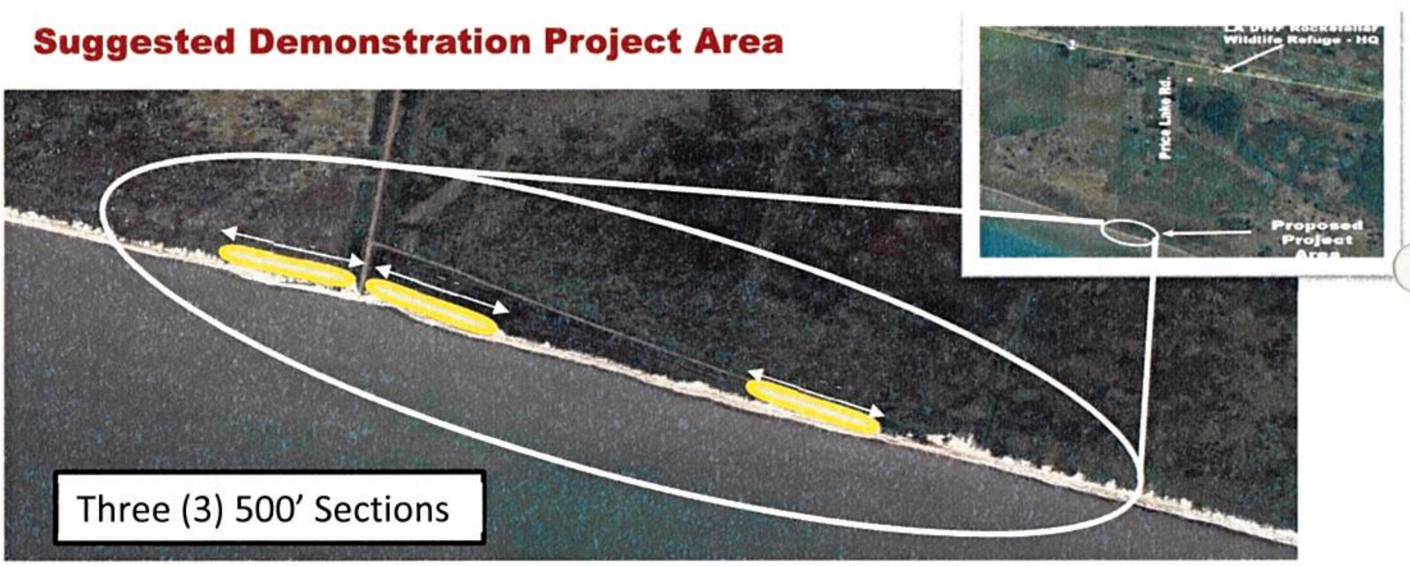
Demonstration Project Name: Shoreline Protection Utilizing Engineered In-situ Native Material by Project Consulting Services, Inc. and RECON

Coast 2050 Strategy(ies):
Maintain Gulf, Bay and Lake shorelines. Is consistent with the State Master Plan.

Potential Demonstration Project Location(s):
Coastwide; Proposing Rockefeller Wildlife Refuge, Cameron Parish

Problem:
Excessive erosion and subsidence to Louisiana's barrier islands, Gulf beachfront, bay and lake shorelines cause loss of thousands of acres of wetlands.

At the proposed demonstration project location shoreline erosion rates at the Rockefeller Wildlife Refuge have been recently measured in excess of 311 feet per year (2015-2016 Survey), which is 253 feet more than the 16-year average from 1998 to 2014 (Google Imagery). A large portion of the coastline contains soils that will support rip-rap and requires non-conventional armament. The need for stabilization in critical areas was noted by both CWPPRA and CPRA.



Goals:
To minimize and/or prevent continued erosion of the shoreline; hence, protecting the interior marsh and estuarine systems from the forces of the Gulf of Mexico.

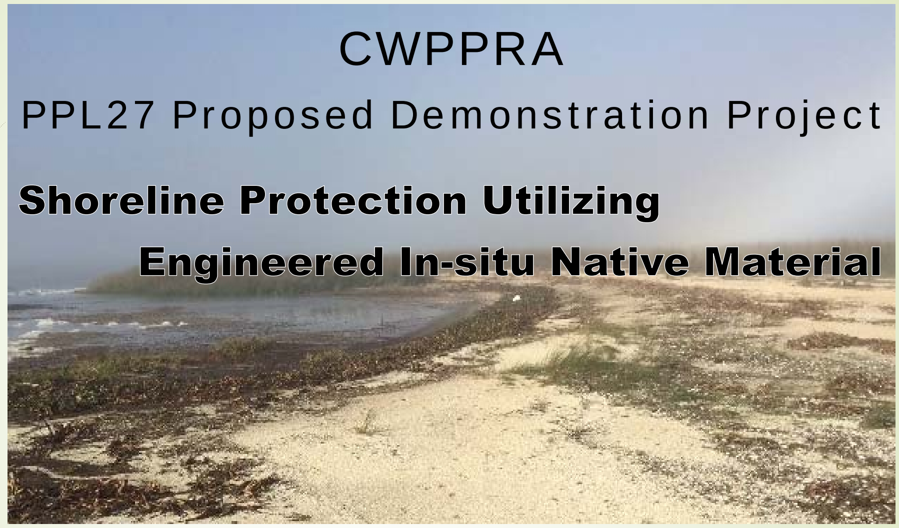
Proposed Solution:
Stabilization will take place in-situ by blending in a combination of patented Low Solids Stabilization (LSS) reagents/ amendments with existing shell hash and clay to create mineral growth that gains in strength and is not susceptible to rehydration. The LSS stabilized materials will not rehydrate and not revert to an unstable, low-strength state. A small dimension of un-amended shoreline between the stabilized native material and open water will eventually erode, exposing the native stabilized material that would serve to protect the remaining coastline. Shell hash will potentially begin to collect along the slope of native material, but will be contained so it doesn't continue rolling over into the marsh.

To simulate real conditions, a total of three (3) 500 foot long by 75 foot wide segments of beach will be stabilized in-situ. All three (3) segments will be stabilized via land access. Marooka LGP tracked dump trucks will be used to haul materials to each segment. The LSS reagent will be spread evenly by the LGP tracked dozer over each grid. Preliminary treatability testing suggests LSS reagent be applied at 7.5% of the combined weight of shell hash and clay mixture. A marsh excavator will primarily be used to stabilize grids 6 feet deep running parallel and adjacent to the Gulf of Mexico. A 300-size conventional excavator will be used to stabilize grids 5 feet deep that eventually interface with the marsh, working from the stabilized grids prepared by the marsh excavator. A low ground pressure (LGP) D6-size dozer will be used to grade the slopes; 5:1 on the Gulf side and 10:1 on the marsh side.

CWPPRA

PPL27 Proposed Demonstration Project

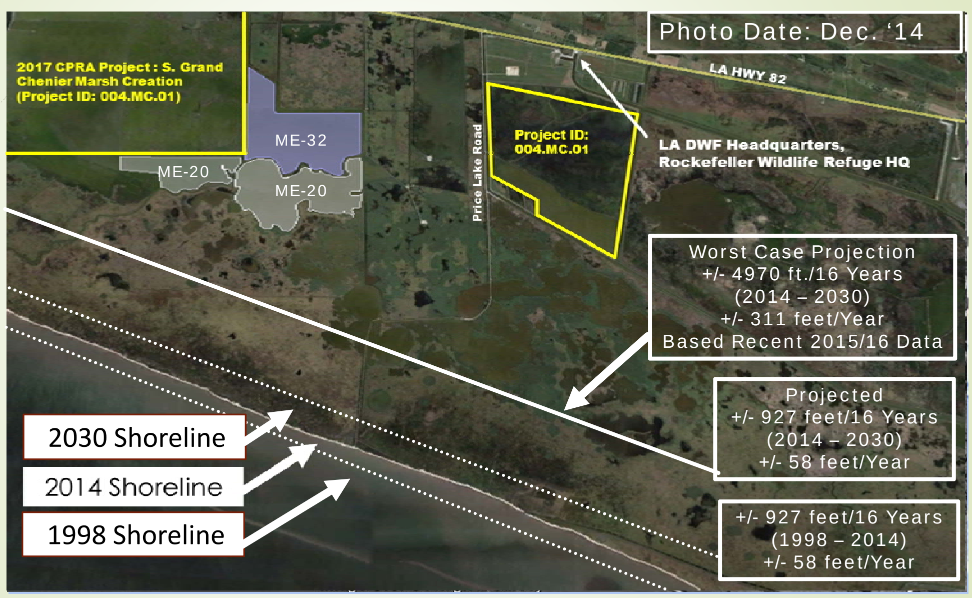
Shoreline Protection Utilizing Engineered In-situ Native Material



January 31, 2017

Main Regional Issues:

1. Receding Coastline
2. Poor Soil Conditions
3. Accessibility
4. Cost Effectiveness
5. Inland Ponds/Lakes Exposure to the Gulf of Mexico



RECON LSS Reagent Material

(Low Solids Stabilization (LSS) Technology)

- **Bayou Trepagnier Remediation**

  St. Charles Parish

  Immobilize 6,000' of Petroleum Contaminated Sediment within Bayou Trepagnier protecting human life, the environment, and ecological receptors within the bayou and the adjacent freshwater marsh and swamp.

