Interreg
EUROPEAN UNION
2 Seas Mers Zeeën
Polder2C's
European Regional Development Fund

WP 1 Living Lab Climate Adaptive Flood Defences

Survey Overview Report


Foto: Davy Depreiter

Adaptation to climate change

WP 1 Living Lab Climate Adaptive Flood Defences
Survey Overview Report

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Authors:
Depreiter, Davy; Peeters Patrik; Vanhille Wijnand; Muylaert Steven; De Backer Griet; Koelewijn, André; Van Calster, Wim

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INTERREG Polder2C's project

The INTERREG Polder2C’s is an international research project within the framework of the updated Sigmaplan for the river Schelde. The Hedwige-Prosperpolder will be transformed into tidal nature. Depoldering of Hedwige-Prosperpolder offers a unique testing ground, the Living Lab Hedwige-Prosperpolder, for flood defence and emergency response experts. In this environment current and innovative techniques, processes, methods and products can be tested for practical validation. Thirteen project partners, led by the Dutch Foundation of Applied Water Research (STOWA) and the Flemish Department of Mobility and Public Works (DMOW, Flanders Hydraulics Research), are working together. Together, they aim to improve the 2 Seas regions’ capacity to adapt to the challenges caused by climate change.

Flood Defence

The rising sea level is a serious threat to the countries in 2 Seas region. How strong are our current flood defences? What is the impact of environmental elements such as the weather, the presence of vegetation or man-made objects on our flood defences? To answer these questions numerous destructive field tests are carried out in the Living Lab to validate flood defence practices. The project entails in situ testing, guidance on levee maintenance and validation of flood defence infrastructure.

Emergency Response

We aim to improve emergency response by developing the right tools for inspection of water defences, risk evaluation and solutions for flooding. If our water defences do not operate as designed, we must take the right measures to prevent flooding of valuable areas. In addition, the Hedwige-Prosperpolder Living Lab offers unique possibilities to exercise emergency measures in the event of calamities under controlled but realistic circumstances. Activities that are part of the programme are levee surveillance and monitoring, emergency response exercises, breach initiation and a large European/crises exercise.

Knowledge Infrastructure

We aim to develop a knowledge infrastructure through which existing knowledge and new insights will become available and accessible. A necessary success factor for any initiative to improve knowledge is to have its outcomes integrated in practices of a wider community. Knowledge Infrastructure focuses therefore on the consolidation of knowledge acquired in the Living Lab with a variety of activities. Accessibility of data in a user-friendly manner, educational activities in the field and incorporation of knowledge in educational curricula are considered key elements.

Field Station

How can we make sure that both experts in the field and the local public benefit from our project and the learnings about climate change, flood resilience, emergency response and the unique environment of the Hedwige-Prosperpolder? An important and unique way of reaching this goal is realising a Field Station at the project site. It will be used during and after the project for educational purposes, research and as a special meeting place for exclusive occasions.

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1 Introduction

Document purpose

The present document constitutes the Survey Overview Report within the framework of Work Package 1 "Living Lab Climate Adaptive Flood Defences" of the Interreg Polder2C's project (**Deliverable 1-1-2** and **Deliverable 1-5-1**).

The term 'Survey' is defined as the investigation of morphological and surface properties, biophysical properties and sedimentological, geotechnical, geophysical as well as hydraulic properties to characterize and assess the levee state and its external environment.

The Survey activities together

1. establish a T0 baseline describing the state of the levee at the start of the project for multiple use by all work packages;
2. describe the state of the levee after the execution of a test episode (defined as the T1, T2 and T3 state after the first, second and third episode of overflow tests).

All survey data is available via the Data Management System (DMS) of POLDER2C's, accessible on the project website (https://polder2cs.eu/data).

Specific links to data sources will be provided further in this document.

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2 Site overview and survey rationale

2.1 Location

The Polder2C's project area is situated at the Belgian-Dutch Border in the area named 'Hedwige-Prosper Polder' and straddles the communities of Hulst in the Netherlands and Beveren (Doel) in Belgium. The area consists of a polder bordered by a levee system. Beyond the levee, a tidal marsh and the river Scheldt is found.

The study area for the Polder2C's project comprises the levee that protects the polder from the Scheldt river. The study area has been divided in 13 levee stretches (Figure 1) as an internal reference system. Sectors I to V are situated in Belgium; sectors VI (except the southernmost part) to XIII are situated in the Netherlands.

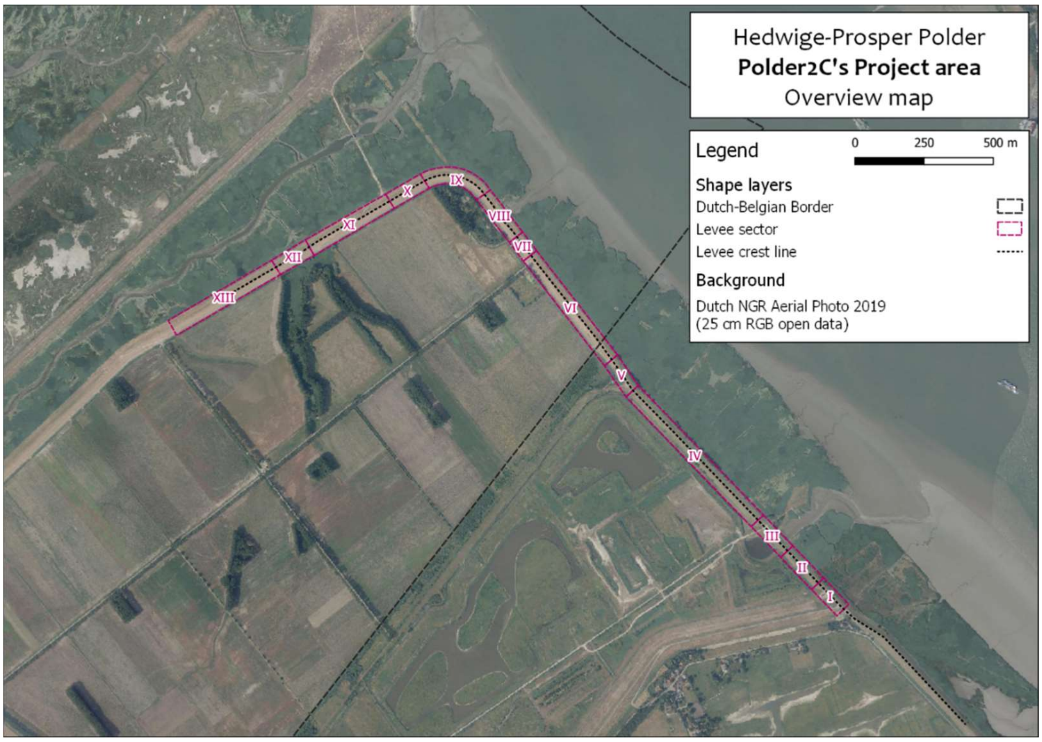

Figure 1: Overview map of the Polder2C's project area in the Hedwige-Prosper polder.

2.2 Experiments and survey

The continuous overflow and wave overtopping experiments chiefly take place in levee stretches IV, VI and X. Wave impact tests are foreseen in stretch IX.

In order to get a good view on the spatial variability of the levee characteristics and properties, survey efforts are spread out over the levee although some concentration takes place in sectors IV and VI.

2.3 Identification of data needs

The levee experiments that are conducted within the context of Work Package 1, relate to a number of research questions. The research questions itself are answered by the experimental scenario setup, including the validation methodology (i.e. the application of numerical models,

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analysis of data obtained during the experiments, analyses to uncover relations between parameters, application of rules of thumb,…).
From these research questions, planned experiments and proposed modeling or analytical methodologies, needs data that relate to the actual state of the levee (morphology, geology, …). Simultaneously, activities within Work Packages 2 and 3 will also benefit from the survey data obtained and have been taken into consideration. The data required is summarized in Table 1.
The **Survey Plan** (Depreiter & Peeters, 2021) gives an overview of all planned surveying techniques. The **Survey Overview Report** presented here, gives a summary of all surveys carried out, displays examples of data retrieved and refers to underlying data sources and/or in-depth survey reports

Survey data will also be made available via the Data Management System (DMS) of POLDER2C's, accessible on the project website (https://polder2cs.eu/data).

Data need	Purpose / justification	Chapter
Morphological and surface Properties	Morphology description, identification of anomalies and defects. Identification of type sections. Geometry of the levee defines the slope stability. Post-experiment morphology comparison yields damage metrics. Surface temperature anomalies.	3
Biophysical properties	Vegetation type and strength are parameters for levee cover strength. Fauna interact with the levee. Characterizing a tidal marsh is the first step towards assessing it's roles.	4
Sedimentological properties	Description of the sediment of which levee and subsurface consist. Identification of internal layering and/or structure. Identification of anomalies and variability.	5
Geotechnical properties	Properties describing the strength of the levee and erosion resistance. Identification of the internal structure of the levee.	5
Geophysical properties	Identification of the internal and surface structure of the levee. Identification of anomalies.	6
Hydraulic properties	Identification of the internal and surface structure of the levee. Identification of anomalies.	7

Table 1: High level survey data needs (Depreiter & Peeters, 2021).

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2.4 T0, T1, T2, ... surveys

There are different times of survey, compared to the state of the levee.

The initial surveys, executed before any overflow or overtopping test (or other activity) has taken place, are all part of the T0 survey.

We define the T1, T2, etc... surveys as the survey work performed after respectively the first, second, etc. period of experiments.

