



36TH INTERNATIONAL CONFERENCE ON COASTAL ENGINEERING 2018

Baltimore, Maryland | July 30 – August 3, 2018

The State of the Art and Science of Coastal Engineering

Effects of Wave Load on the Long-Term Vegetation Development and its Resistance as Grass Revetments on Sea Dikes

Jochen Michalzik, Sven Liebisch, Torsten Schlurmann



Ludwig-Franzius-Institute

for Hydraulic, Estuarine and
Coastal Engineering



Leibniz
Universität
Hannover





Outline

- Motivation
- Outdoor Wave Basin
- Ecodike-Project
 - Idea and Overview
 - Methods
 - Measuring Techniques
 - Model Set Up
 - Test Program
 - Current State
- Outlook



Univ.-Prof. Dr.-Ing. Holger Schüttrumpf



Institut für Umweltforschung



Hydromechanik
Binnenwasserbau
Küstenwasserbau



Universität
Rostock

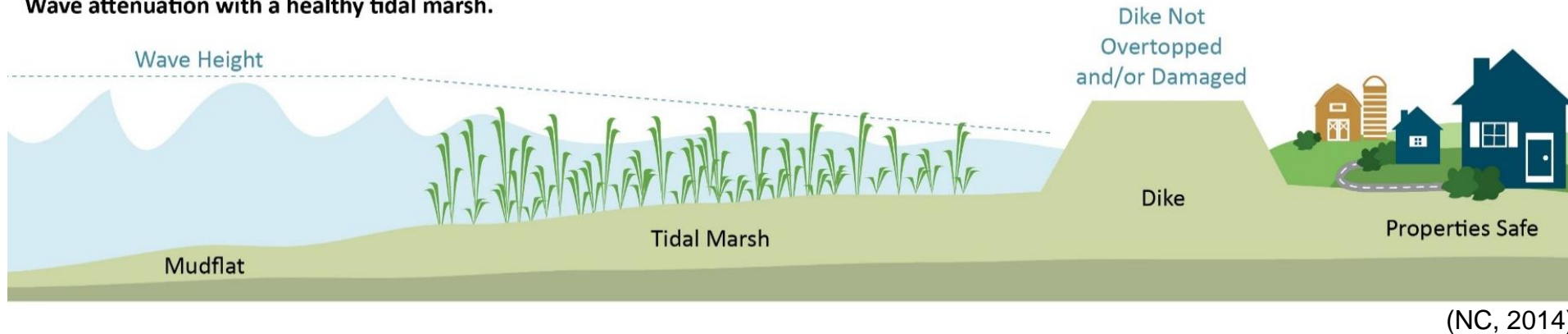
AGRAR- UND
UMWELTWISSENSCHAFTLICHE
FAKULTÄT



Motivation

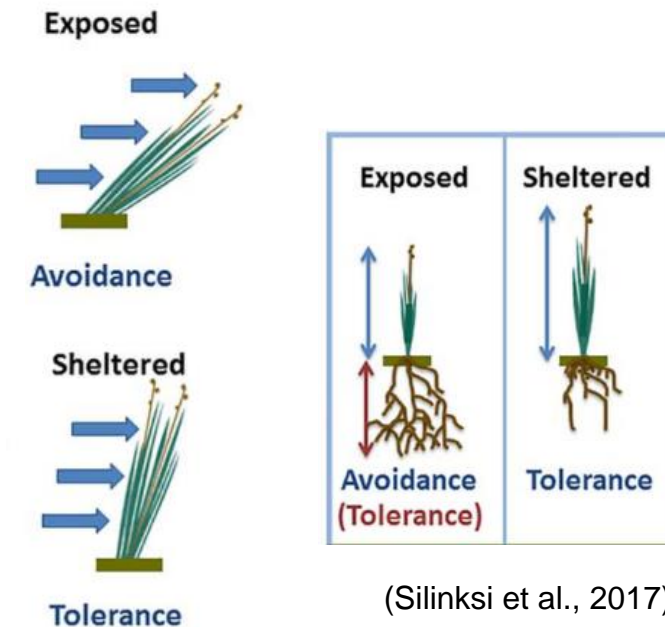
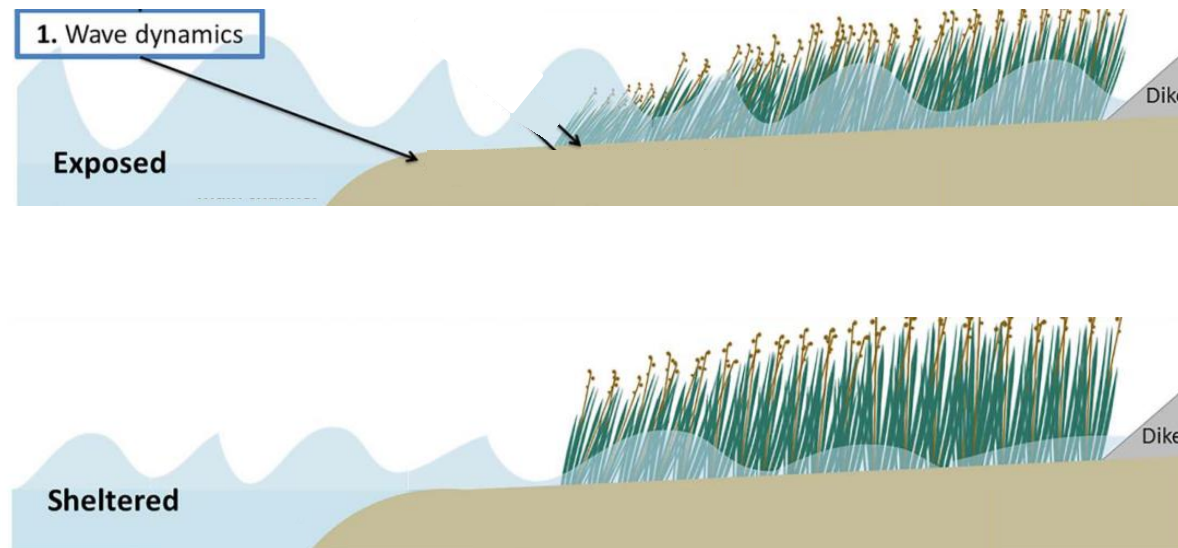
- **High demand for physical model tests with real vegetation**
 - Elucidate the performance and durability of green coastal infrastructures
 - Ensure and promote ecosystem services of the environment

Wave attenuation with a healthy tidal marsh.