- **Sabine Pass LNG Protection Levee**

  Cameron Parish

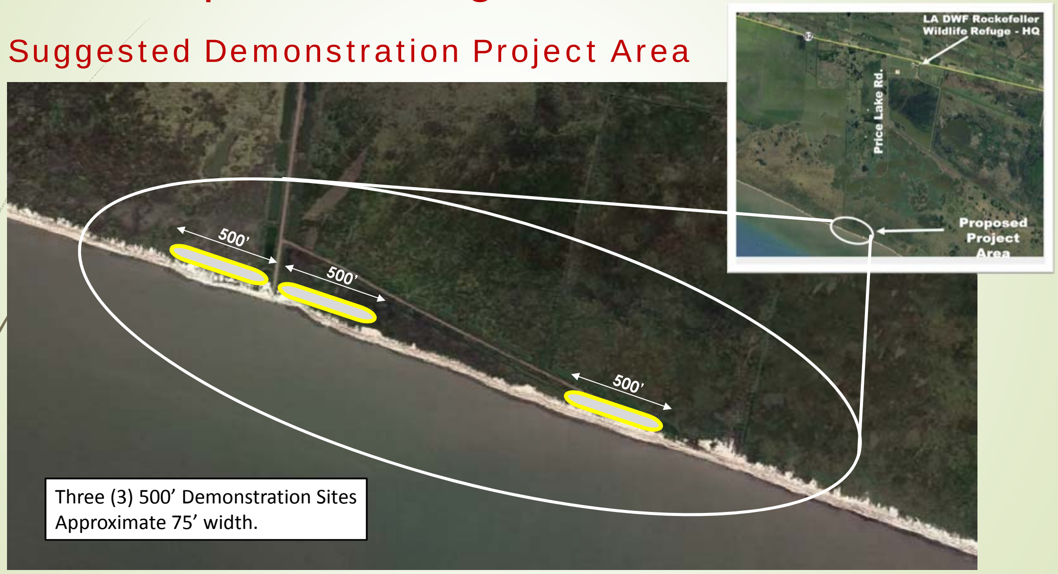
  Utilized LSS stabilized dredge spoils to construct stormwater dikes/ levees 30' high on 2:1 slopes to protect LNG tanks from hurricane storm surges and to serve as double containment. The levees were tested by storm surges of hurricanes Rita and Ike, required no repair.

RECON's LSS – Reagent

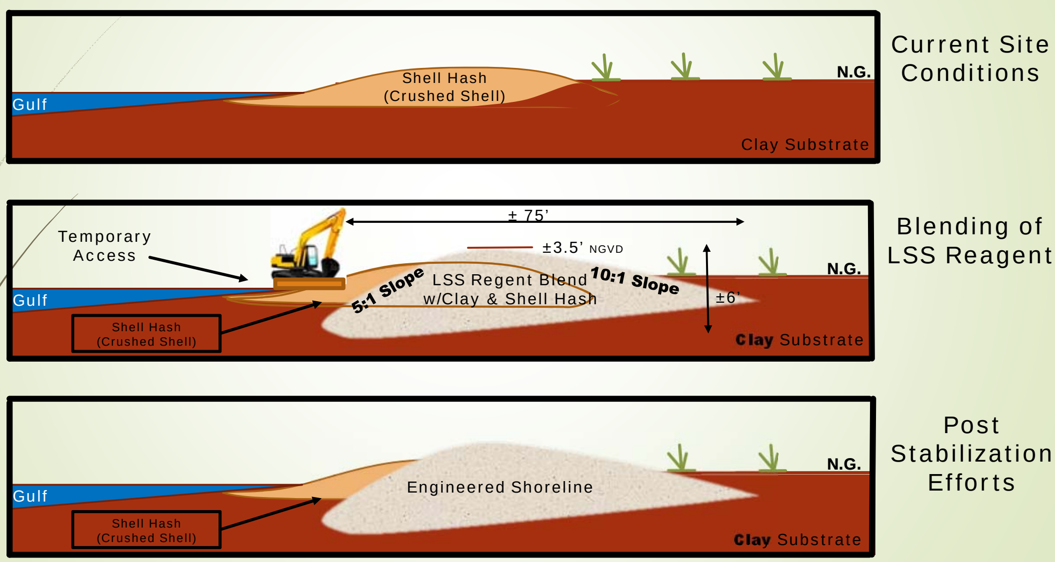
Chemical Makeup Composition	• Aluminosilicate Glass………………………	25 – 50%
	• Crystalline Silica, Total………………………	3 – 6 %
	• Calcium Oxide……………………………………	3 – 55 %
	• Magnesium Oxide……………………………	1 – 2 %
	• Calcium Sulfate Anhydrite…………………	5 – 45 %
Physical Properties	• Appearance………………………………………	Tan or Gray to White
	• Odor………………………………………………	No Odor
	• Specific Gravity (Water = 1)………………	2.2 to 2.9 lb./cubic foot
	• Bulk Density (Loose)…………………………	50 to 85 lb./cubic foot
Origin of Material	• Regionally: Louisiana, Texas & Alabama • Products & By-Products of Cement & Power Plants	
Comparative Materials	• Cement • Soil Cement • Calsorb-Calbase	
Bench Test Results	• Shell Hash, Native Clay & Reagent Blend – Initial Test Favorable • Shell & Clay Materials for Bench Test obtained from Rockefeller Coastline	

Conceptual Design: LSS Reagent Implementation

Suggested Demonstration Project Area



Conceptual Design: LSS Reagent Implementation



Advantages: RECON's LSS Reagent

- LSS Reagent
  - **Utilized in Sensitive Areas & Proven in Challenging Conditions**
- Installation Methodology
  - **Less Intrusive compared to other materials**
- Light Weight but Durable
  - **Not likely to subside with the ability to withstand wave energies**
- Cost Effective:

PRODUCT/CONSTRUCTION METHODLOGY - COST COMPARSION
RipRap (ME-18) Project vs RECON LSS Reagent

Product	Rip-Rap (ME-18)	LSS Reagent	Cost Savings
Per Linear Foot Est. Cost	$2,083	$476	$1,607
Per Linear Mile Est. Cost	$11M	$2.51M	$8.49M
Estimate Project Cost 1	$3.13M 2	$0.88M 3	$2.24M

NOTES:
1. Estimate based 1500' of armament as design in the ME-18 project drawings, and assuming total cost of project is 33M.
2. Costs provided includes Mobilization & Demobilization.
3. Demonstration Project cost estimated on limited field data & pre-engineering, also includes mobilization & demobilization.
General Note: Cost variables based on accessibility, delivery method & volume.

DEMO-03

Crescent Stabilization System

Demo: 03

PPL 27 Project Nomination Fact Sheet; January 28, 2017

Demonstration Project Name: Crescent Stabilization System™

Potential Demonstration Project Location(s): Coastwide

Problem:
The problem statement is twofold. First, marsh creation investments sited along canals or large open water bodies are subject to erosion from waves, tidal currents and vessel wakes. Armoring of earthen containment dikes is often confounded by poor geotechnical conditions, made worse by the excavation of containment dike material.

Second, dedicated shoreline protection projects perform poorly in the CWPPRA scoring process due to high cost to benefit ratios. Yet, shoreline protection still remains a critical tool for maintaining existing landforms and hydrologic patterns.

Goals:
The specific goal of this proposal is to equip the CWPPRA program with a new tool for stabilized marsh fill containment and shoreline protection. Our proposed demonstration project will validate the efficacy of the Crescent Shoreline System™ for retaining dredged material in challenging environments and/or reducing shoreline erosion.

Proposed Solutions:
The Crescent Stabilization System™ is a modular precast concrete armor unit designed to contain dredged material and break waves in the most economical way possible. The Crescent™ units are simple to fabricate, simple to install and use the least concrete per length of shoreline for the given design conditions. The articulating crescent shape allows the Crescent Stabilization System™ to follow shorelines or bottom contours while maintain continuous contact, which gives it a unique attribute of containment of dredged material and an advantage over other precast shoreline protection structures currently on the market. The Crescent Stabilization System™ can also be filled and planted to provide additional stability. Openings can be formed in the face of the structure to transform it into a reef structure.

Proposed uses for the Crescent Stabilization System™ include:

- Creating containment cells for dredged material
- Tying into earthen containment dikes where project edge is exposed to erosive forces
- Stabilizing canal banks, containing maintenance dredging material
- Creating reef and living shoreline structures
- Creating bird islands
- Creating alternative bulkhead structures

Preliminary Project Benefits:
Key project benefits are 1) a cost competitive method for containing dredged material in erosive conditions and 2) a cost effective alternative for shoreline protection. Specific project benefits will be contingent upon final design of the project.

Preliminary Construction Costs:
Estimated construction cost is dependent on demonstration project scope. We estimate the installed cost of the Crescent Shoreline System™ to be about $325 per foot of shoreline for the 11 ft dai x 5 ft tall Crescent™, not inclusive of other project features.