The T1, T2, ... surveys are focused on the areas that have been subject to overflow, overtopping testing. The levee parts outside these areas are considered unaltered compared to the original T0 state and therefore not re-surveyed.

In the following chapters, it will be detailed which datasets are part of the T0, T1, ... surveys.

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3 Topography and surface inspection

The topographic and surface survey data provides information about the shape and geometry of the levees and its surroundings. Combined with (visual) surface inspection, features and anomalies can be described.

In order to collect this information, several datasets have been collected:

1. Topographic profiles
2. Data derived from drone based imaging: DTM, DSM and orthophoto
3. 3D Laser Scanning of test locations
4. Infrared photography
5. Visual surface description

For each of the methods (to be) applied, a brief description and intended deliverable or result is listed.

3.1 RTK Topographic profiles

Description In July 2020, DMOW-ATO has produced a set of 8 perpendicular profiles acquired with high ((sub)centimeter) accuracy using Real-Time Kinematic (RTK) GPS equipment over the levee in HPP and one profile outside the HPP area ("Profiel 9" on Doeldijk).

State T0 survey

Result Topographic data along profiles (Dataformat: AutoCAD DXF format and PDF renders.)

References (links to Polder2C's Onedrive)

- Data folder

Location map

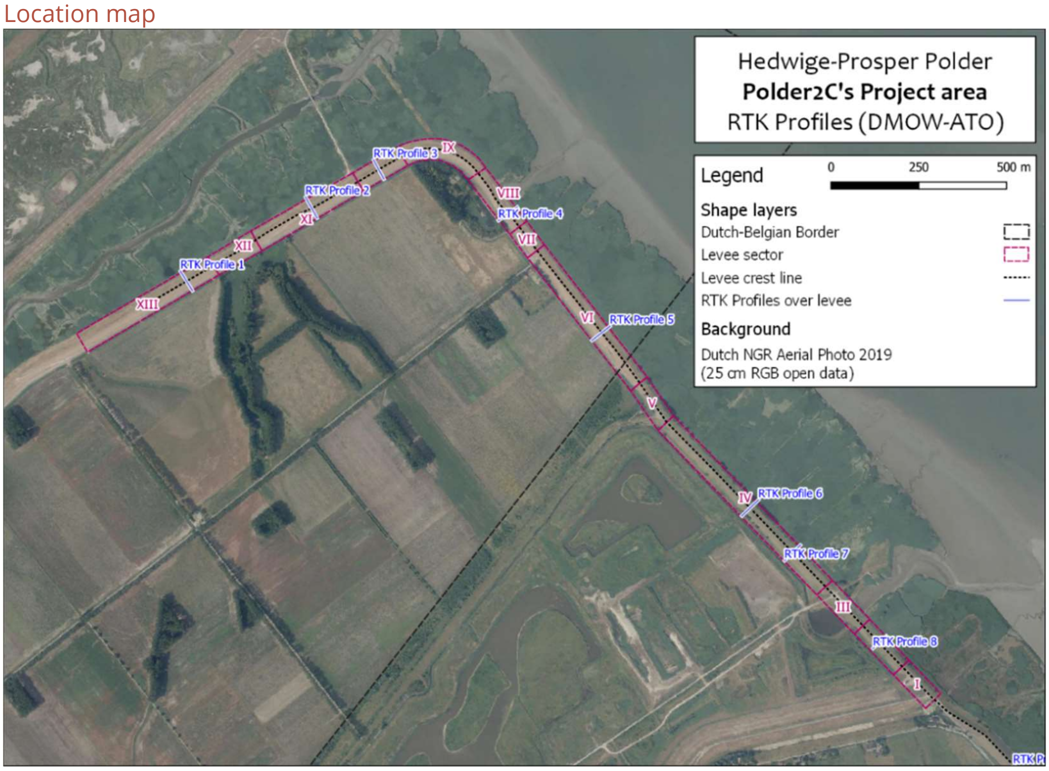

Figure 2: Location of the T0 topographic profiles.

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Data example

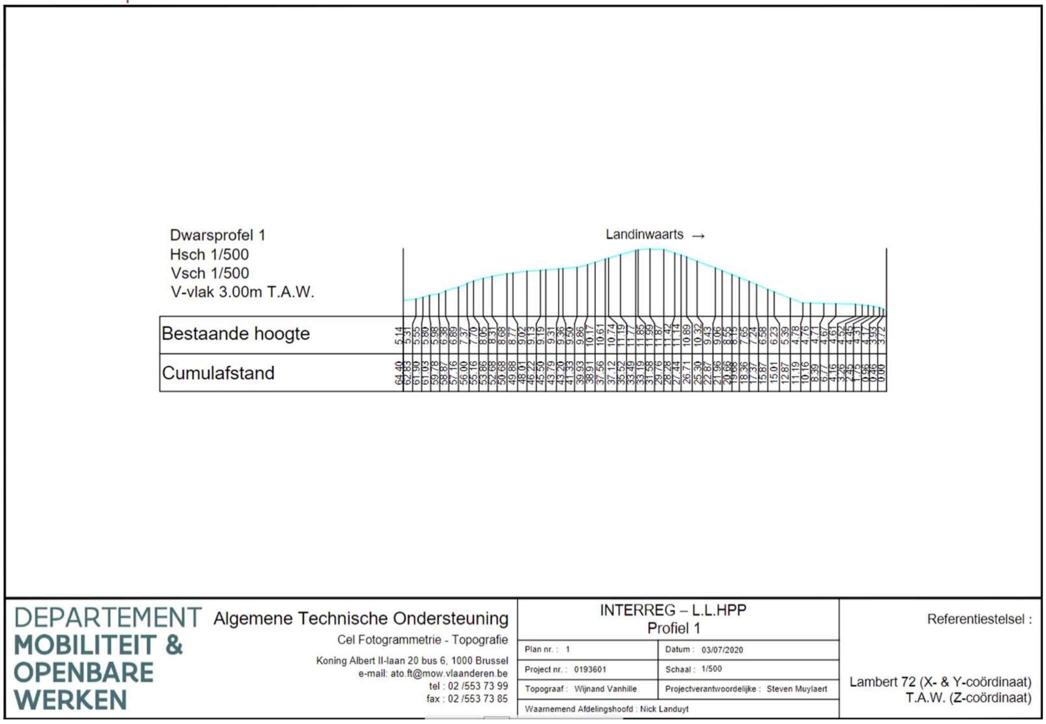

Figure 3: Exampleof a topographic profile

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3.2 Digital Terrain model

Description In June 2020, a **drone flight** was carried out by DMOW-ATO for aerial imagery. Through stereo-imagery, a detailed Digital Surface Model (including object heights) and Digital Terrain Model (ground surface height) could be generated.

State T0 survey

Result The images below shows a rendering of this DTM as an overview, as well as a detailed image. The pixel size of the data is 4.8 cm in X and Y direction. Dataformats: GeoTIFF; PointCloud; 2D, 2.5D and 3D mesh objects.

References

- Drone calibration reports
- Data folder Point Clouds
- Data folder Meshed data
- Data folder DTM and DEM as GeoTIFF

Data examples

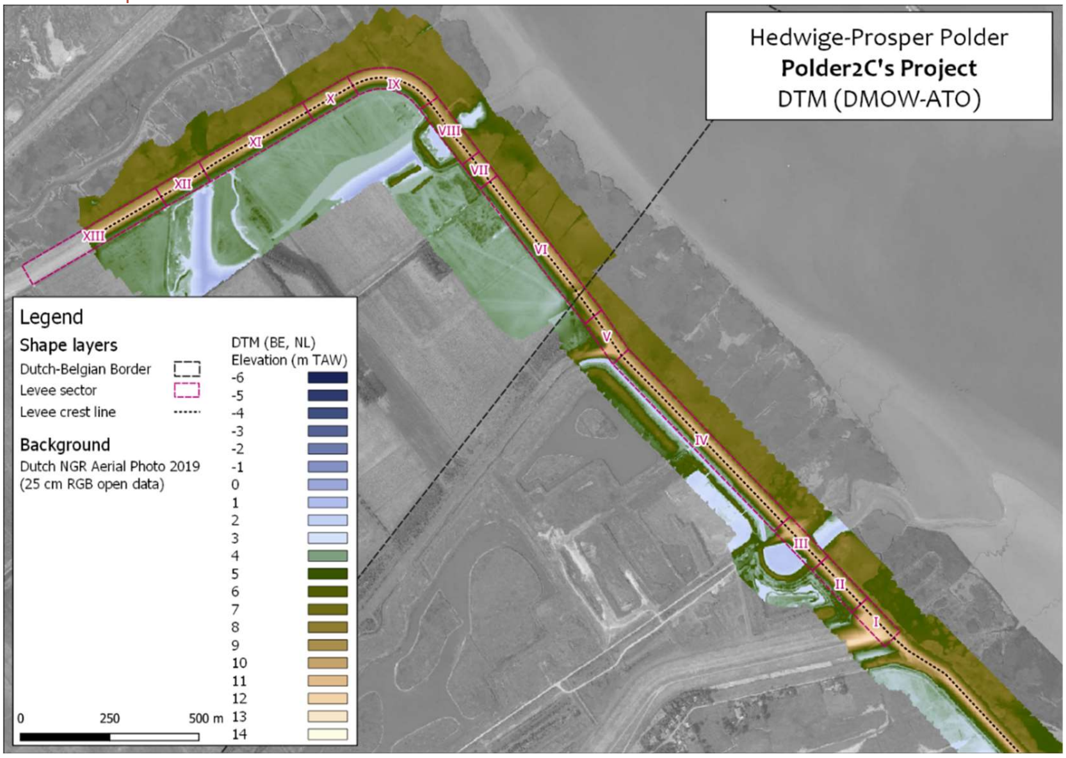

Figure 4: Overview map showing the Digital Terrain Model.