Motivation

- **Ecosystem based solutions require the development of a deep understanding of:**
 - Processes and interactions between vegetation and hydraulic boundary conditions
 - Long-term development and long-term quantification of ecosystem services

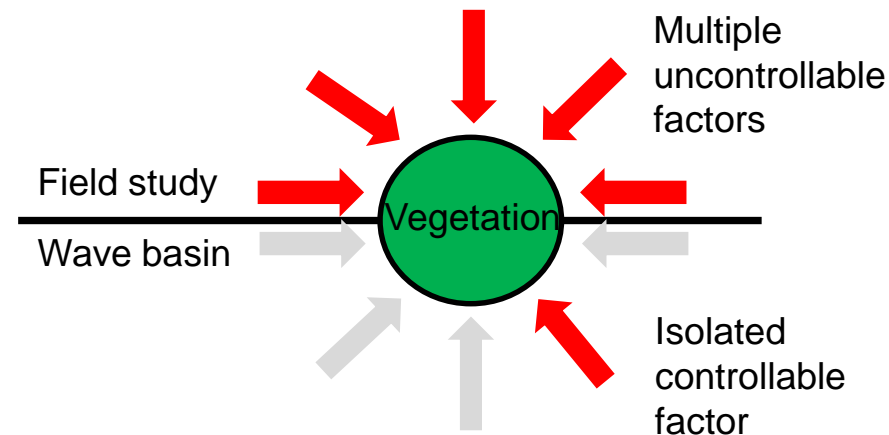


(Silinksi et al., 2017)



Motivation

Field study vs. (outdoor) wave basin



- Investigation of the vegetation adaptation to **specific hydraulic load** under **controlled boundary conditions**
- An outdoor wave basin is the **most appropriate** and **cost efficient** method to mimic **nature-like conditions**