Preparer(s) of Fact Sheet:
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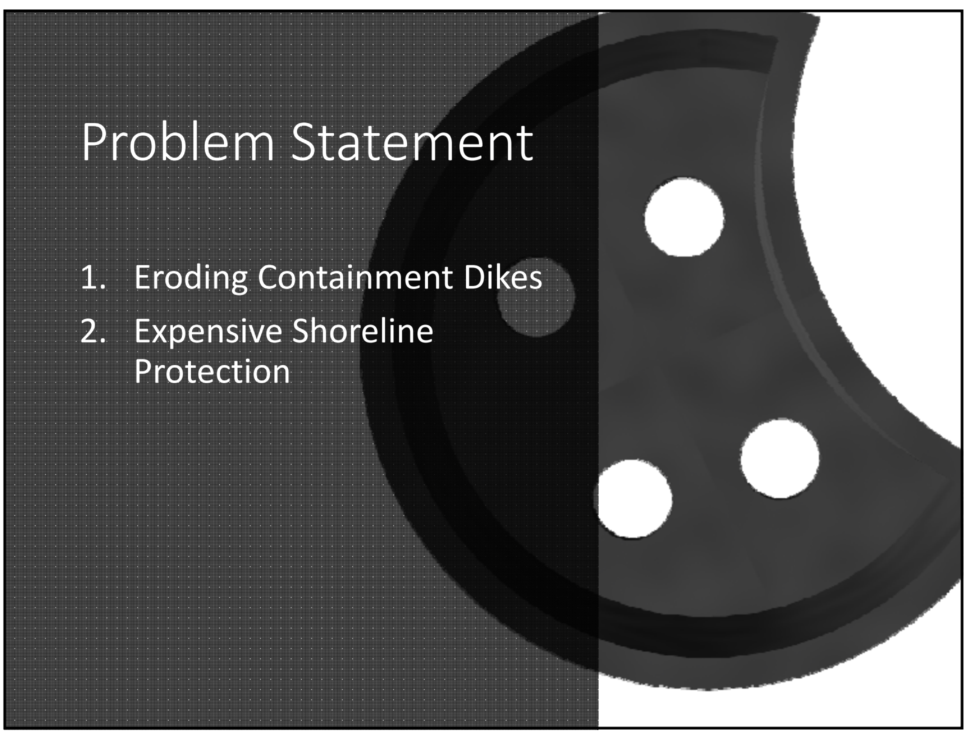
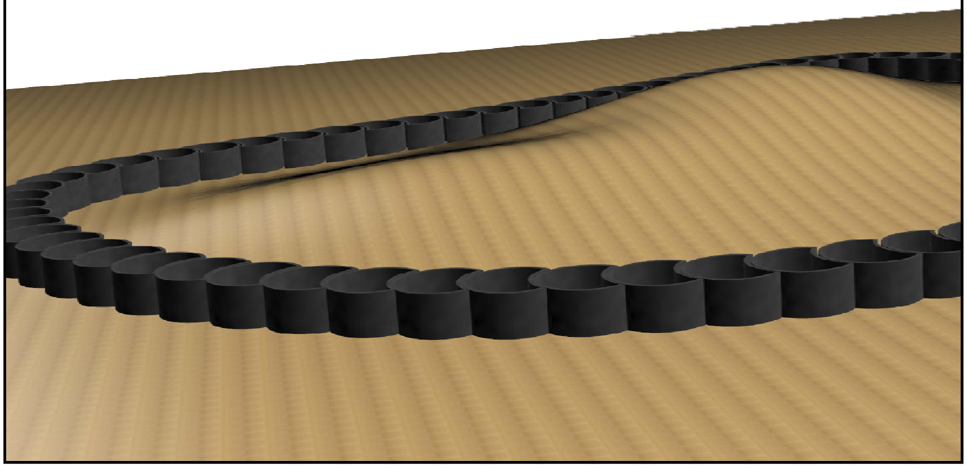
Matthew Campbell, Coastal Resilience Group, LLC, 225-372-5570, matt@coastalrg.com

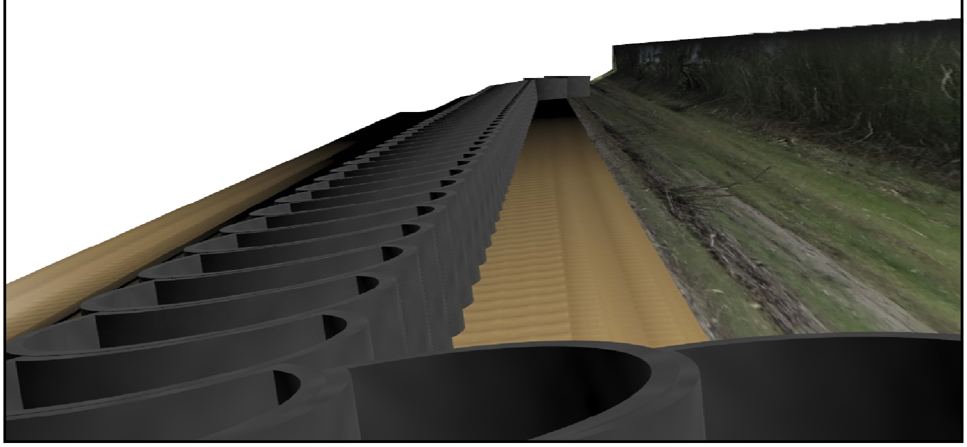

Crescent Stabilization System™
PPL 27 Demonstration Project Proposal
Tyler Ortego
Coastal Resilience Group, LLC
Patent Pending


Problem Statement
1. Eroding Containment Dikes
2. Expensive Shoreline Protection

Use Case: Dredged Material Containment



Use Case: Canal Bank Stabilization

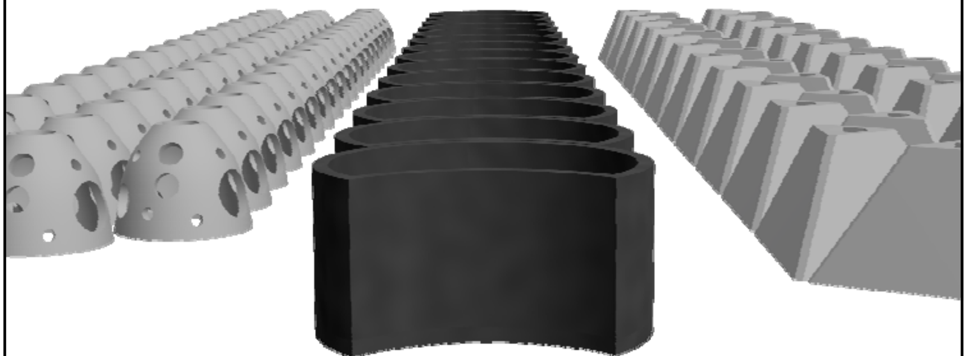


Use Case: Living Shorelines (Compare to PO-148 Top Performers)

$350/LF
1.0 tons/LF

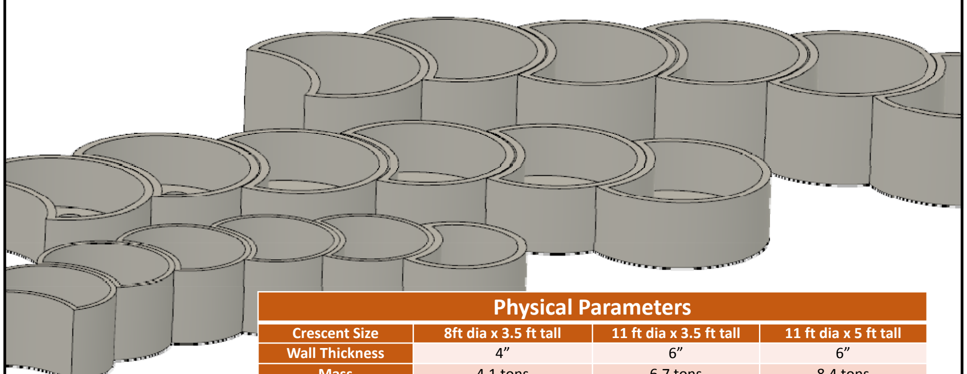
$325/LF (est.)
1.1 tons/LF

$390/LF
1.3 tons/LF



CRG Crescent Shoreline System

Design | Simplicity | Efficiency



Physical Parameters			
Crescent Size	**8ft dia x 3.5 ft tall**	**11 ft dia x 3.5 ft tall**	**11 ft dia x 5 ft tall**
Wall Thickness	4”	6”	6”
Mass	4.1 tons	6.7 tons	8.4 tons
Distance On Center	5.5 ft	7.5 ft	7.5 ft
Volume Concrete per Length of Shoreline	8.7 ft^3/LF	12.3 ft^3/LF	15.5 ft^3/LF

Value Proposition

Unaddressed Need – No precast concrete solutions on the market can contain hydraulically dredged material. Current practice is to create a sacrificial *in situ* dike, or armor with rock/ACB.

Short Time To Market – Simple design, plus simple function means that there are no major technical hurdles to implementation. A number of developing projects would benefit from the crescent.

Brought to you by Coastal Resilience Group, LLC.

Patent Pending.