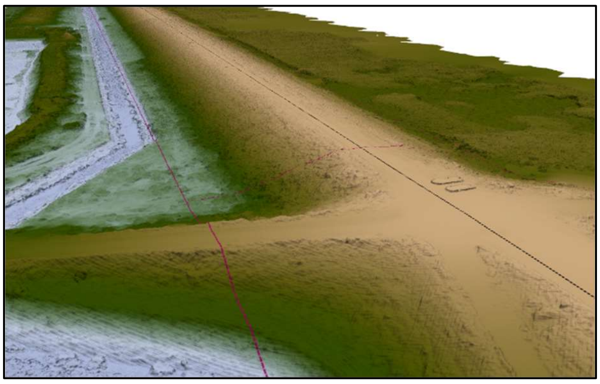

Figure 5: Example of a 3D render of the DTM.

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3.3 Orthophoto

Description Aerial imagery acquired by drone flight over the levee acquired in June 2020. The images are corrected to be georeferenced (orthorectified) to yield a spatially correct high resolution image of the surface of the levee and its surroundings.

State T0 Survey

Result The image is available as GeoTIFF data. The Pountcloid data of the DTM (see previous paragraph) also contains RGB data. The images below portray the coverage of the orthophoto and a second image is shown as impression of the data quality and resolution.

References

- Drone calibration reports
- Orthophotos (GeoTiff format) Dutch part
- Orthophotos (GeoTiff format) Belgian part

Data examples

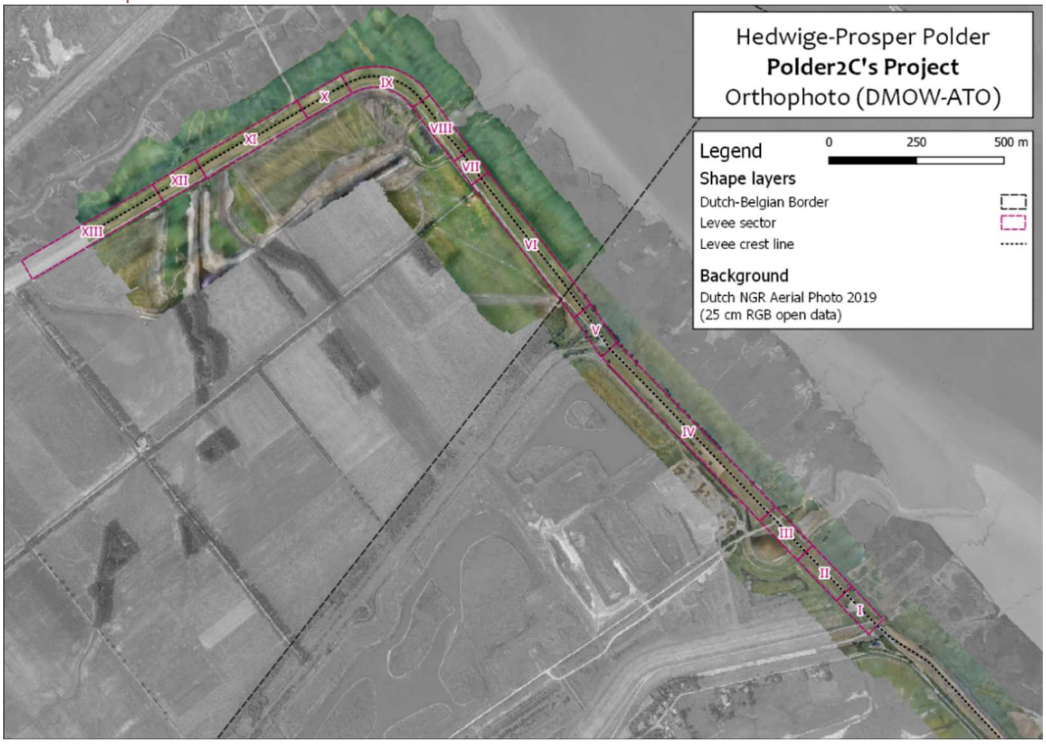

Figure 6: Overview map showing the T0 Orthophoto.

Figure 7: Example of a 3D render of the Orthophoto draped over the DTM.

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3.4 3D Laser scans of test sections

Description Laser scanning technique employed to create a 3D point cloud of the environment, yielding detailed and extensive digital terrain models. Optionally, color data is acquired in each scanning point to enable a photorealistic digital representation of the environment.

Result Spatial (and coloured) point cloud data (Pointcloud E57 format; ascii pts file)

State T0, T1, T2, T3, T4 surveys

References

- 3D Laser scans Doeldijk (Fox burrows on levee adjacent to LLHPP area, March 2020)
- T0 state 3D Laser scans of different test sections in NL and BE (November 2020)
- T1 state 3D Laser scans of different test sections (February 2021)
- T2 state Lidar Drone survey (partial) (2021)
- T3 state 3D Laser scans of overflow test sections in the Netherlands (December 2021)
- T3 state 3D Laser scans of overtopping test sections in the Netherlands (January 2022)

Data examples

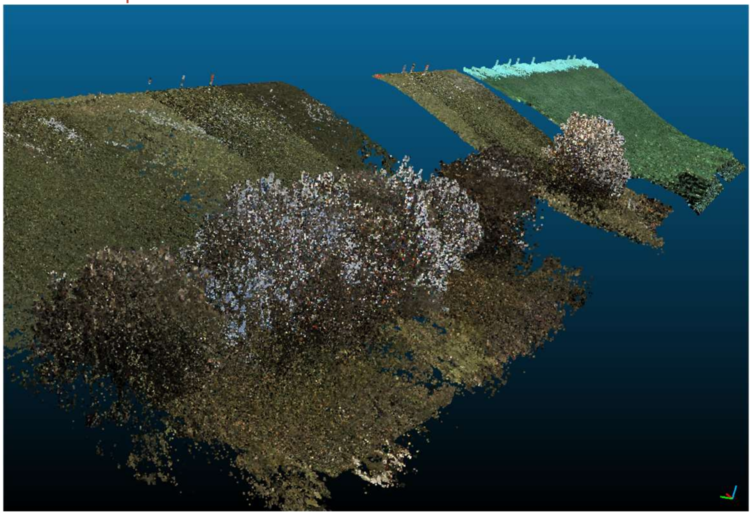

Figure 8: 3D view of T0 state 3D laser scans of Belgian test sections.

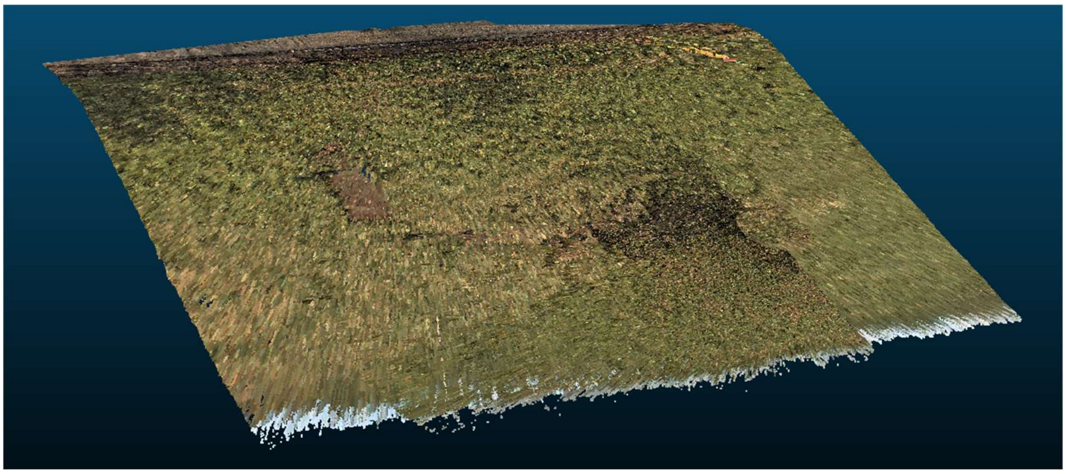

Figure 9: 3D view of T0 state 3D laser scans of Dutch test sections with animal burrow.

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3.5 Handheld Lidar data

Description Laser scanning technique created by using a smartphone and/or tablet with an integrated Lidar sensor. Results in a 3D point cloud of the environment, yielding detailed and extensive digital terrain models. Optionally, color data is acquired in each scanning point to enable a photorealistic digital representation of the environment.

Result Spatial (and coloured) point cloud data

State T3 survey

References

- T3 state detailed laser scans (2021) and description
- Memo describing the Handheld Lidar vs. 3D Laser scanning (Depreiter, 2022)

Data example

Figure 10: 3D view of the Handheld Lidar point cloud data of a damaged section.

3.6 Infrared photography

Description The planned acquisition of aerial infrared imagery by drone flight over the levee, has not been executed due to instability of the drone with the IR camera mounted. Handheld IR imagery has been made of specific locations (reed area on the levee slope in sector VI).

State T0 survey

Result IR Images of levee surface in selected area (Dutch levee)

References

- IR data folder

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4 Biophysical properties

4.1 Vegetation mapping

Description During spring 2019 and spring 2020, a vegetation map of the levees in the study aread has been created by the Research Institute Nature and Forest (RINF; Instituut voor Natuur en Bos Onderzoek, INBO). The methodology is described in Vandevoorde et al., 2019.