Outdoor Wave Basin

Hannover, Germany





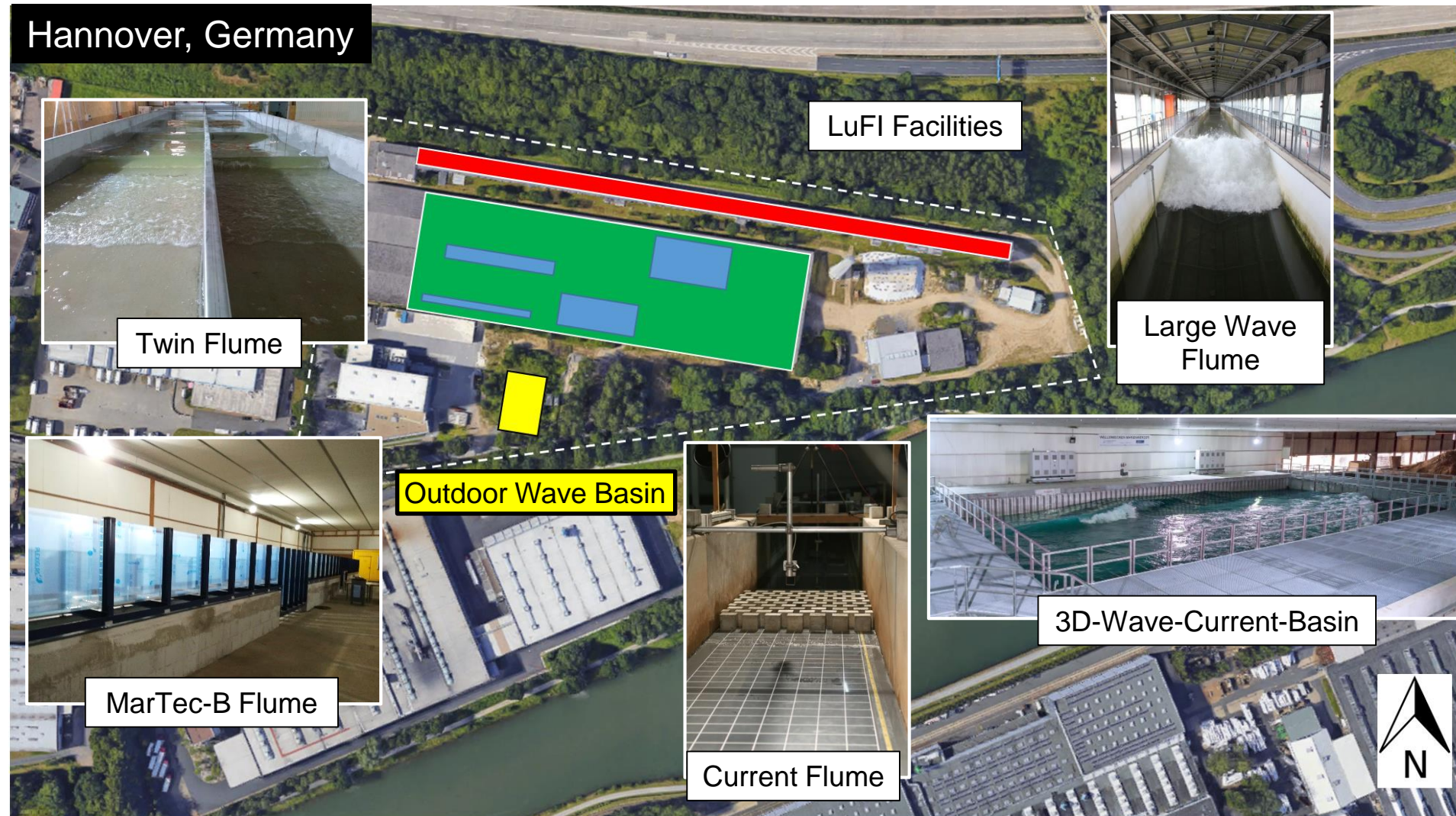
Outdoor Wave Basin

Hannover, Germany

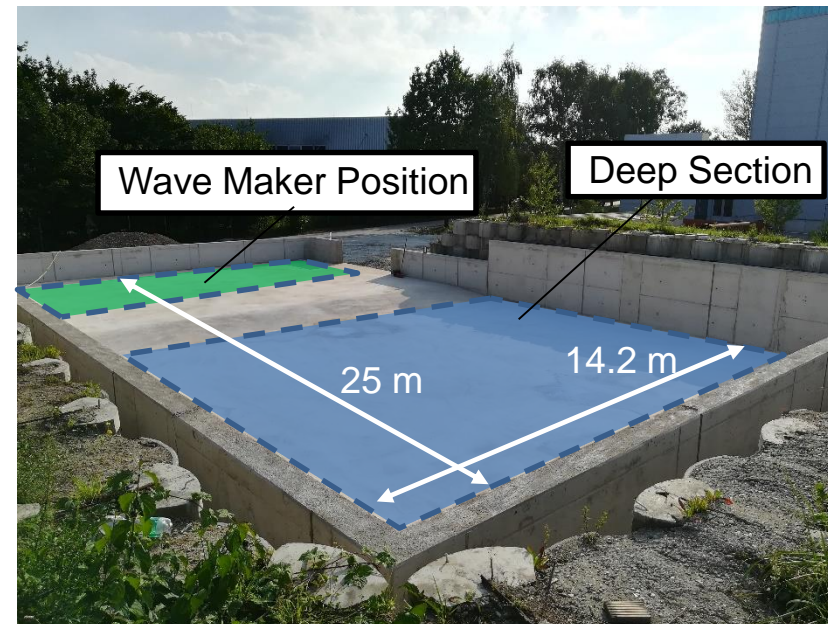


Outdoor Wave Basin

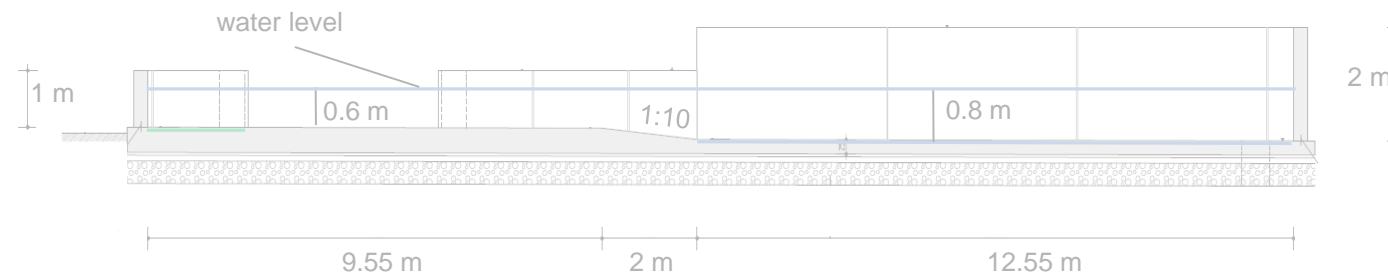
Hannover, Germany



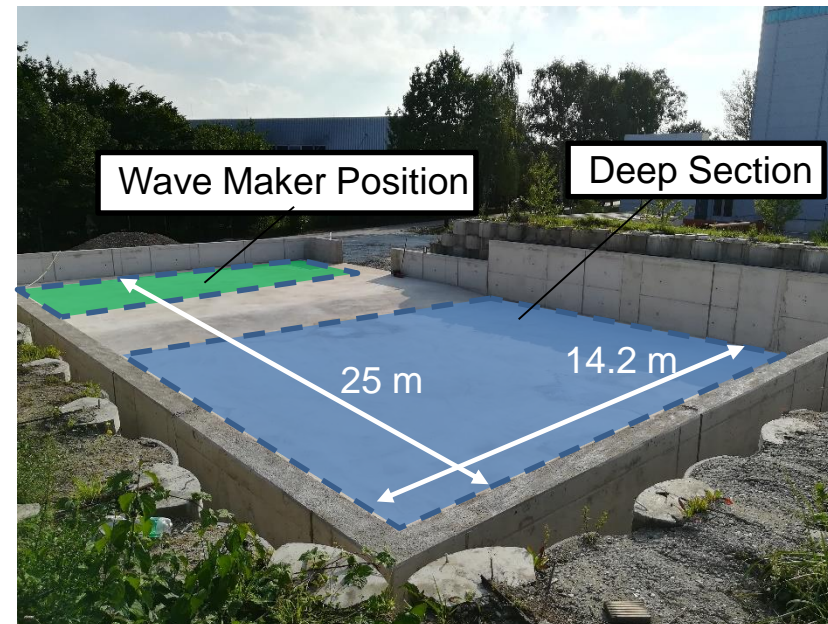
Outdoor Wave Basin – General Facility Characteristics