For more information contact tyler@coastalrg.com


Crescent Stabilization System™
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Patent Pending

DEMO-04

CWPPRA Project Monitoring & Assessment with Unmanned Aircraft Systems (UAS)

Demo 04

CWPPRA Project Monitoring and Assessment with Unmanned Aircraft Systems (UAS)
a PPL 27 Demonstration Project Proposal

Potential Demonstration Project Location: Coastwide

Problem: Monitoring coastal restoration projects is time consuming and costly. Good, site-specific monitoring and assessment data, however, is necessary to assure that current projects are performing as intended, are being properly maintained and provide information needed to modifications, if necessary. The feedback information is also important for managers and planners as they adapt and design future projects.

Goal: The goal of this project is to evaluate the effectiveness of small Unmanned Aircraft Systems (UAS) to monitor and assess the performance of projects funded and completed under the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) program. UAS have already demonstrated their effectiveness to efficiently collect aerial imagery and elevation data for various industries. This project will test the application of UAS technology within the CWPPRA program.

Proposed Solution: The use of UAS equipment requires a remote pilot and specific operating rules in accordance with the Federal Aviation Administration (FAA) rules and regulations. This demonstration project will work with certified, trained, and knowledgeable consultants and universities, in collaboration with the CPRA Operations Division, to evaluate and develop a methodology and standard operating procedure for using UAS to monitor CWPPRA projects. On-the-ground monitoring data will also be collected to ground truth and validate the results from the UAS data collections and analysis. To accomplish this objective, we propose data collection and analysis at 6 locations. Two sites, one established project location and one recently completed project location, are suggested from each of 3 project types, shoreline protection, marsh creation, and barrier island restoration. UAS vehicle type (fixed wing vs multi-rotor), ground control (e.g. the number of ground control points and the accuracy of the survey necessary to meet performance standards), sensor type (visible light vs multispectral vs lidar), data products (orthomosaics vs point clouds vs digital surface models), and analytical methods (pixel-based vs object-based imagery analysis) will be evaluated to produce the most appropriate information that meets CPRA monitoring requirements. Results of the research will produce (1) data products used to evaluate the restoration success at these locations and (2) a standard operating procedure that could guide the implementation of UAS in the CWPPRA program.

Project Benefits: UAS technology has the potential to benefit monitoring, assessment, and even inspections of nearly all future projects. UAS equipment can save time and money, reducing the cost of monitoring CWPPRA projects while providing additional, high quality/resolution data. UAS are cheaper to fly than manned aircraft, faster than human surveyors, and can collect data more frequently than more expensive ground surveys. With the right software and analysis, the collected data can be developed into high resolution 3D structural models, orthomosaic images of entire projects, elevation models, and volumetric measurements. Unlike traditional surveying techniques, using a UAS is requires less staff and time in the field while also overcoming common site access issues such as impenetrable vegetation and shallow water. UAS imagery can produce raw aerial photographs of 1mm-2.5cm and project monitoring is improved as UAS data collections allow a site to be monitored more frequently. Potential improvements to current monitoring programs include accurate measurements of settling along shoreline protection systems, monitoring of initial elevation and compaction at marsh creation sites, high resolution maps of the land-water interface at any project site, and vegetation expansion and species identification of marsh creation and barrier island restoration sites. A major deliverable of this project will be a CWPPRA program UAS standard operating procedure (SOP) and/or protocol.

Project Costs: The estimated cost including field data collections, model development and analysis, and SOP development for 2 years is $1,250,000.

Preparer of Fact Sheet: Tom Cousté, P.E. Senior Engineer | JESCO Environmental & Geotechnical Services, Inc. | *SBA 8(a), EDWOSB, SDB, & Woman Owned Small Business* | 1701 S. Thibodeaux Road, Jennings, LA 70546 | Office: 337-824-9074 | Mobile: 337-515-0493 | Fax: 337-824-9076 | Email: tcouste@jescous.com | www.jescous.com

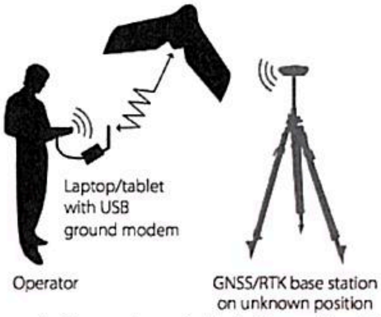


Figure 1: Ground control station with data link and GPS positioning for UAS data collection. (Image credit SenseFly)

Figure 2: Trimble ZX5 Multi-rotor UAS (Image credit: Trimble Navigation Limited)

Figure 3: Trimble UX5 fixed wing UAS (Image credit: Trimble Navigation Limited)

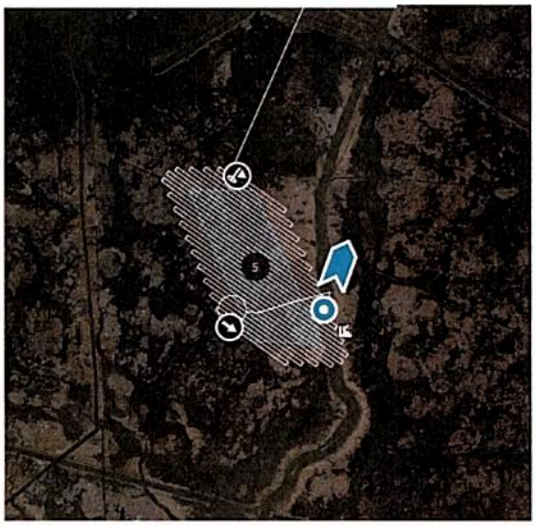


Figure 4: Flight path of fixed wing UAS aerial data collections in Terrebonne Basin that produced 2.5cm visible light and near infrared imagery. (Image credit: Jesco Environmental)

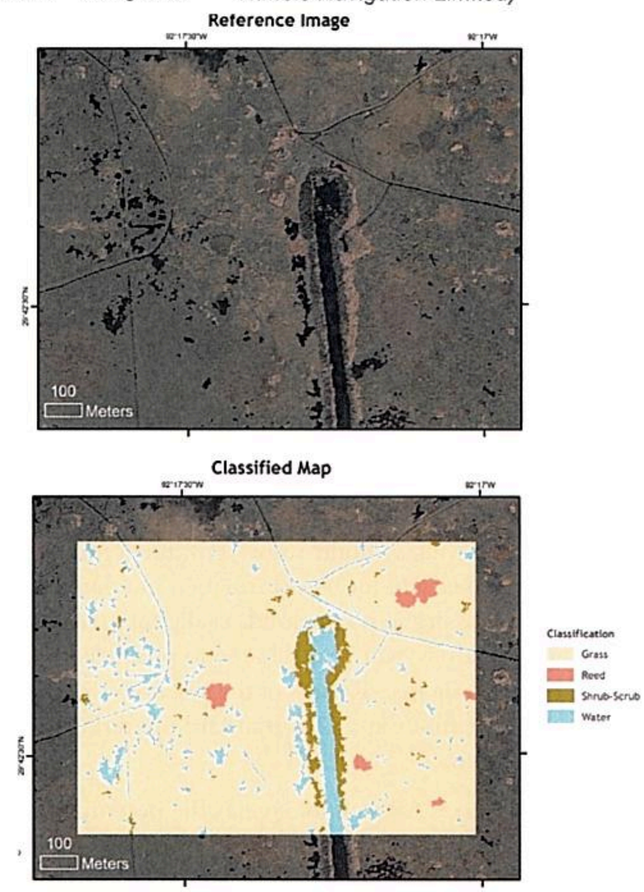


Figure 6: Example of 1 meter aerial image classification into dominant vegetation type. We propose to use similar methods using UAS data to create classified maps at 2.5 cm resolution.

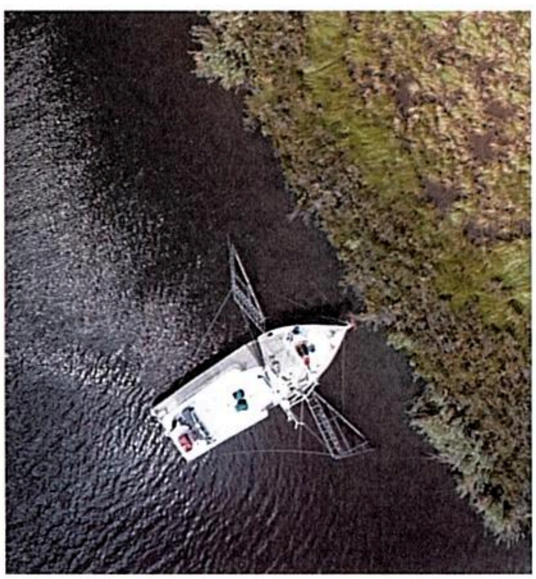


Figure 5: 2.5cm aerial photograph captured from a Trimble UX5. (Image credit: Jesco Environmental)

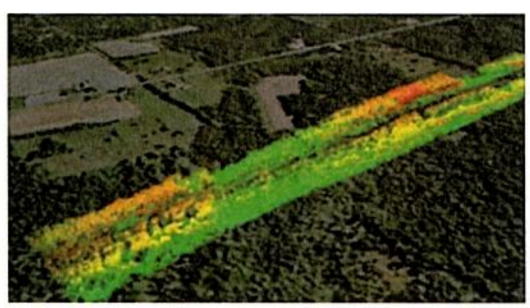


Figure 7: Example of a lidar point cloud. (Image Credit: Geodetics, Inc.)