State T0 survey

Result A GIS shapefile has been supplied with polygons of 11 vegetation types and additional information in the feature comments.

References

- Data report describing the methodology (Vandevoorde & Van Lierop, 2019)
- GIS shapefile of vegetation map for Polder2C's

Data example

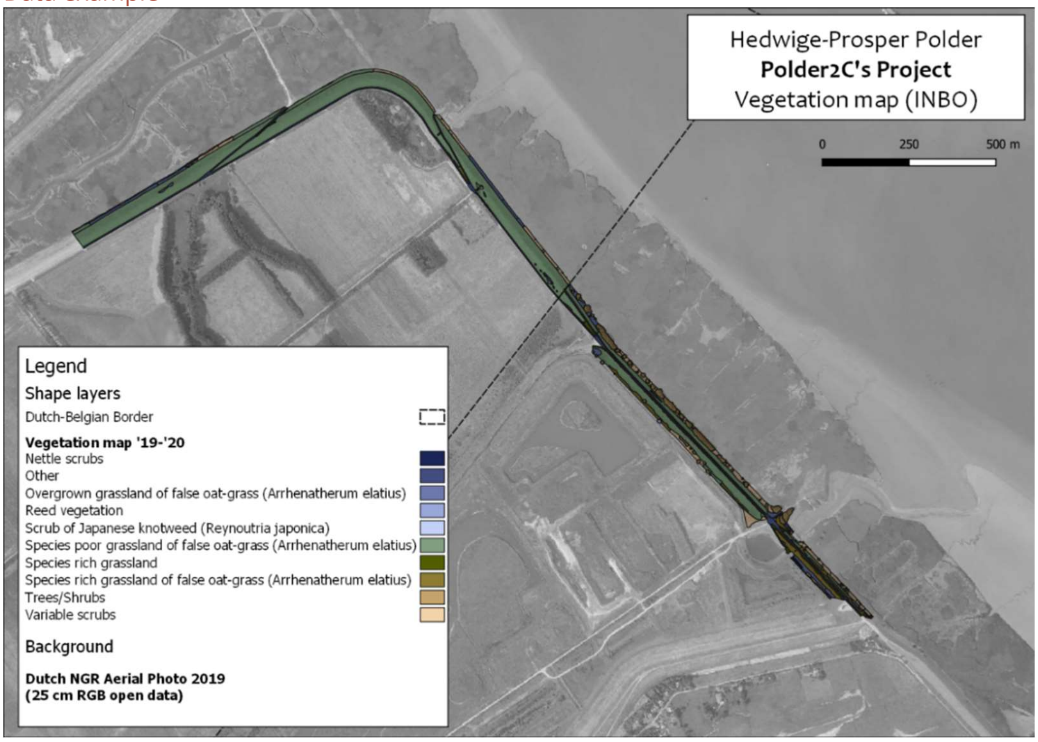

Figure 11: Polder2C's T0 vegetation map

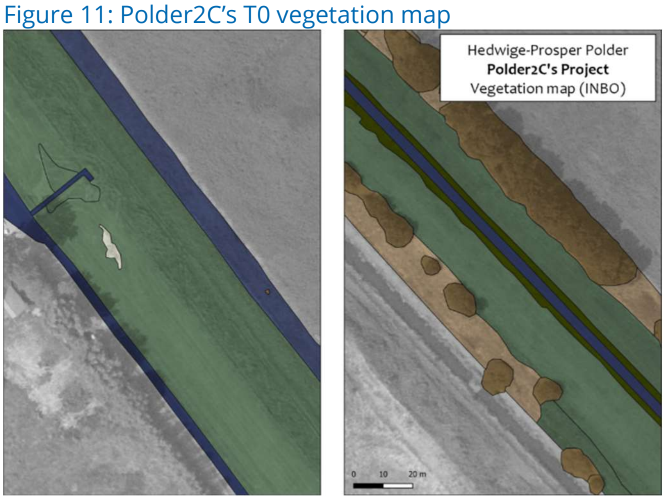

Figure 12: Polder2C's T0 vegetation map example of detail

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4.2 Detailed vegetation mapping

Description On selected levee stretches, detailed vegetation mapping has been carried out by the Research Institute Nature and Forest (RINF; Instituut voor Natuur en Bos Onderzoek, INBO). The analysis is described in Vandevoorde & Van Lierop (2021). Including vegetation description, Biomass, Coverage, Soil composition.

State T0 survey

Result A GIS shapefile has been supplied with polygons of 11 vegetation types and additional information in the feature comments.

References

- Data and report (Vandevoorde & Van Lierop, 2021)

Data example

LamX (punt a)	139938.360	Vegetatietype	Type 3 Soortenarm glanshavergrasland
LamY (punt a)	226852.927	Aantal soorten	6
Z mTAW (punt a)	8.442	Shannon-diversiteit	1.35
LamX (punt b)	139940.358	Ellenberg nutriënten	5.3
LamY (punt b)	226850.981	Biomassa (ton DS/ha)	7.8
Z mTAW (punt b)	7.819	Bedekking (%)	75.0
Helling (°)	18.1	Worteldichtheid	matig
Helling (%)	32.8		
Expositie	Z		
Afstand kruin (m)	15 (land)		

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4.3 Characterizing tidal marsh

Description In collaboration with NWO HPP erosion resistance experiments of the tidal marsh are foreseen. University of Antwerp will perform lab tests on marsh soil samples related to erosion resistance.

State T0 survey

References

- Marsh soil tests and analyses (UAntwerp Report: Schouten et al., 2022)

Data example

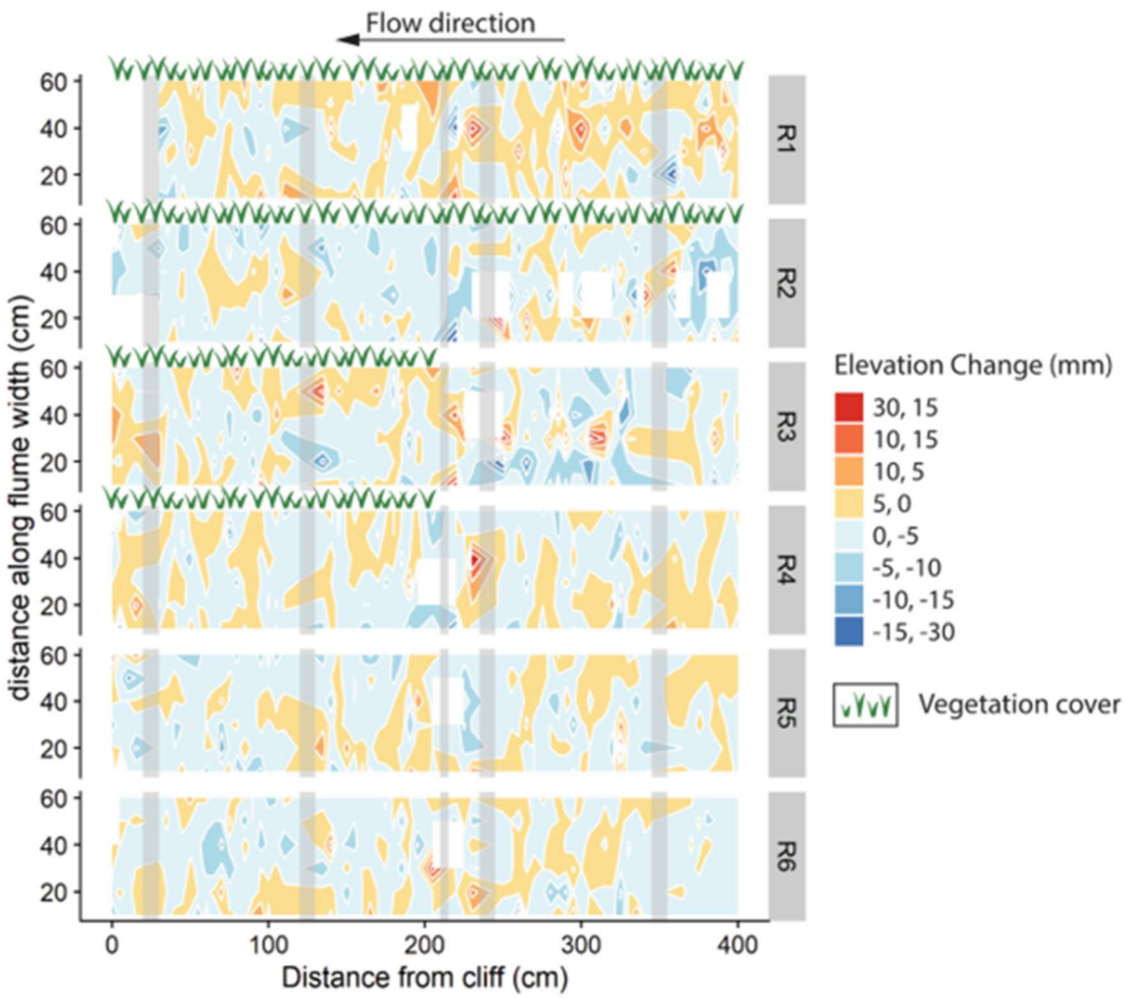

Figure 13: Elevation change measured during the experimental runs (R1, R2, ..., R6)

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4.4 Assessing strength of grass sod

Description With the sod pulling method (Bijlard, 2015) the actual strength of the grass by lifting the grass sod out of the top layer is determined. Utilizing a specific device, a sod of grass is lifted (or pulled) out of the top layer of the levee cover (see e.g. Steendam et al., 2014) during which the vertical force required is measured. The entire structure of soil grains and particales, pores, roots and other components of a soil layer, determine the strength. From this data, the derivation of critical velocity can be evaluated.