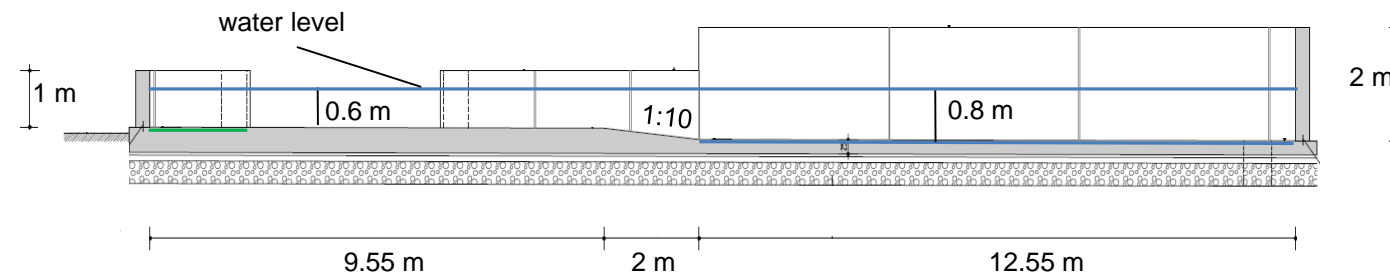
water level $h = 0.60$ m
wave height $H_s = 0.3$ m
wave period $T_p = 1-3$ s



Outdoor Wave Basin – General Facility Characteristics

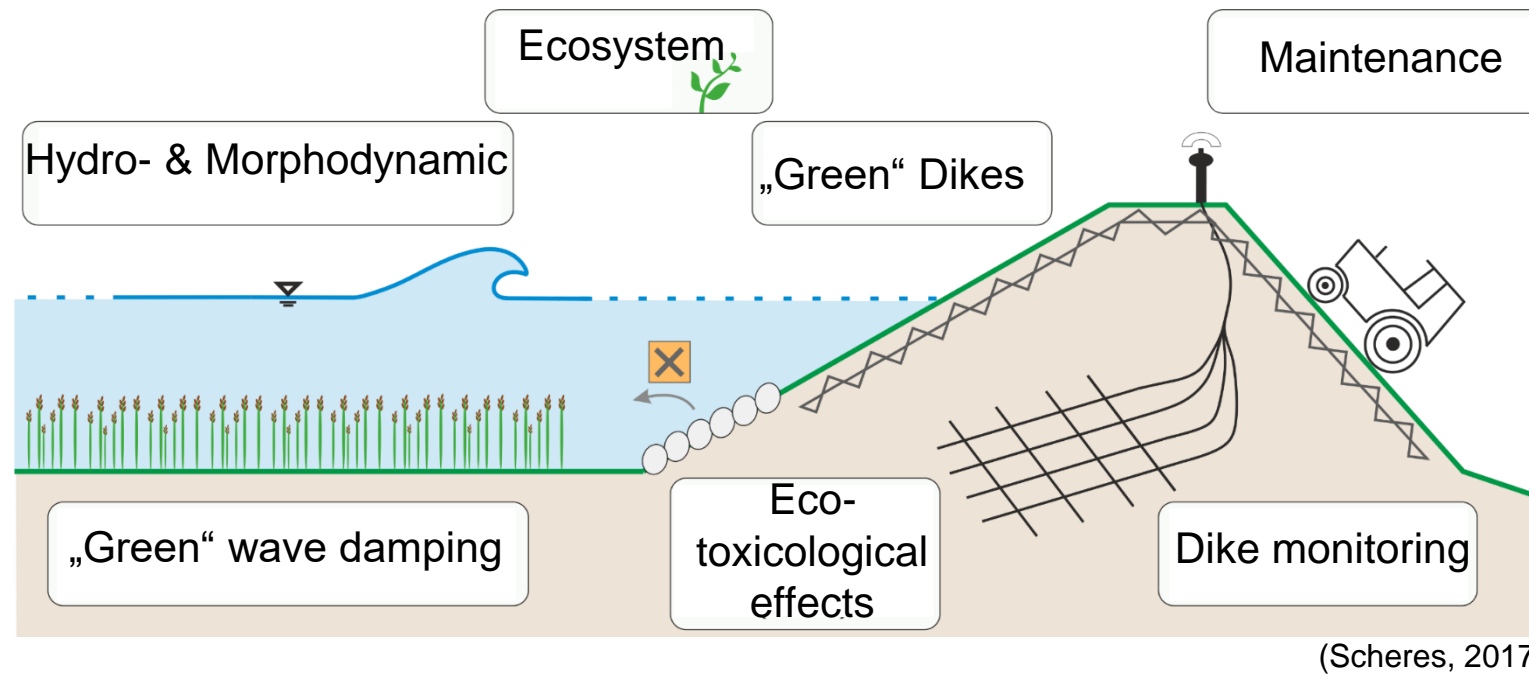


water level $h = 0.60$ m
wave height $H_s = 0.3$ m
wave period $T_p = 1-3$ s



Ecodike – Idea and Overview

Structure



- **Objective:** Development of **recommendations to increase** the **ecosystem value** of sea dikes and revetments while preserving or possibly **enhance** the existing **safety standards**



Ecodike – Idea and Overview

- **Issue** Is commonly **visually** performed **monitoring** of dikes and revetments possible for **„green“ dikes** and revetments?

„grey“ model-dike



visually monitoring sufficient



„green“ model-dike



innovative monitoring required?

- How to develop an innovative monitoring techniques for „green“ dikes and revetments?
- Which factors allow the evaluation of the safety standard of the complex and seasonal varying surface structure?