CWPPRA Project Monitoring and Assessment with Unmanned Aircraft Systems (UAS)

a PPL 27 Demonstration Project Proposal

CWPPRA PPL 27
RPT Region III Meeting
Morgan City, LA
February 1, 2017

JESCO ENVIRONMENTAL & Geotechnical Services, Inc.
UNIVERSITY of LOUISIANA LAFAYETTE

Background and Goal

- Background and Current Problem
  - Collecting monitoring data is labor intensive and costly
  - Site locations are often difficult to access
  - UAS data collection and analysis is increasingly fast and cost effective
  - Need Standard Operating Procedures using off-the-shelf technology
- Proposed Project Goals
  - The primary goal of this project is to evaluate the effectiveness of small Unmanned Aircraft Systems (UAS) in their ability to monitor and evaluate projects funded and completed under the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) program.
  - UAS have already demonstrated their cost effectiveness to efficiently collect aerial imagery and elevation data for other industries. This project will test the application of UAS technology within the CWPPRA program.
  - Project design includes 3 restoration types, 2 sites each (one newly created and one established site)

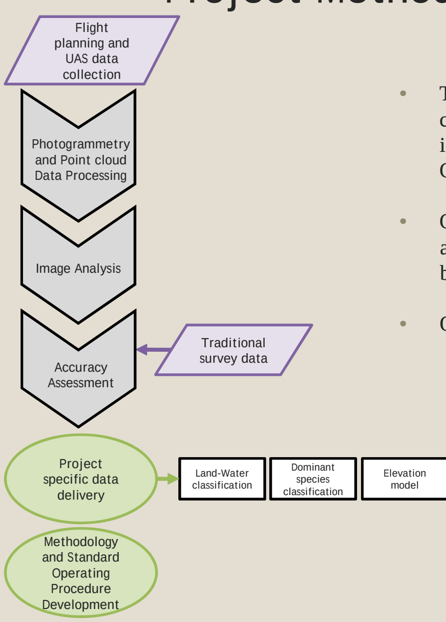
A marsh vegetation and elevation survey in a fringe marsh.

Project Design

UAS Aerial Photography – 2.5cm GSD

Image credits (counterclockwise): Qassim Abdullah, Trimble Navigation Limited, Geodetics, PIX4D, Jesco Environmental

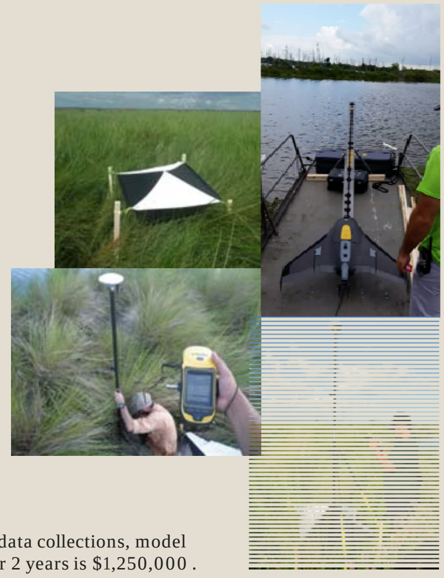
Project Method and Solutions



- This project will implement a pilot study to collect hyperspatial/multispectral aerial imagery and lidar data from a UAS over 6 CWPPRA restoration projects
- Create point clouds and raster datasets that are georeferenced and ready for object-based image analysis
- Object-Based Image Analysis
  - Vegetation classifications
  - Land-water interface
  - Elevation

Expected Project Benefits

- Save time and money
- Increased efficiency for vegetation and elevation surveys
- Fewer personnel requirements and ability to overcome site accessibility issues
- More frequent monitoring events
- Develop high resolution 3D structural models, orthomosaic images of entire projects, surface elevation models, and volumetric measurements
- Potential improvements:
  - settling along shorelines barriers
  - marsh creation compaction
  - high resolution maps of the land-water interface
  - vegetation expansion and species



Project Costs: The estimated cost including field data collections, model development and analysis, and SOP development for 2 years is $1,250,000 .

DEMO-05

Marine Gardens/Marsh Armor

Fact Sheet for PPL27 Demonstration Project Shoreline Protection, Preservation and Restoration Panel

Project Location:

Coastwide: Louisiana Gulf Coast anywhere, can be deplored from barge or land using light/medium weight equipment. Can be used for ridge building, shoreline protection, breach repair, protection of critical infrastructure or barrier island protection and can also be incorporated into existing projects.

Problems:

Traditional materials for coastal restoration armoring projects are expensive, have high environmental and transportation costs, accrue large mobilization expenses for heavy equipment handling and a high percentage of conventional materials (limestone) become buried into the sediment increasing costs exponentially. The present materials and coastal restoration methodologies are limited.

Goals:

Demonstrate the use of geopolymers as superior construction materials for coastal erosion structures. Prove strength, durability, versatility, lower costs, sustainability and numerous environmental benefits, such as increased shellfish production and buffering of sea water.

Demonstrate the use of 3D shotcrete printing as a superior construction method for coastal erosion armor structures proving lower startup costs, lower operating costs, design versatility, rapid construction, techniques that allow easy transferability and duplication of technology. Prove material versatility as an adjunct in combination with all restoration types. Prove the versatility of the 3D shotcrete printer to create customized structures, pylons, coatings and to move aggregates and sediments placing them exactly where needed for structure stabilization.

Demonstrate benefits of a continuous trapezoid tube modular design construction as a rapid ridge builder, for shoreline protection, highway/infrastructure protection and as a useful tool for coastal engineers, environmentalist and biologists.

Demonstrate the benefits of a monolithic structure in exponentially spreading displacement footprint allowing for a structure to utilize less non-local materials. Test designs as a sediment/ water diversion pipeline and to pump Geopolymer concrete to further expand structure and engineering infrastructure.

Monitor and document the ability of the project to meet stated goals.

Proposed Solution

The proposal is to design, build and install a 500' long trapezoidal erosion control structure using an in-expensive reinforced Marine geopolymer concrete and Kenaf fiber matrix. A portable 36' shotcrete Robotic arm manufactured by Shotcrete Technologies Inc. would be installed on a Marsh Master II light weight marsh buggy and used to form/ print and install the coastal erosion structure. Design example and a mock up picture of the mounted mobile shotcrete equipment is in Appendix A.

The project will mix a low-cost, sustainable, Marine geopolymer concrete formula using local minerals and soils. Most geopolymer materials are common soils including sand from the river or gulf (55 -60%) and waste mineral streams (38%) from local industrial plants. Binding agents/depolymerizing agents compose the remaining 2- 6% of the elements in the geopolymers and when all the materials are properly mixed and cured, the geopolymer forms an agglomerated stone, in our case its similar to quartzite/ hematite with fiber reinforcement.

These local geopolymer formulas are constructed from ordinary sands and industrial mineral waste streams, they are inert, water-based materials primarily based on a Ferrous/ alumni silicate bond. They have demonstrated adsorbent qualities, so they bind or entrap heavy metals, toxins, and even radioactive waste, putting them in an inert state. Properly mixed they are not only environmentally safe, they are substantially beneficial for the environment. Geopolymers are used in industry to bind environmental toxins and radioactive waste.

Costs for Construction and Monitoring

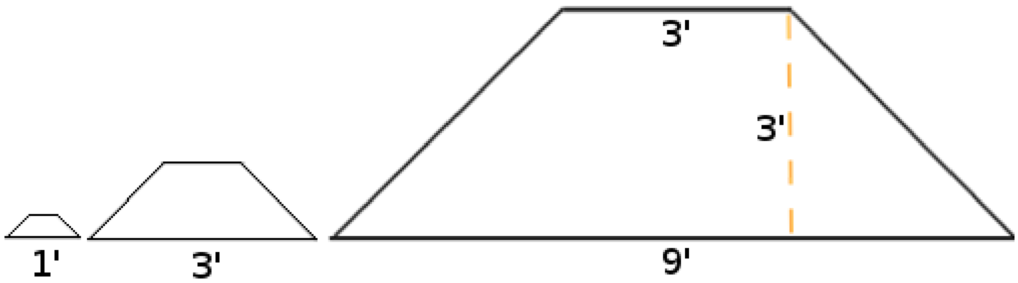
Estimated total cost of the completed proposed project approximately $2,100,000. Cost of the project includes all engineering and development cost, equipment and materials. Independent materials certification costs, Long and short term monitoring, financial analysis, modeling and comparatives for future scaled up use of the technology. Scaled up use of delivered materials is estimated between $75 and $100 per ton

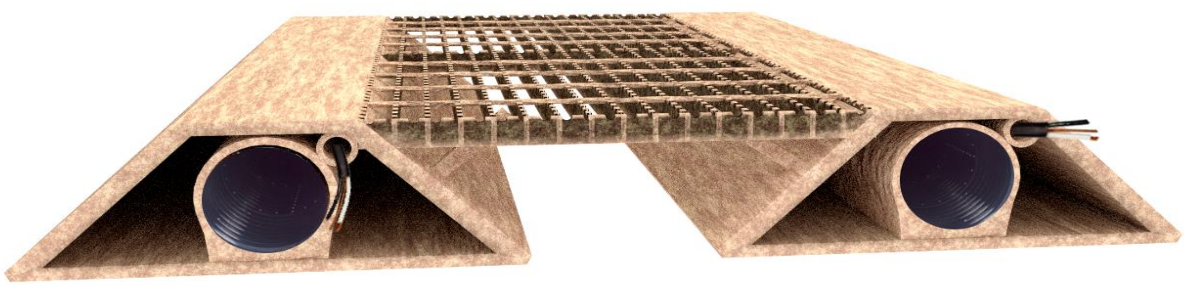
Prepare of Fact Sheet

Michael Boatright; Marine Gardens LLC 504 430 8900 MichaelBoatright@ecorigs.org

Appendix A

Figure 1. Marsh Armor Trapezoidal coastal erosion structure made with geopolymers marine concrete and Kenaf or mineral reinforcement fibers.