State T0 survey

References

- Grass pulling results in Infram report concerning wave overtopping and grass pulling tests. (incl. Annex F). (Infram Hydren, 2022)

Example data

Tabel 6: Resultaten grastrekproeven locatie België

Vak	Aantal	Conditie	Gemiddelde maximale trekkracht* [N]	Standaardafwijking Trekkracht** [N]	Minimum Trekkracht** [N]	Maximum Trekkracht** [N]
Noord	16	2	719	280	439	1.479
	4	4	503	111	400	648
Zuid	16	2	765	244	453	1.262
	4	4	330	130	206	458
Noord+Zuid	32	2	742	260	439	1.479
	8	4	417	145	206	648

*exclusief gewicht zode

Figure 14: Example results table from the draft report (Ch. 6).

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4.5 Animal burrow activity

Description In collaboration with Deltares, the spatial dimensions of animal burrows will be assessed via intrusive and non-intrusive methods)

State T0 survey

Result Spatial extent of animal burrows on site based on ERT measurements, and result of other inspection and investigation activities.

References

- Geophysical ERT burrow investigation report
- Hi-resolution images of fox burrows on Doeldijk (03/2022)
- Report of the burrow inspection activities (BZIM, 2021)

Data examples

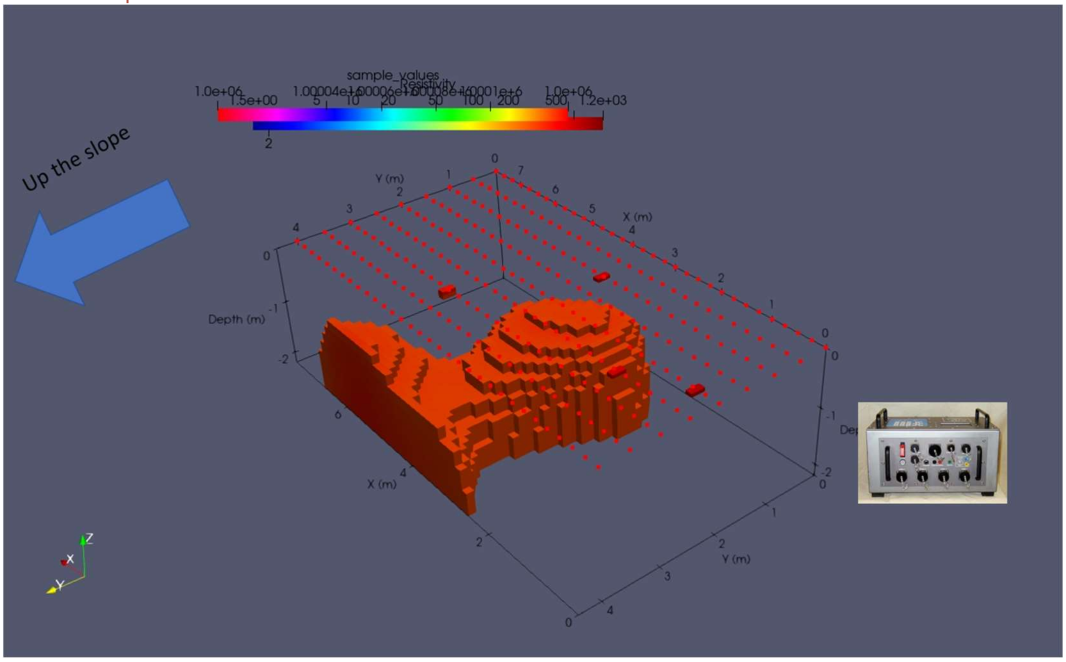

Figure 15: 3D ERT inversion image of the void created by burrow inside a levee (draft result).

Figure 16: Excavated burrow structure after grouting.

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5 Geotechnics and sedimentology

5.1 Jet Erosion Test

Description The Jet Erosion Test is a technique in which the erosion of soil by a small, high-pressure water jet, is measured under controlled conditions. After modelling the properties of the jet vs the advancing of the erosion, soil strength parameters can be deducted.

State T0 survey

Result The jet erosion test has been performed on 20 soil samples of the levee cover, distributed over the levee study area. The locations of the JET test samples is shown in the figure with the soil sample locations. The report is attached to this report.

References

- Full report and data (Geophyconsult, 2020)

Data example

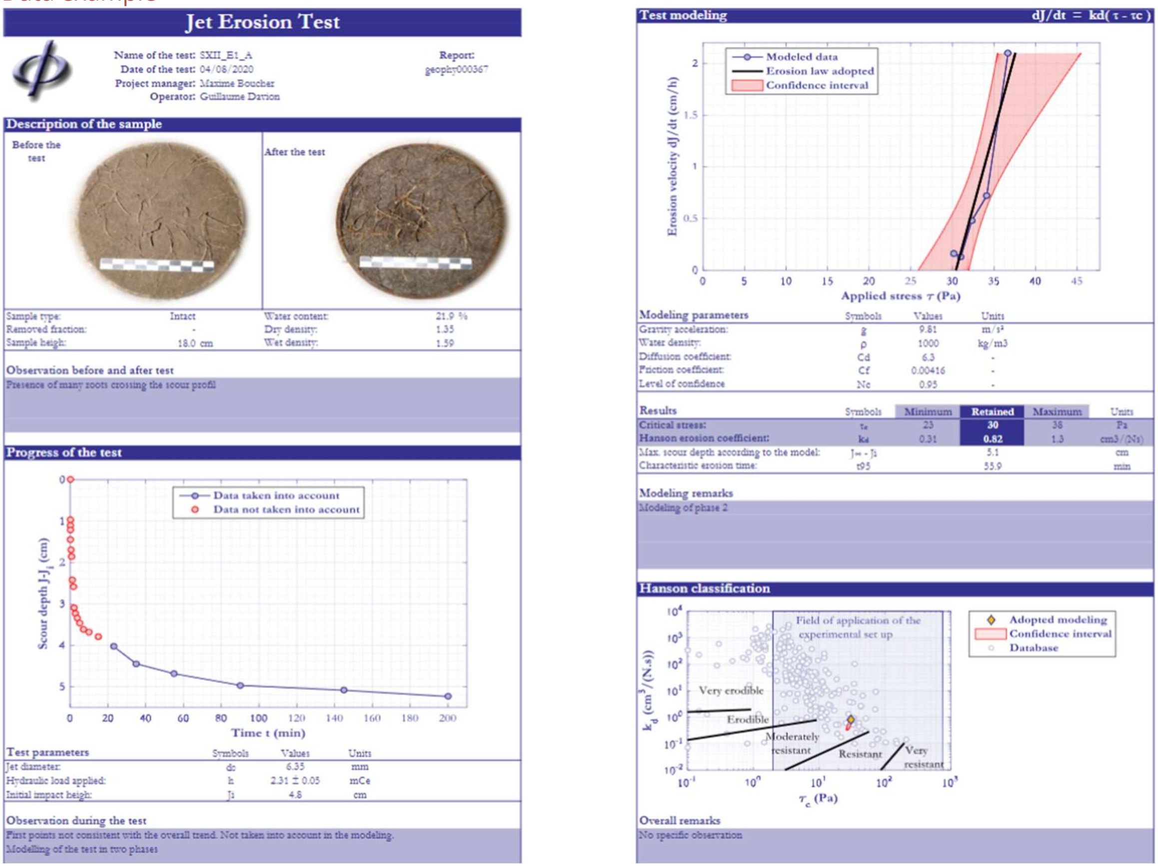

Figure 17: Example of a JET erosion test data sheet.

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5.2 Cone penetration testing

Description The classical cone penetration test consists of measuring cone resistance and cone sleeve friction while pushing a rod into the soil at a speed of 2 cm per second. Measurements with a resolution of 2 to 5 cm yield insight in the strength properties of the layers. The CPT depth goes up to 20 m.

State T0 survey

Result Vertical profile of cone resistance, sleeve friction and derived geotechnical parameters. Layer model and properties interpretation.

References

- CPT reports
- Full data access via Databank Ondergrond Vlaanderen or indirectly.