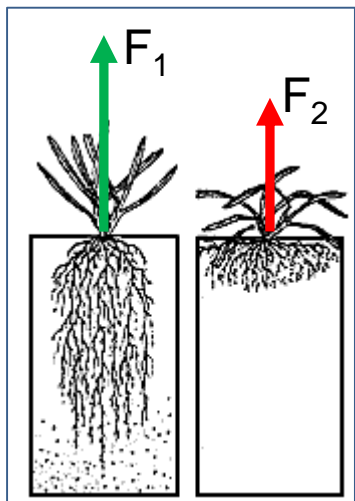


Ecodike – Methods

Comparing the vegetation development with and without wave load:

1. Root parameter (depth, density and thickness)
2. Vegetation parameter (e.g. coverage index)
3. Nutrient concentration (plant-available nutrients)
4. Dike resistance (**pull-out tests**, shearing strength, erosion)
5. Vegetation vitality (chlorophyll fluorescence)

1



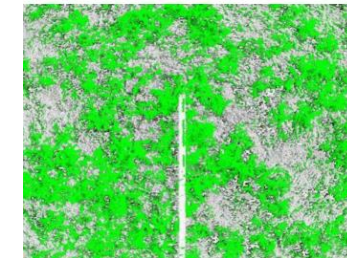
(source: www.tobinlawn.com)

4



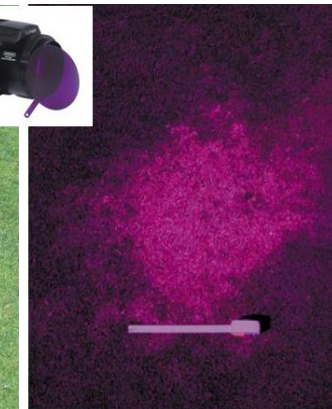
(Kesel, 2013)

2



(Kubetzek, 2015)

5



(source: www.turf-tec.com)

Ecodike – Methods – Dike Resistance

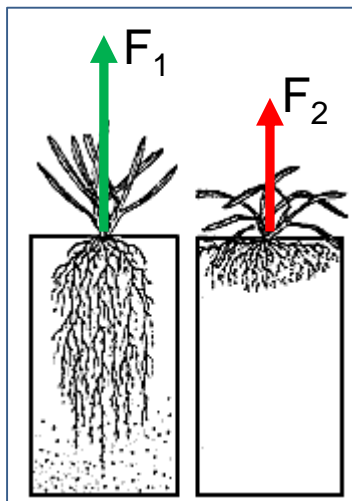
■ Pullout Tests: Evaluation of the test vegetation **resistance**

Methods

- Measuring **force - displacement** curve
- Calculation of the **critical grass normal stress** (N/cm²)

Objectives

- Investigate **correlation** with **root parameters**
- **Identification** of the most **resilient** “green” test vegetation
- **Quantification** of the long-term **effects** of **wave load** on ecosystem services



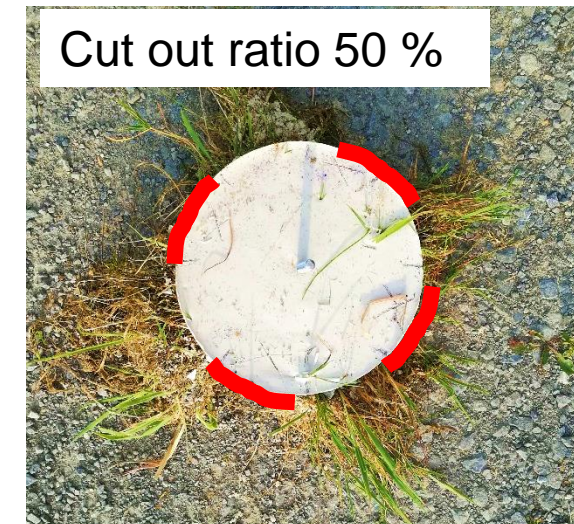
(source: www.tobinlawn.com)



Ecodike – Methods – Dike Resistance

■ Pullout Tests: Test concept

- Gypsum block to grip the grass
Dimensions: area = 0.031 m², height = 4 cm
- Anchor with reinforcement mesh to lift up the gypsum bloc
- Optional cutting out the gypsum block partly (50 %) for sections with poor grass quality



Ecodike – Methods – Dike Resistance

■ Pullout Tests: Test procedure

1. Position frame and anchor ($\varnothing = 20$ cm)
2. Fill up with gypsum (hardening time ~24 h)
3. Remove frame and water the test area
4. Perform Pullout Test (pull velocity = 1 mm/s)