Marsh Armor trapezoidal tubes are stable concrete structures that can be used to take back land, by mending long shallow breaches with a solid protection barrier. Designed for hard to access areas by creating its own infrastructure path. It has versatile features that give project designers access, control and infrastructure to make new ground. These can be used in single or in double row configuration for maintenance vehicles. They can include power lines, piping and control systems built into the structure. Piping can be used for water or sediment diversion. Tubes are secured to an engineered pre-stabilized kenaf foundation geopolymer mat. They are light-weight structures that give flexibility to achieving stable, modular coastal erosion designs. They can be ballasted with sediment, rock or sand to engineering specifications. Geopolymer composite cement is saturated within the kenaf mat or steel fiber and combined with aggregate for trapezoid tubes, shotcrete applications with mat, mat tubes, mat structures and raw bat fiber. It is used with or without rock and sand aggregate and it can be used to composite steel, iron, HDPE, PVC, limestone and other materials. Formulas can be designed and changed for flexible properties. It is mixed with a coarse quartz sand and other aggregate and sizes to form a geopolymer concrete. Shotcrete sizes are limited to ½ inch aggregate.

Figure 2. Extrusion technology is well developed, Geo Polymers can be extruded with any concrete extruder or can be 3D printed free style or by mold injection.

This extrusion and 3D SCP process allows large scale production of simple designs that are continuous in length, machines that are small lightweight and compact can produce linear footage of tube armor very quickly and efficiently. Larger sizes can be prefabricated and delivered or scaled up extruder machines can do very large structures. Optimal efficiency is reached with mechanization of many of the processes. Economies of scale allow easier budgeting, calculating a given product by the meter or linear foot for both manufacture and installation on site. The surfaces can be made solid with reinforcement to support maintenance vehicles, foot traffic walkways and platforms for pumping equipment and marker lights. Outriggers can be added to produce stable platforms where needed. Areas that are inaccessible and unprotected can be armored and easily accessible for coastal erosion management.

Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA)

Proposed Demonstration Project

Marine Gardens - Marsh Armor

3D Shotcrete Printer/ Geopolymer Structures

Demonstration Project Shoreline Protection, Preservation and Restoration Panel

Prepared by

Marine Gardens LLC - Marine Gardens Collaborative
Michael Boatright
michaelboatright@ecorigs.org

January 31st, 2017

Demonstration Project Shoreline Protection, Preservation and Restoration Panel

Abstract: The proposed project would use a 3D shotcrete printer utilizing a cost effective customized Marine geopolymer concrete as construction materials for a coastal erosion structure. The proposal is to design build and install a 500-ft. trapezoidal coastal erosion structure using a marine grade geopolymer concrete and a kenaf fiber matrix. A mountable 36 ft. shotcrete Robotic arm manufactured by Shotcrete Technologies Inc., installed on a Marsh Master II light weight marsh buggy and will be used to form/ print and install a trapezoidal coastal erosion structure. The project will mix a low-cost Marine geopolymer concrete formula using local minerals and soils at ambient conditions. Most geopolymer materials are common soils including sand from the river or Gulf (55 -60%) and waste mineral streams (25-38%) from local industrial plants. Binding agents/polymerizing agents compose the remaining 2 - 6% of the elements in the geopolymer concrete composite and when all the materials are properly mixed and cured, the geopolymer forms a new mineral specie or stone. This is a well proven science established in 1972 by Dr. Davidovits of The GeoPolymer Institute. Recent construction projects that use geopolymers include the W. Brisbane airport in Australia. In our case, the specie is an agglomerated stone similar to quartzite/ hematite, with fiber reinforcement. Our geopolymers are constructed from ordinary sands and industrial minerals waste, they are inert, water-based materials primarily based on a ferrous/ alumni silicate bond.

Project Location:

Coastwide: Louisiana Gulf Coast anywhere, can be deployed from barge or land using light/medium weight equipment. Project can be used for ridge building, shoreline protection, breach repair, protection of critical infrastructure or barrier island protection and can also be incorporated into existing projects.

Problems:

Traditional materials for coastal restoration projects are expensive, have high environmental and transportation costs, accrue large mobilization expenses for heavy equipment handling and a high percentage of conventional materials (limestone) become buried into the sediment increasing costs exponentially.

Goals:

Demonstrate the use of geopolymers as superior construction materials for coastal erosion structures. Prove strength, durability, versatility, lower costs, sustainability and numerous environmental benefits, such as increased shellfish production.

Demonstrate the use of 3D shotcrete printing as a superior construction method for coastal erosion armor structures proving lower startup costs, lower operating costs, design versatility, rapid construction, techniques that allow easy transferability and duplication of technology. Prove material versatility as an adjunct in combination with all restoration types. Prove the versatility of the 3D shotcrete printer to create customized structures, pylons, coatings and to move aggregates and sediments placing them exactly where needed for structure stabilization.

Demonstrate benefits of a continuous trapezoid tube modular design construction as a rapid ridge builder, for shoreline protection, highway/infrastructure protection and as a useful tool for coastal engineers, environmentalist and biologists.

Demonstrate the benefits of a monolithic structure in exponentially spreading displacement footprint allowing for a structure to utilize less non-local materials. Test design as a sediment/ water diversion pipeline and to pump geopolymer concrete to further expand structure and engineering infrastructure.

Monitor and document the ability of the project to meet stated goals.

Proposal

The proposal is to design, build and install a 500' long trapezoidal erosion control structure using an in-expensive reinforced Marine geopolymer concrete and Kenaf fiber matrix. A portable 36' shotcrete Robotic arm manufactured by Shotcrete Technologies Inc. would be installed on a Marsh Master II light weight marsh buggy and used to form/ print and install the coastal erosion structure. Some design example structures and a mock up picture of the mounted mobile shotcrete equipment in Appendix A.

The project will mix a low-cost, sustainable, Marine geopolymer concrete formula using local minerals and soils. Most geopolymer materials are common soils including sand from the river or gulf (55 -60%) and waste mineral streams (38%) from local industrial plants. Binding agents/depolymerizing agents compose the remaining 2- 6% of the elements in the geopolymers and when all the materials are properly mixed and cured, the geopolymer forms an agglomerated stone, in our case its similar to quartzite/ hematite with fiber reinforcement.

These local geopolymer formulas are constructed from ordinary sands and industrial mineral waste streams, they are inert, water-based materials primarily based on a Ferrous/ alumni silicate bond. They have demonstrated adsorbent qualities, so they bind or entrap heavy metals, toxins, and even radioactive waste, putting them in an inert state. Properly mixed they are not only environmentally safe, they are substantially beneficial for the environment. They are used in industry to bind environmental toxins and radioactive waste.

Project Features

Before the geopolymer mix hardens, they are thixotropic and malleable, they can be formulated to be used in shotcrete 3D print applications. They can be mixed on-site or pumped through pipes or hoses up to a mile. The shotcrete device has a robotic arm with a 36-foot reach from center. It can rotate 360 degrees and has an articulated head that can be remote controlled or programed for 3D structures. It pumps up to 50 cubic yards of material per hour, can precision print up to 15 cubic yards per hour and can be automated on a compact tractor, marsh buggy or utility vehicle. It is lightweight equipment, versatile and the device can operate anywhere along the coast. The equipment can be mobilized on light weight personnel marsh buggies, at lower start up and operating costs than traditional construction methods. These tools and materials can be used for any number of coastal marsh armoring projects and can be used as an adjunct in enhancing all restoration types. Geopolymers set underwater. Seawater/water is used in the curing process. Once set, the ferrous elements contained in this formula have demonstrated a small negative discharge allowing the structure to attract positively charged ions.

These minerals are known adsorbents, that attract and bind heavy metals and hydrocarbons from the water column into the structure where they become bound and inert. They are continuously coated with a growing calcium coat and a Ph buffer. The effect is also seen as the galvanic effect on the protective cathode systems of oil rigs and other reef grid products such as BioRock ™ invented by Tom Gorue and widely used in reef building projects.