Data example

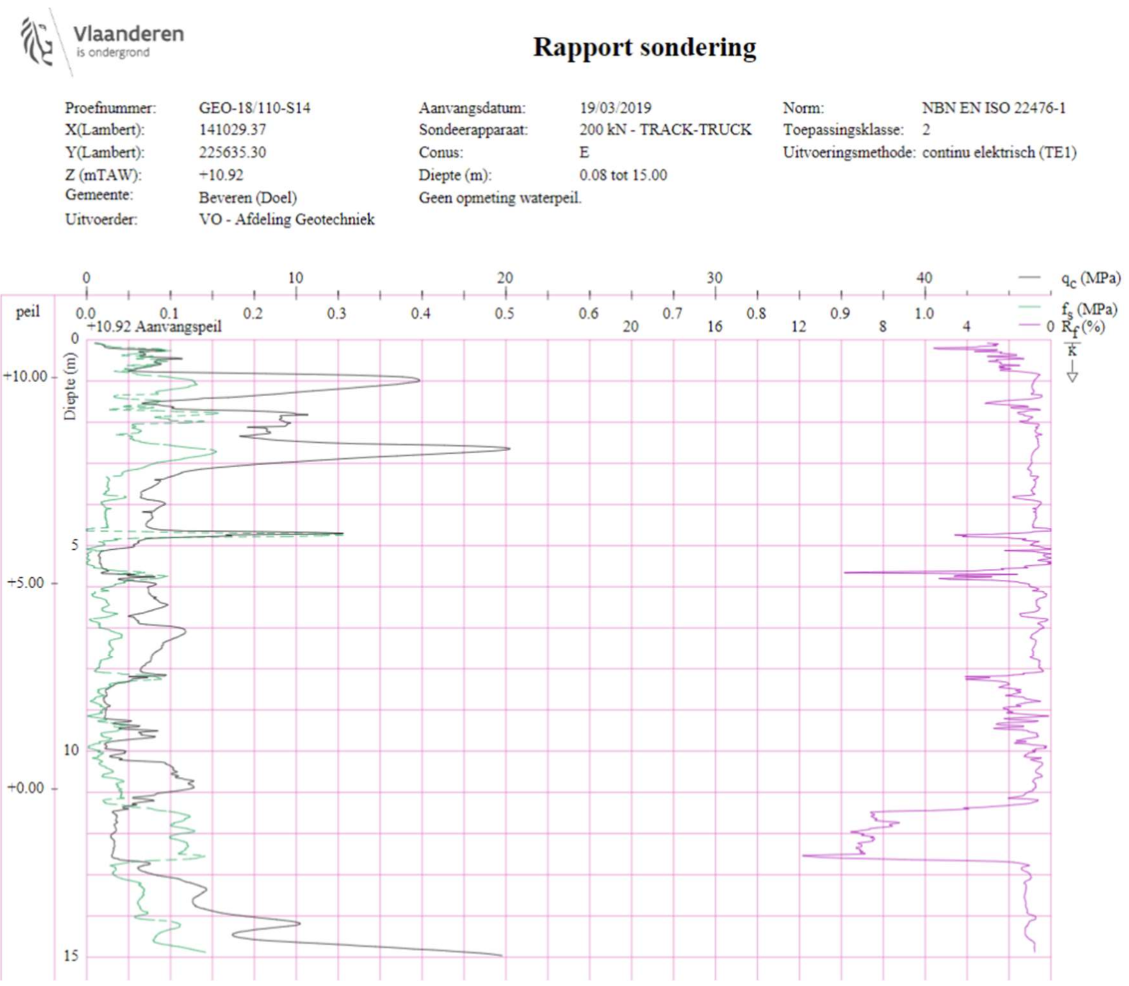

Figure 18: Example of a CPT (S14) taken on the levee.

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5.3 Geotechnical lab testing on borehole samples

Description Soil samples derived from hand or deep drilling will are subject to geotechnical tests in the laboratory.

Tests on disturbed and undisturbed samples:

- Identification tests – determination of soil type: by Grain size distribution with hydrometer and sieving and by determining plasticity index (Atterberg limits) according the ASTM (=American society for testing and materials standard) and the Flemish standard specifications (SB 260).
- Determination of soil density and compaction tests (Proctor), if requested.
- Water content
- Organic content
- Carbonate content
- Dry matter content

Tests on undisturbed samples only:

- Shear resistance by Triaxial tests/(simple shear tests)
- Deformation characteristics by compression tests
- Permeability tests (constant & variable head)

Locations

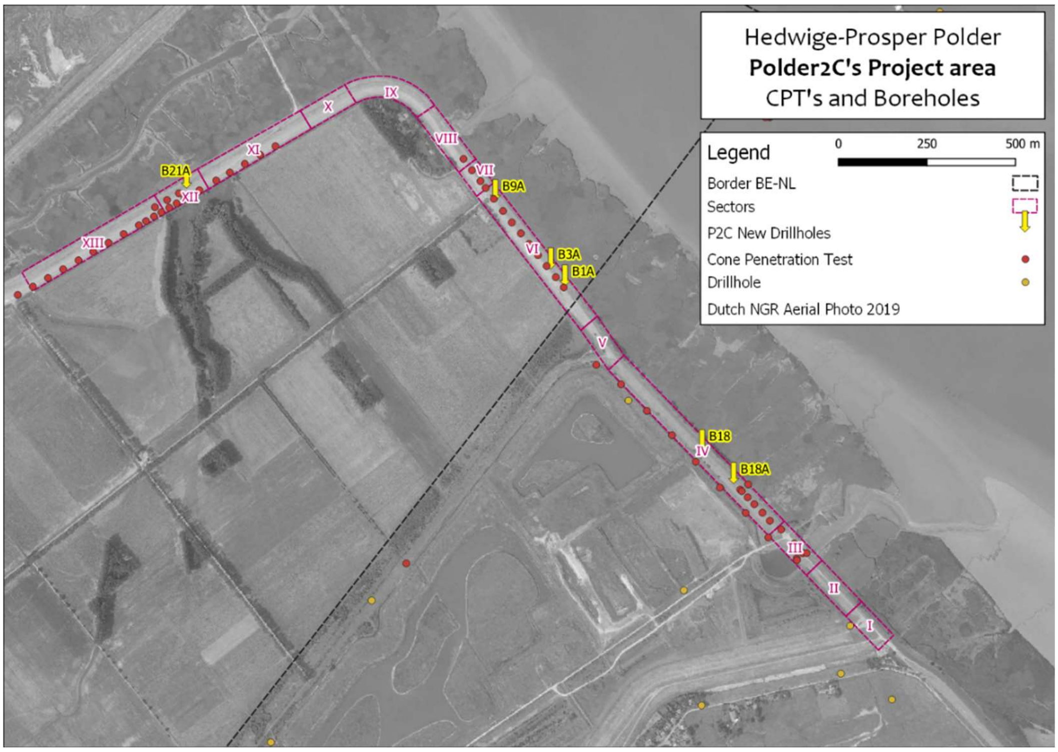

Figure 19: Drillhole map

State T0

References

- Full report (De Backer & D'heer, 2022)

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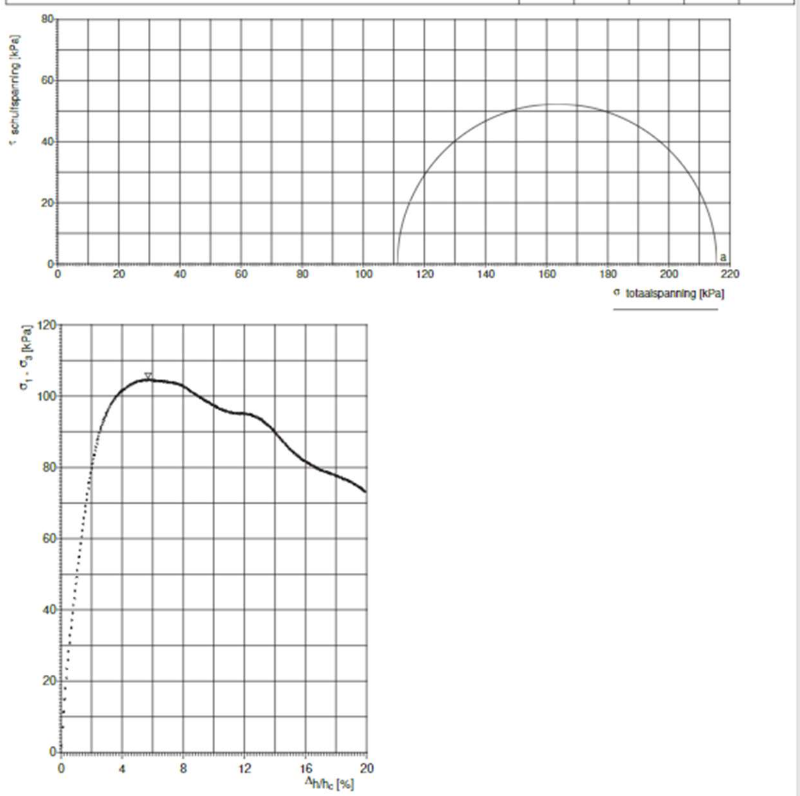
Data example



Triaxiaalproef : UU BS 1377:Part 7:1990

Opdracht		Boring
GEO-18/111	**Beveren (Doel), Hedwige-Prosperpolder**	**B18A**

Monsternummer : 20/3801-B18A/N004 Diepte : 10,00-10,50 m

NIET GECONSOLIDEERD NIET GEDRAINEERD

Proef	D	h	v	σ_s	u_i	u_r	$\sigma_{3,r}$	$(\sigma_1-\sigma_3)_r$	$\sigma_{1,r}$	$(\Delta h/h_c)_r$	c_u	ρ_d	w	S_r	Type breuk
	mm	mm	mm/min	kPa	kPa	kPa	kPa	kPa	kPa	%	kPa	t/m³	%	%	
a	38,0	88,0	0,198	110,6	0,0	0,0	111,1	104,6	215,7	5,7	52,3	1,06	56,3	99,3	2

Breukcriterium Legende Type breuk 1 2 3 4

AFDELING GEOTECHNIEK

GEO-18/111
Annex: 12/2

Figure 20: Example of a triaxial test data sheet.