1



2



3

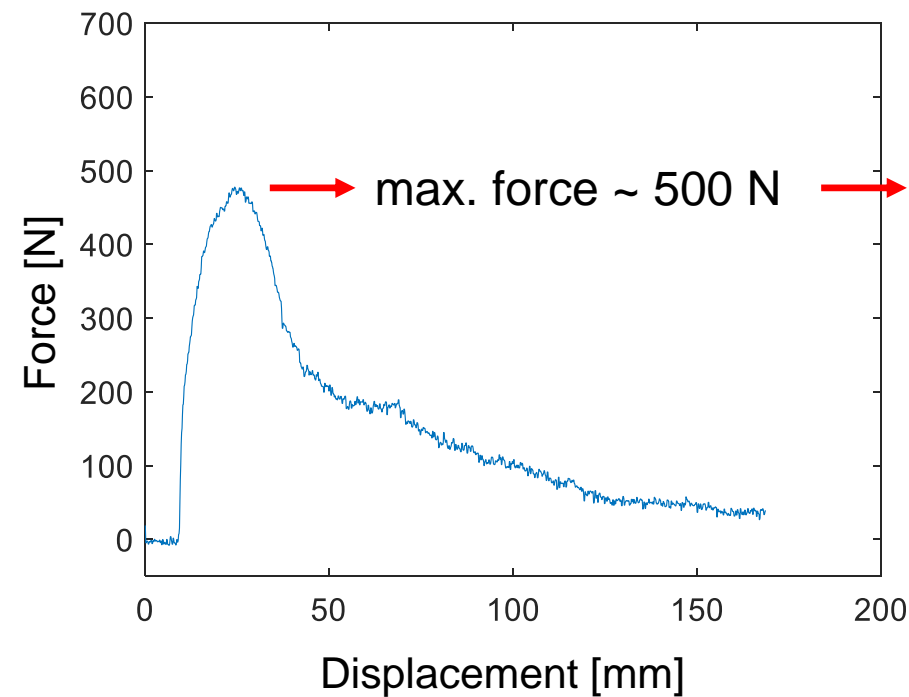


4



Ecodike – Methods – Dike Resistance

■ Pullout Tests: Exemplary test results

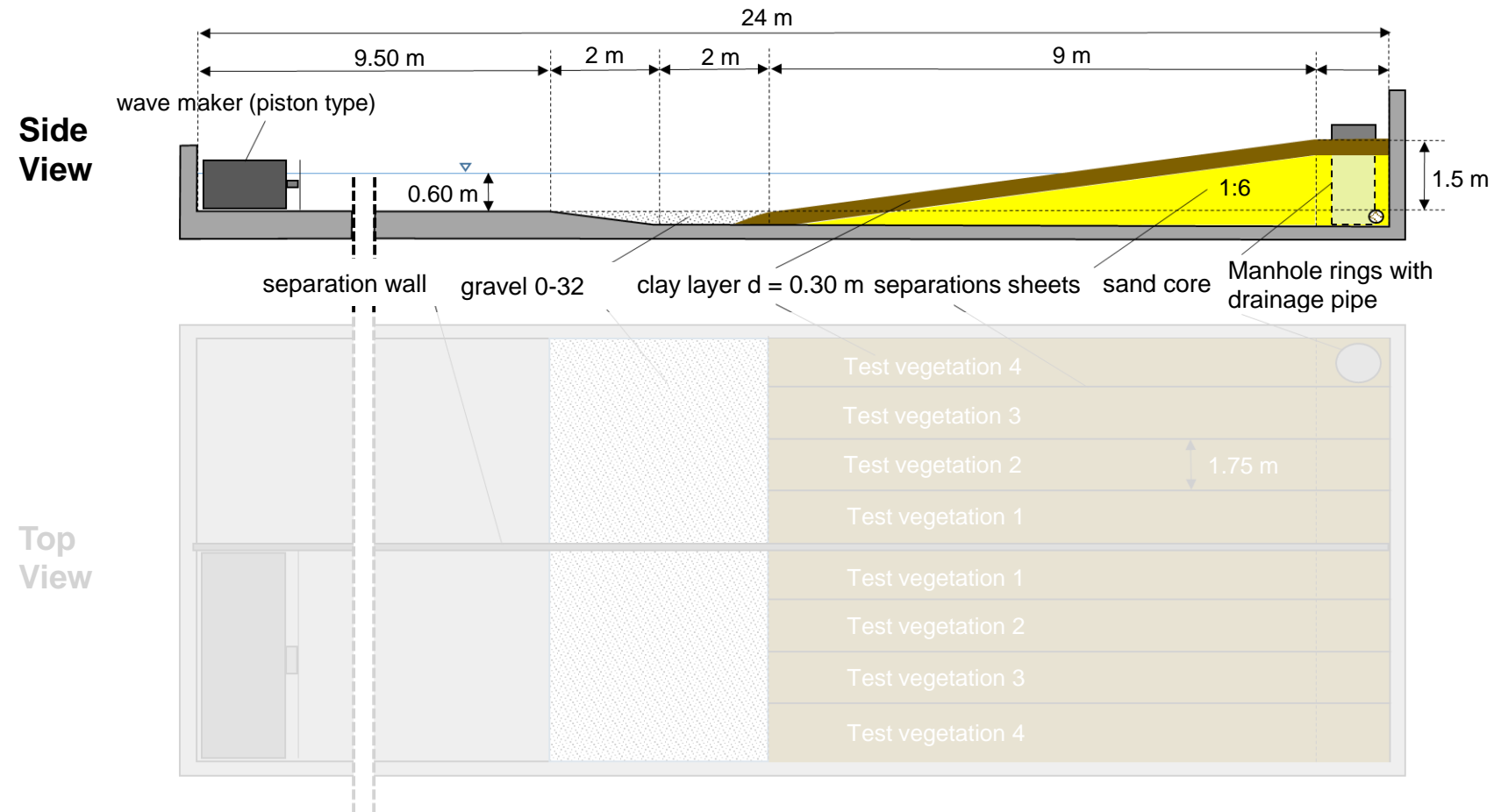


Calculation:

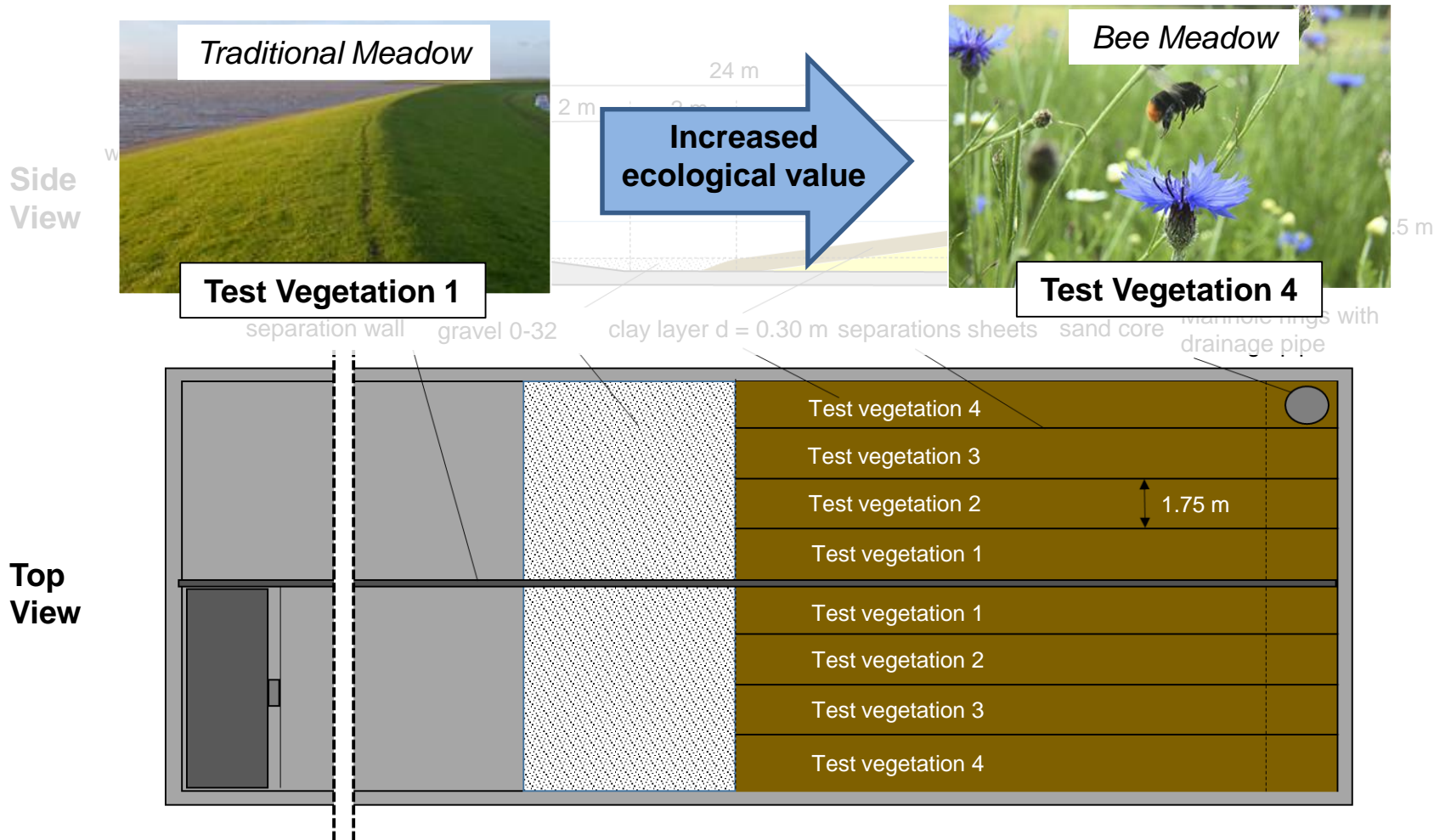
- Critical grass normal stress $\sim 1.6 \text{ N/cm}^2$



Ecodike – Model Set Up



Ecodike – Model Set Up



Testing Program

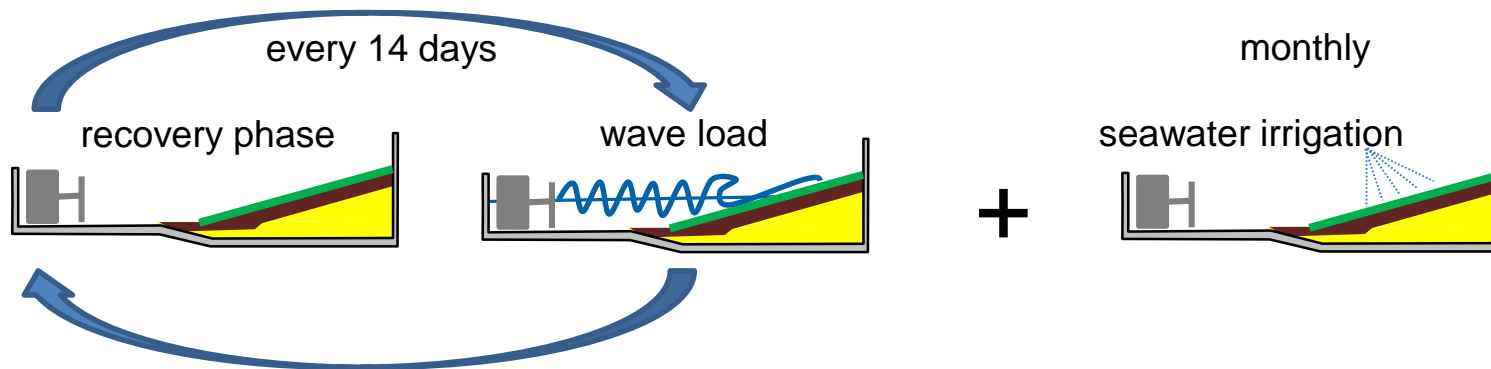
Growing phase (spring and summer 2018)



- nutrient concentrations
- monitoring data

- Extreme dry summer with continued heat wave and drought
- Low growing rate

Testing phase (fall 2018?)