Geopolymers are primarily local sands, minerals and soils, mixed and formed on-site. This reduces the costs associated with the transportation of large quantities of materials, e.g. limestone, riprap, and infrastructure equipment. Geopolymers are permanent, can be custom designed to cover a much broader surface area than limestone and can be installed at significant savings, with a much lower mobilization and demobilization costs of traditional coastal erosion armoring methods.

Monitoring Plan

The project biologists and engineers would implement a monitoring plan according to guidelines recommended by the Coastal Wetlands Planning, Protection, and Restoration Act and the Louisiana Coastal Wetlands Conservation and Restoration Task Force. Any analysis of structural and environmental samples collected would follow Louisiana State Quality Control and Assurance Plan procedures for federally sponsored projects. All structural materials are independently tested. Outside testing, formulas, operating procedures and certifications will be in accordance with standards established by The GeoPolymer Institute. The recognized authority of Geopolymer Sciences.

Costs for Construction and Monitoring

Estimated total cost of the proposed project approximately $2,100,000. Cost of the project include all engineering and development cost of the equipment and materials. Long and short -term monitoring, financial analysis modeling and comparatives for future scaled up use of the technology. All certifications. Scaled up use of delivered materials is estimated between $75 and $100 per ton

Innovativeness and Transferability

The Marsh Armor consists of geopolymer composite stone, metal fiber, mineral fiber and kenaf fiber materials to armor and promote the growth of natural living habitats. Simple standardized product designs allow project flexibility for coastal protection that can be proactively and practically managed to create abundant healthy ecosystems. Marsh Armor can be rapidly produced and implemented with lightweight designs and light weight extruder/printer machines, 3D shotcrete printing, by small trained crews. This can lower cost significantly, quickly repair breaches and stabilize rapidly eroding areas. Marsh armor trapezoid tubes, combined with shotcrete geopolymer, stabilized kenaf foundation mats, and kenaf tubes, provide planners and engineers project flexibility with a variety of new tools.

Innovativeness and Transferability - continued

Also, geopolymers conform to shapes easily and can be used with traditional rebar, steel reinforcement and aggregates. They set within 2 hrs. in ambient conditions and takes slightly longer time underwater. Materials such as steel, iron and kenaf matting can be protected by the geopolymer composite making the structure

more durable and long-lasting. Shotcrete devices offer rapid application to any shape. Composite can be applied manually for small jobs and repair. Geopolymers can be cast as blocks or larger construction projects by batch mixing and concreting in situ.

Potential Cost-Effectiveness

3D construction printing and GeoPolymer Materials Science are both exponential industries that are both experiencing rapid exponential growth, they are both poised to disrupt other industries. Printing structures is very cost effective it has the potential to disrupt the construction industry. Homes can be printed in hours. These savings can be applied to coastal erosion efforts.

Our geopolymer concrete is specifically formulated for the marine environment with unique features. It is non-porous, forms ionic and covalent bonds with iron reinforcement that protects reinforcement from sodium ions, sulfates, caustics and all but the most potent acids. Created with the closest most common and most cost effective local materials. River/gulf sand and mineral waste. It's a well proven material science that is safe, inexpensive and permanent. It also has known properties that create positive effects on shell bearing organisms. It is a superior alternative to porous ordinary Portland cement (OPC) concrete that is unsuited for reinforced marine structures. Marine geopolymer concretes offer an opportunity to convert a variety of burdensome mineral waste streams into useful by products that enhance nature and fill a specific need. In many areas, it is possible to utilize the sands on site and avoid the additional expenses of materials transport to the jobsite.

Potential Cost-Effectiveness - continued

Geopolymers are Nano polymers that form new macromolecular structures, unlike OPC they can utilize finer silica and quartz aggregates and fillers such as river and gulf sands with good compressive strength. Initial estimates for large scale production using geopolymers to construct most coastal erosion hard armor is about $75 - $100 /ton, this is comparable to what is paid for limestone rip rap but at a far less cost. It costs less than OPC estimated between $120-$160 a ton. It is far less expensive than limestone or OPC by its use. By customizing the design into a monolithic structure the surface displacement of the structure dramatically increases and substantially lowers the costs. The exponentially larger surface area allows for a lighter structure that sinks less, so it is far less tonnage then for the same size structure made of dense limestone boulders. The surface area is exponentially greater for 1 ton of geopolymer reinforced structure than 1 ton of limestone.

The density of the limestone also requires many more tons for the same surface area making the cost significantly higher. Without allowing for sinking a 166 sq foot print of monolithic reinforced geopolymer slab 2 inches thick would be approximately the same weight as a limestone boulder that may occupy 9-12 sq ft. Factor in sinking, it will require exponentially more limestone tonnage to build the same size armor protection. In the instance, a greater weight is desired it can be filled with local sediment. Footers and pylons can also be made onsite. Due to its strength, durability and fiber matrix it can be made to cover even greater surface areas with less materials than OPC.

It's much faster utilizing the shotcrete 3D SCP, smaller lighter equipment with smaller manpower requirements allow for quicker deployment, less setup and relocation time and more rapid construction. The same systems allow for inexpensive low cost duplication of readily available equipment that can be operated most anywhere with minimal set up.

Potential Environmental Benefits

These geopolymers utilize solid mineral wastes from industrial processes. The beneficial use of solid mineral waste involves identifying and using industrial mineral waste as a substitute for virgin mineral construction materials. The environmental benefits of substituting industrial waste minerals for virgin materials includes conserving energy, reducing the need to extract natural resources and reducing demand for disposal facilities. The other environmental benefits include a reduction in CO_2 air emissions, geopolymers are green, they do not require clinker lime. Most industrial waste streams are pre-sintered and amorphous in nature making them excellent geopolymer components. This produces a 64% reduction of carbon dioxide as compared to Portland cement CO_2 emissions (McLellan et al. 2011). Properly prepared they are non-porous inert stone agglomerates, they do leach nor pose any negative environmental impact.

Bound ferrous components in geopolymers have been demonstrated to produce a small negative charge similar to Bio-Rock TM and to the galvanic protection of Oil rigs. In peer, reviewed documents on Bio-Rock TM this reaction has consistently produced exponential abundance in reef health. Coral and shellfish have an 8-1 growth and reproduction increase, 20-1 increase in skeletal strength and 50-1 in resistance to environmental stresses. It was proven the organism spends less energy calcium building and diverts that energy to growth and reproduction.

Adsorbent qualities, the same charge theoretically also attracts waterborne hydrocarbons, heavy metals and other waterborne pollutants that have a + electron. It would bind to the structure making it benign and inert, its further covered in CA+

The rapid speed and reduced costs of constructing versatile hard armor with off the shelf exponentials, would have an exponential effect on the master plan, allowing an increase in the ability to protect and build structures at such a savings that much more can be done with much less funds and much less time. This leads to exponential environmental benefits.

Recognized Need for the Information to be Acquired

Geopolymers used with mobile shotcrete installation systems have limited use in history. Most of the use has been in private industry for subsurface construction and rebuilding of large drainage projects to faulty pipes under city infrastructure, it's also used in the tunneling industry and for high cliff mountain stabilization projects. Geopolymers can be useful in all restoration types of coastal erosion. Shoreline armoring, as diversion infrastructure, as an adjunct for terracing and vegetative protection, barrier island restoration and hydraulic barriers. The information and knowledge gained from the proposed project will be used to demonstrate the versatility of the materials, construction methods and design. Geopolymers have been used successfully on a very limited basis in coastal erosion projects in India and on shoreline home protection in Venice, Italy.

Further studies are needed to evaluate reef growth potential, the materials have little research done as to the positive effects of bio accretion reef properties and or on tweaking of these properties. Data presented is from a cross discipline of sciences, practical implementation is needed to evaluate the impact of new materials, materials sciences, and new construction techniques on coastal erosion. This needs to be evaluated for potential benefits for the master plan.

Potential for Technological Advancement

Great technological advancements can be realized by merging off the shelf exponential technologies. 3D Robotic construction printing and geopolymer sciences are both recognized exponential industries. Exponential industries are disruptors. These are industries that are experiencing such rapid growth, that they will disrupt and replace entire industries and ways of doing things. Large complex buildings are being printed with 3D construction techniques at significant savings. Combining the two creates exponential abundance for the coastal erosion program.

The advancement potential for geopolymers is its abundance, versatility and low costs. Geopolymer cement is known as a green cement, it has a different chemical structure than Portland cement or alkaline activated materials (Davidovits 1994).

Potential for Technological Advancement - continued

The exothermic reaction, set and results are different. Portland cement is a hydraulic binder, whereas geopolymer cements are nano polymers that form new macro molecular structures or new mineral species (Khale D Chaudary 2007). These materials can be shaped, molded, or printed into monolithic structures, and installed in seawater. It will normally set in 2-hrs. Geopolymers are an alumina silicate species, that when properly set form covalent bonds (Wagh 2016). They vary widely in geometric bonding structures and by formula. Many cannot be distinguished from natural rock by trained mineralogist. They do not dry, nor do they bond as hydraulic binders do and they don't require lime (Yip et al. 2005). They set by polycondensation, forcing moisture out of the new structure (Xu 2000; Phair et al. 2001). They can provide compressive strength of up to 20 megapascal [MPa] (2900 psi) at 4 hours and up to 95 MPa (14000 psi) at 28 days or full cure (Rowles and O'connor 2003).