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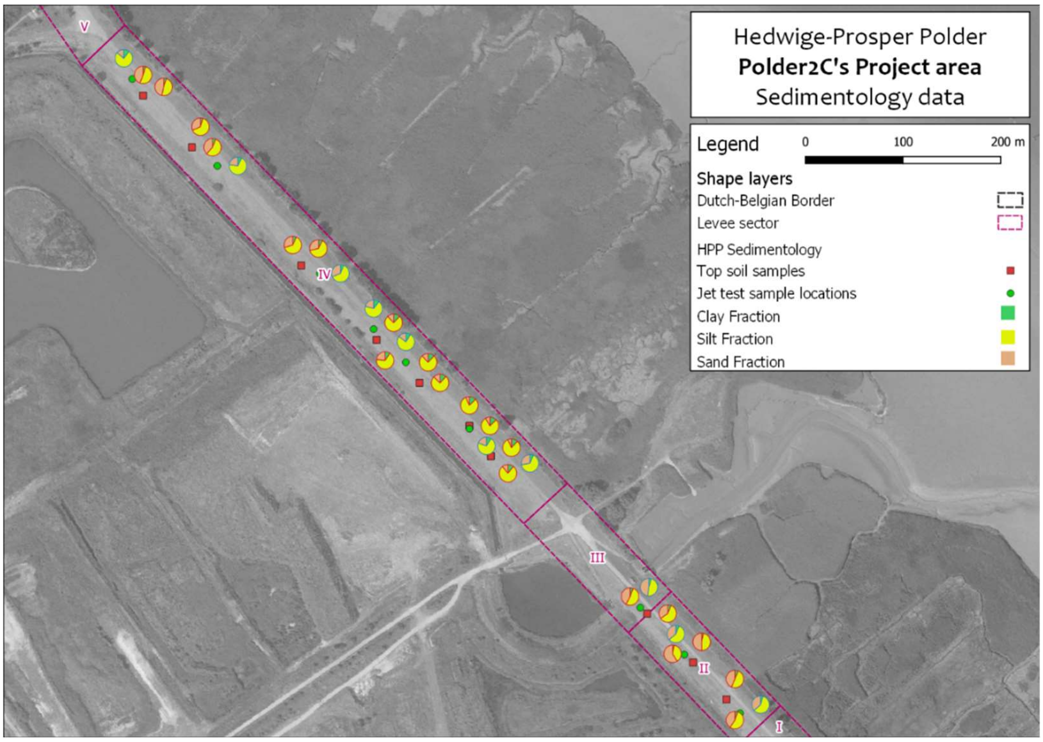
5.4 Levee cover sedimentology (hand drilling)

Description During the project, surface soil samples will be collected to characterize the sedimentological properties of the levee cover.

Result The soil samples are being analyzed with methods depending on the data need (granulometry, sedimentology, geotechnical parameters). The image shows the distribution of samples and the fractions of sand, silt and clay for a spread of samples.

Reference

- Cover layer soil samples July 2020 (dataset and pictures from sampling activity)



5.5 Cover layer description at overtopping location NL

Description Prior to the overtopping tests, a detailed description of the cover layer structure has been carried out in the planning phase.

Result Detailed soil structure description (in overtopping planning document)

Reference

- Included in the Erosion modelling report (van Damme et al., 2022)

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6 Geophysics

6.1 Electrical Resistivity Tomography

Description The ERT method uses an array of electrodes inserted in the soil to inject a small current between 2 electrodes, and measure resulting potential values between couples of electrodes. By varying the distances between injecting and measuring electrodes, the pseudo-volume or pseudo-depth of the measurement can be varied. Numerical inversion techniques are then used to calculate a resistivity model of the subsurface, which gives insight in sedimentology and conductivity parameters. ERT is carried along longitudinal and transversal transects.

State T0 survey

References

- 2019 ERT campaign Dutch Levee data and report
- 2020 ERT campaign Dutch and Belgian Levee data folder (including papers)
- Report on Geophysical and Geotechnical measurements (Fauchard et, 2022)

Data example

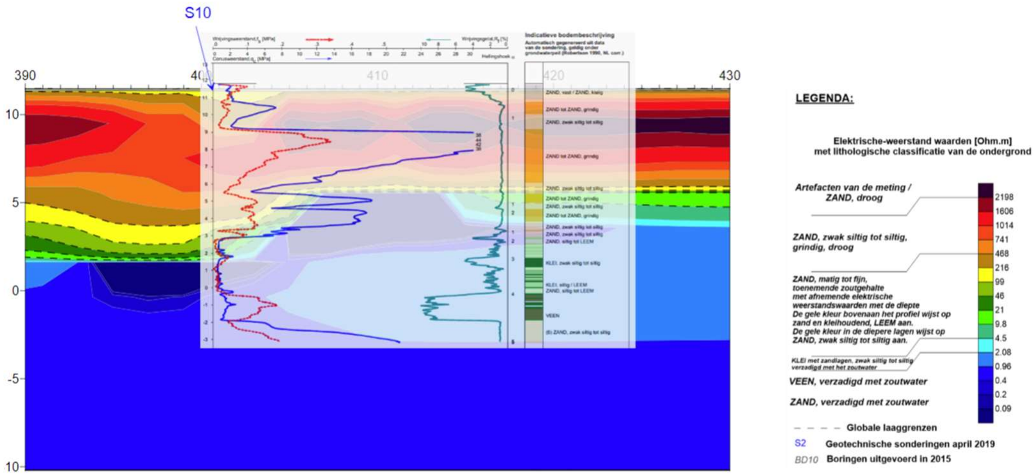

Figure 21: 2019 ERT data example (Dutch levee)

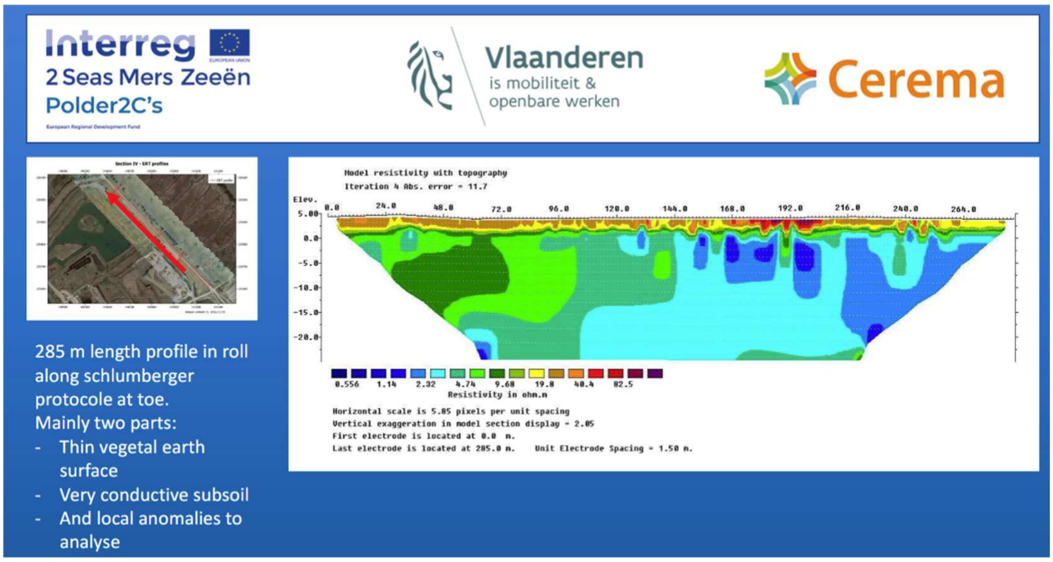

Figure 22: 2020 ERT data example (Dutch Levee)

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6.2 Electromagnetic method: slingram (EM31)

Description The Geonics EM31 devices is used to measure apparent conductivity of the top soil (2-4 m depth) along a profile. It is a quick method to search for anomalies or longitudinal subsurface variability of the upper part of the levee.

State T0 survey

References

- Due to hardware failure, the method has not yielded any result.

Data example N/A

6.3 Ground Penetrating Radar

Description The ground penetrating radar is a technique that uses antennas to transmit high frequency pulses in to the soil and capture reflections on interfaces with changes in dielectric permittivity. Frequencies used are 200 and 400 MHz. GPR profiles require elaborate processing but if successful, the image can indicate layering structures below the structures. Limitations for the technique include the presence of strongly conductive elements (e.g. clays, saline water, ...).

State T0 survey

References

- 2020 measurements data folder (including papers)
- Report on Geophysical and Geotechnical measurements (Fauchard et, 2022)

Data example

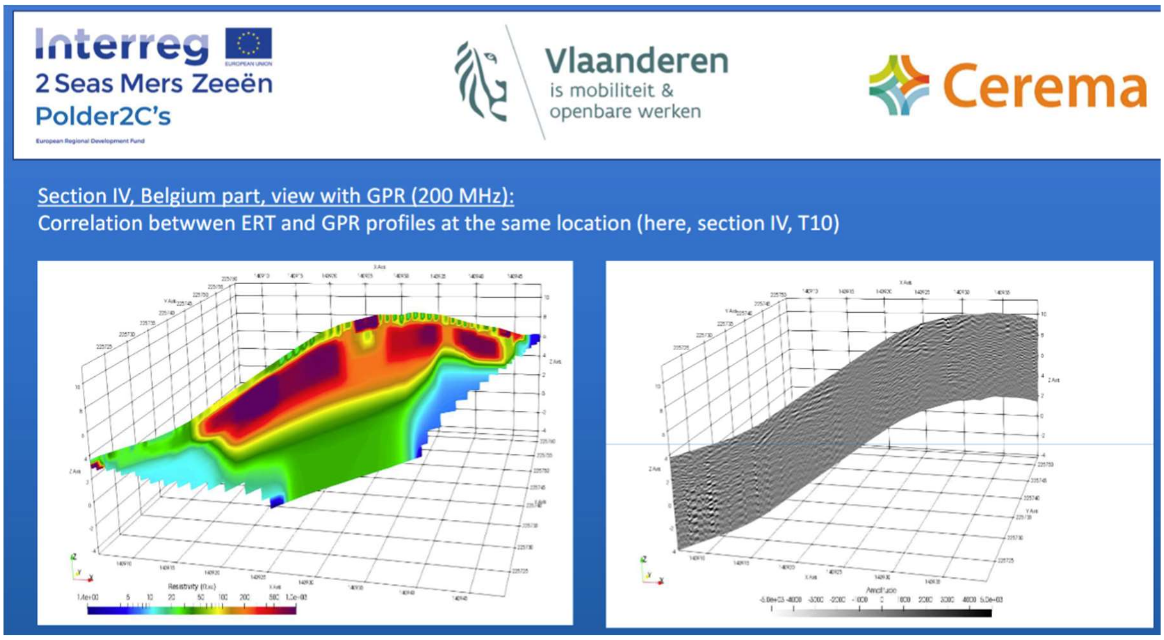

Figure 23: Example view on levee transect with ERT and GPR.