Detailed investigations



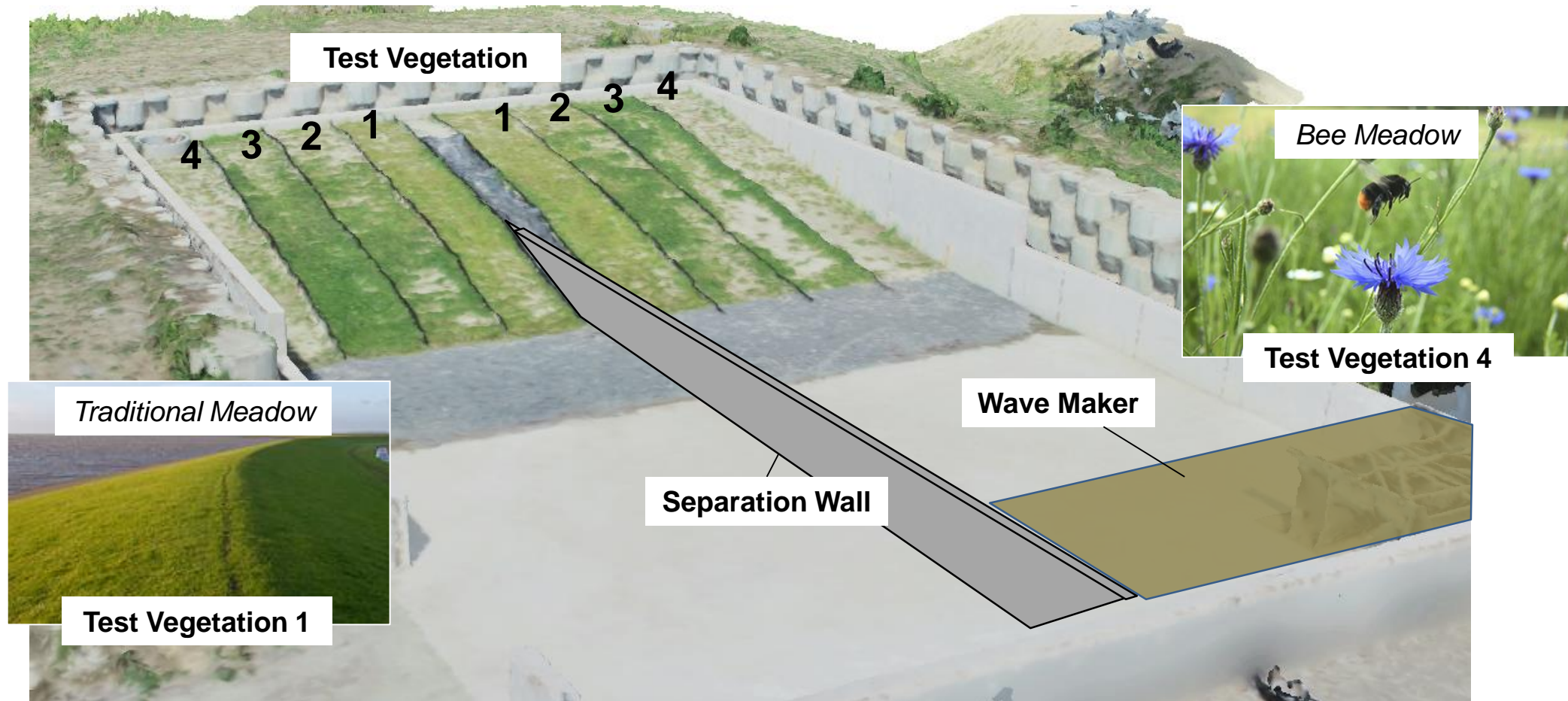
- Vegetation parameters
- Root parameters
- Dike resistance
- Nutrient concentrations
- Analysis of monitoring data

Recommendations and
quantifications for
green coastal infrastructures



Model Set Up

- Current state – Photogrammetric 3D Model



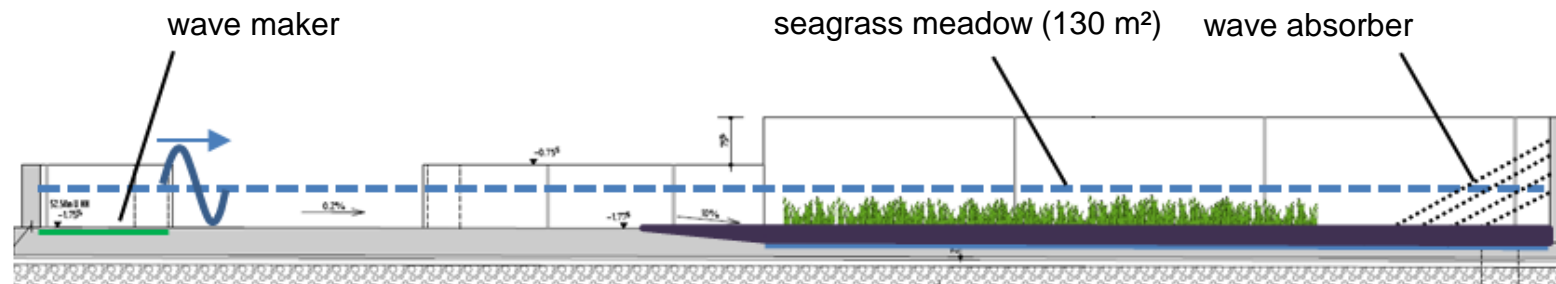
Outlook

▪ Ecodike

- Further **development** of the **pullout test** procedure (field campaign)
- Start with the **testing phase** in September 2018
- **First results** of the effects of wave load on the test vegetation (proceedings ICCE2018)

▪ Outdoor wave basin

- Investigation of the **long-term development** of seagrass meadows or salt marshes
- **Degradation** process of artificial, bio-based seagrass or geotextiles for coastal protection
- Investigate the effect of rapidly **changing environmental conditions** in the vegetation (for e. g. temperature, radiation, nutrients, salt stress etc.)





Thank you for your attention



Hydromechanik
Binnenwasserbau
Küstenwasserbau



Technische
Universität
Braunschweig



Universität
Rostock

AGRAR- UND
UMWELTWISSENSCHAFTLICHE
FAKULTÄT

RWTH AACHEN
UNIVERSITY

Institut für Umweltforschung



Univ.-Prof. Dr.-Ing. Holger Schüttrumpf

RWTH AACHEN
UNIVERSITY

TUHH
Technische Universität Hamburg
WASSERBAU
River and Coastal Engineering





ICCE
2018

36TH INTERNATIONAL CONFERENCE
ON COASTAL ENGINEERING 2018

Baltimore, Maryland | July 30 – August 3, 2018