We will be testing the hydraulic features of the Marsh Armor trapezoid design; initial dimensions are proportional to the width of the base. It's at a 3 -1 ratio scalable in size. Ratios and angles can be changed to engineering specifications. Tubes can be designed to meet different functions, permanent hardened structures or living structures designed for a natural takeover. They can be modified for wildlife applications from barriers to nurseries. They can be used with softer soils or in open water. The design can have optional openings to allow water and sediment flow through, with interlocking ends, footers and pylon collars. The top has access for pump, plumbing and utility options, they can have hardened surfaces or can be open on the top to allow plant and tree growth and seedling protection. They can be lined with kenaf mat seeded with natural plants to form natural ridges. Engineers can custom design the structures to meet the needs of the project.

Project Collaboration

This demonstration project is a collaborative group effort. These are key organizations that will provide ongoing support and expertise to this effort.

- Marine Gardens LLC
- Noranda Aluminum USA Inc
- Kiran Global Inc.
- Shotcrete Technologies Inc.
- KenGro Inc.
- Marsh Masters Inc.
- EcoRigs Non-Profit Organization
- Ecologic Environmental
- GeoPolymer Institute – Independent Standards and Certification of Materials

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McLellan BC, Williams RP, Lay J, Van Riessen A, Corder GD. (2011) Costs and carbon emissions for geopolymer pastes in comparison to ordinary Portland cement. Journal of Cleaner Production. Jul 31;19(9):1080-90.

Phair JW, Van Deventer JS. Effect of silicate activator pH on the leaching and material characteristics of waste-based inorganic polymers. Minerals Engineering. 2001 Mar 31;14(3):289-304.

Rowles M, O'connor B. Chemical optimisation of the compressive strength of aluminosilicate geopolymers synthesised by sodium silicate activation of metakaolinite. Journal of Materials Chemistry. 2003;13(5):1161-5.

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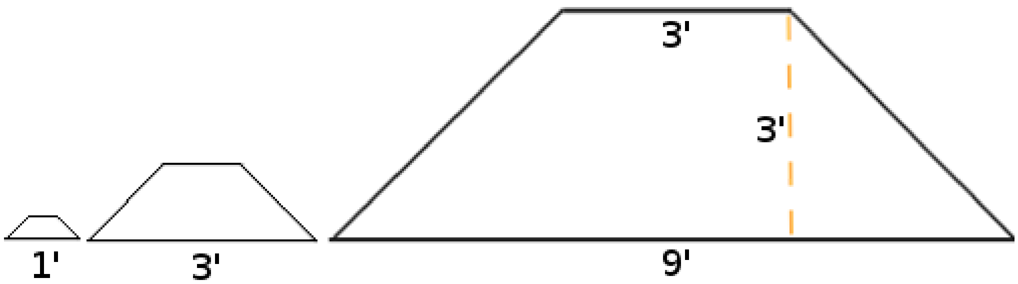
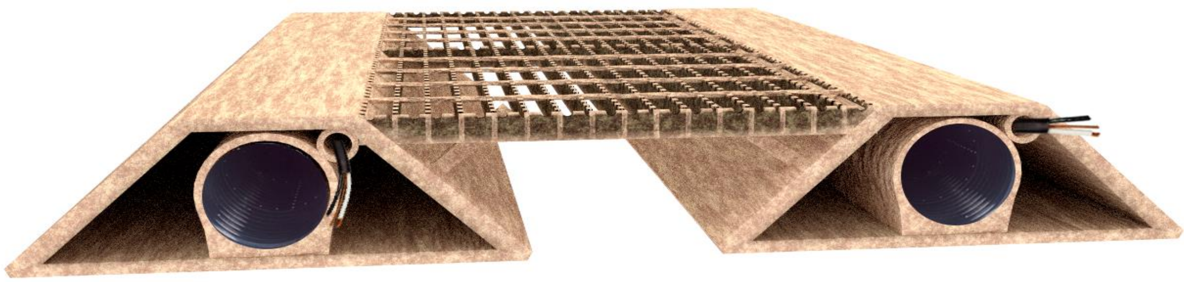
Xu H, Van Deventer JS. The geopolymerisation of alumino-silicate minerals. International Journal of Mineral Processing. 2000 Jun 30;59(3):247-66.

Yip CK, Lukey GC, Van Deventer JS. The coexistence of geopolymeric gel and calcium silicate hydrate at the early stage of alkaline activation. Cement and Concrete Research. 2005 Sep 30;35(9):1688-97.

Appendix A

Figure 1. Marsh Armor Trapezoidal coastal erosion structure made with geopolymers marine concrete and Kenaf or mineral reinforcement fibers.





Marsh Armor trapezoidal tubes are stable structures that can be used to take back land, by mending long shallow breaches with a solid protection barrier. Designed for hard to access areas by creating its own infrastructure path. It has versatile features that give project designers access, control and infrastructure to make new ground. These can be used in single or in double row configuration for maintenance vehicles. They can include power lines, piping and control systems built into the structure. Piping can be used for water or sediment diversion. Tubes are secured to an engineered pre-stabilized kenaf foundation geopolymer mat. They are light-weight structures that give flexibility to achieving stable, modular coastal erosion designs. They can be ballasted with sediment, rock or sand to engineering specifications. Geopolymer composite cement is saturated within the kenaf mat or steel fiber and combined with aggregate for trapezoid tubes, shotcrete applications with mat, mat tubes, mat structures and raw bat fiber. It is used with or without rock and sand aggregate and it can be used to composite steel, iron, HDPE, PVC, limestone and other materials. Formulas can be designed and changed for flexible properties. It is mixed with a coarse quartz sand and other aggregate and sizes to form a geopolymer concrete. Shotcrete sizes are limited to ½ inch aggregate.

Figure 2. Extrusion technology is well developed, Geo Polymers can be extruded with any concrete extruder or can be 3D printed free style or by mold injection.

This extrusion and 3D SCP process allows large scale production of simple designs that are continuous in length, machines that are small lightweight and compact can produce linear footage of tube armor very quickly and efficiently. Larger sizes can be prefabricated and delivered or scaled up extruder machines can do very large structures. Optimal efficiency is reached with mechanization of many of the processes. Economies of scale allow easier budgeting, calculating a given product by the meter or linear foot for both manufacture and installation on site. The surfaces can be made solid with reinforcement to support maintenance vehicles, foot traffic walkways and platforms for pumping equipment and marker lights. Outriggers can be added to produce stable platforms where needed. Areas that are inaccessible and unprotected can be armored and easily accessible for coastal erosion management.

PPL 27 PROPOSED DEMONSTRATION PROJECT
MARINE GARDENS – MARSH ARMOR
3D SHOTCRETE PRINTER/ GEOPOLYMER STRUCTURES

Versatility Project – cost effective solutions, merging transferable off the shelf exponential technologies.

Shoreline Protection/Ridge Building/Barrier Island

PPL 27 PROPOSED DEMONSTRATION PROJECT
MARINE GARDENS-MARSH ARMOR

- Location: Anywhere in Louisiana, can be incorporated into existing projects
- Problem: High cost of traditional methods and materials for hard armor protection, limited funding for projects. Present materials and methodologies are limited.

- Goals to demonstrate:
- Versatility, durability and cost effectiveness of Marine geopolymer concretes
- Versatility, speed and cost effectiveness of 3D shotcrete construction
- Ability for stone to attract and enhance shellfish production
- Versatility of modular trapezoid tube structure in sediment/fresh water diversion, shoreline protection , ridge building, cost effectiveness
- Potential benefits of merging exponential technologies

WHAT ARE GEOPOLYMERS?

- Made from ordinary soils and industrial mineral waste streams (fly ash, GGBS, Red Mud, Cu slag) Simple minerals – depolymerized silica and alumina, sand and clay
- Inorganic Nano polymers that form new macromolecular structures.
- Concretes, Ceramics, Foams and other materials based on well proven sciences using an alumina silicate bond.
- Produced locally, inert, non porous, protects iron, fire proof building materials
- Superior material to OPC (portland cement)
- Can be worked as traditional OPC, extruded or 3D printed.

PROPOSED TEST SOLUTION

- 500’ geo polymer reinforced trapezoid tube 9’ base with 2 sediment diversion pipes
- Can be used for Shoreline protection or Ridge Building wherever needed
- Proof of concept for all stated goals


Our project :
Is a collaboration between 10 different organizations, to create a rapid infrastructure in coastal erosion protection in the Gulf of Mexico, by merging exponential off the shelf technologies and well developed material sciences.
Geo Polymer Sciences - 3D Print Industrial Building Scale production
Guidelines, independent testing and certification of materials in accordance with established procedures and guidelines of "The Geopolymer Institute".
Products - Marsh Armor, Marsh Crete, Marsh Matts, Marsh Tubes, Marsh Mender Products and Delivery methods to bring coastal erosion infrastructure
Submitting for PPL27 Demonstration Project
Total costs to CWPPRA capped 2,000,000
MARSH MASTER