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7 Hydraulic properties

7.1 Permeafor permeability sounding

Description The Permeafor system (see Antoine et al. (2015) for a description of the technique) is a hydraulic profiling variant of the cone penetration test, where the tip of the sounding rod is equipped with a water injector. At intervals of 20 cm, water is inject in the soil and the dissipation is monitored. From this information, hydraulic or hydrogeological parameters can be derived.

State T0 survey

Result Hydraulic and hydrogeologic parameters along a vertical profile.

References

- Report on Geophysical and Geotechnical measurements (Fauchard et, 2022)

7.2 Long-term water level monitoring

Description The water level of the Scheldt River is being monitored in many stations. In front of the marsh, the Prosper tidal monitoring station, provides continuous monitoring data of water level.

Result Water level time series through www.waterinfo.be and available through the DDSC as a WMS service.

References

- High resolution tidal timeseries (graph, data) of water level on the Scheldt river

Example data

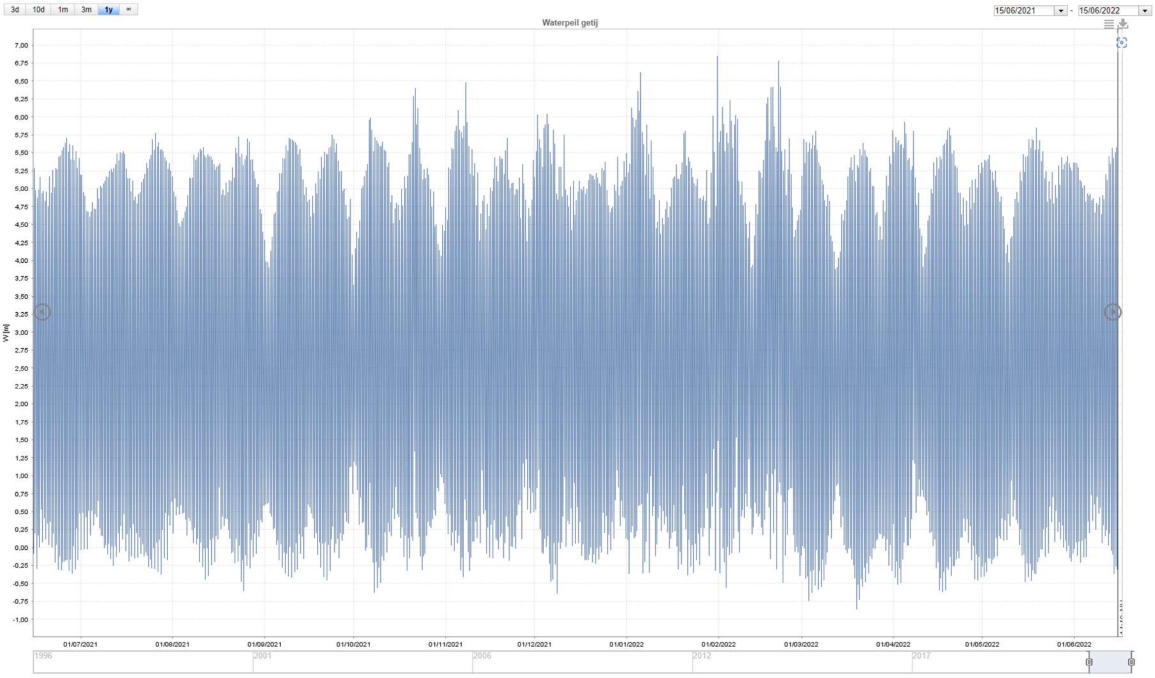

Figure 24: Screenshot of the interface to visualize and download continuous timeseries data.

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7.3 Long-term soil moisture monitoring

Description The installation of soil tensiometers (Watermark) on two sites (Dutch and Belgian location) allows to monitor the soil moisture or pore pressure in or below the levee cover layer.

Result Pore pressure or soil moisture timeseries are reported in the Factual Data reports of the relevant overflow tests (in concept). The data is reproduced below and stored online.

References

- Dutch site soil moisture recording in factual data report N-OF10.
- Belgian site soil moisture recording in factual data report B-OF09.
- Data (Dutch and Belgian site)

Data examples

Figure 25: Soil moisture evolution in 7 measurement points at N-OF10 test site.

7.4 Cover layer permeability test

Description By the use of the double ring method, the permeability of the cover layer on the Dutch part of the levee has been determined.

Result Permeability data and interpretation, field pictures and notes.

References

- Data and information

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7.5 Hydraulic head in boreholes

Description The deep boreholes that will be installed by DMOW-GEO, will be equipped with water level divers to monitor the head levels inside the levee.

Result Hydraulic head timeseries in point locations on the dike. Data will be extracted at fixed intervals and provided to the project team (no real-time connection).

References

- Data and description in geotechnical borehole report (De Backer & D'heer, 2021)

Data examples

diver PB18b

Project	GEO-18/111 Beveren / Doel / Hedwigepolder - Prosperpolder / Dijkproeven
Beheerder	griet.debacker@mow.vlaanderen.be
Lambert 1972	140.928,51, 225.740,71
Peil	11,02 mTAW
Maaiveld	11,1 mTAW
Periode	25-8-2021 15:00 ↦ 31-1-2022 15:00
Datum plaatsing peilbuis	2021-02-01
Diameter peilbuis	50,0 mm
Lengte geperforeerd deel van de buis	2,0 m
Lengte van de peilbuis	17,56 m
Peil bentonietstop bovenkant	10,6 mTAW
Peil bentonietstop onderkant	-3,3 mTAW
Peil filtrerend gedeelte (+filterzand) bovenkant	-3,3 mTAW
Peil filtrerend gedeelte (+filterzand) onderkant	-6,38 mTAW
Peil onderkant peilbuis	-6,38 mTAW

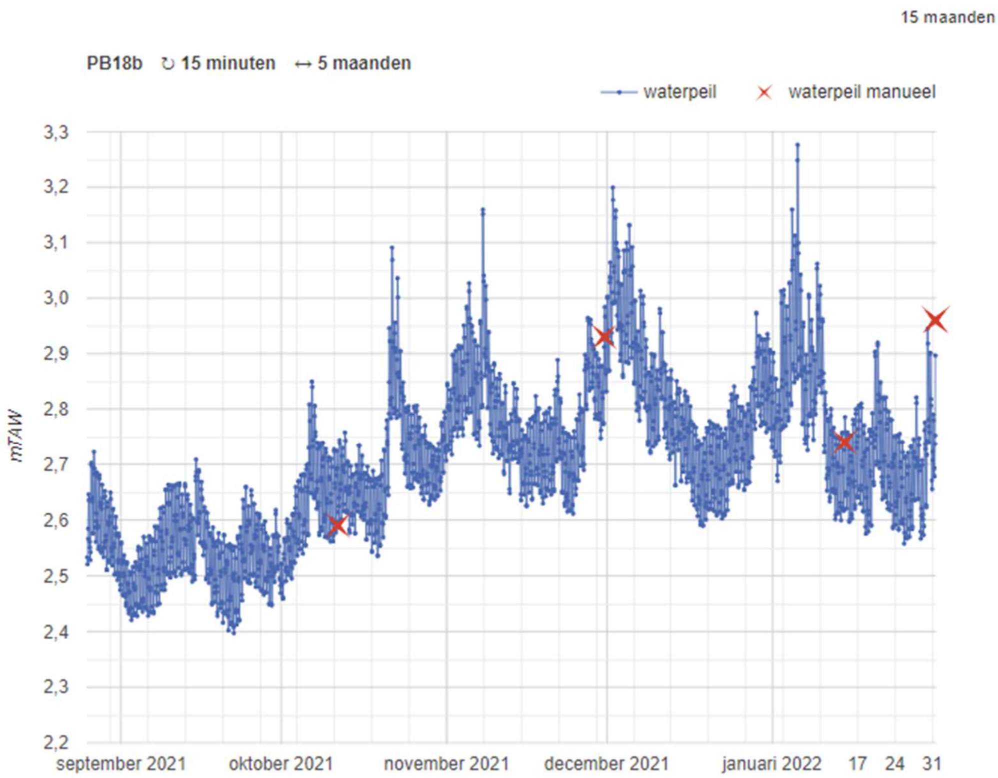

Figure 26: Diver measurement of water levels in borehole during 15 months.

This project has received funding from the Interreg 2 Seas programme 2014-2020 co-funded by the European Regional Development Fund under subsidy contract No [2S07-023]

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