LIFE SURE

Sediment Uptake and Remediation on an Ecological Basis

LIFE15 ENV/SE/000279

Action	**B1 Construction**
Deliverable title	**Design document of the adapted dredging and dewatering system**
Version no.	**3**
Document date	**16 June 2021**
Author (s)	**Renate Foks, Fabio Kaczala, Ulf Rickardsson**
Responsible partner	**Kalmar Municipality**
Contributing partners	

Pictures in this document by: Renate Foks and Ulf Rickardsson. Design-images by Ulf Rickardsson.

Dissemination level:	**PU**	
PU = Public, PP = Project Participants and Commission Services		
Version	**Date**	**Comment** *working version, completed or updated*
1	*June 2020*	*Working version*
2	*Dec 2020*	*Updated with Mudster design*
3	*June 2021*	*Updated with new pictures, completed*

Content

BACKGROUND

LIFE SURE has as the main objective to demonstrate an innovative, cost-effective and ecologically sustainable process to remove sediments from shallow waters and to use it as a resource.

This report shortly describes the dredging system and the land-based treatment that is implemented at LIFE SURE in Kalmar.

SEDIMENT REMOVAL SYSTEM

During the cope of LIFE SURE, a new removal and steering solution was developed and new robots were designed and tested. A patent application has been sent to the Patent Agency in Sweden.
The sediment removal system consists of a dredging robot, Mudster, and a pump island.
Four floating devices with special anchors are placed in the area for dredging and Mudster is connected to them using special wires.

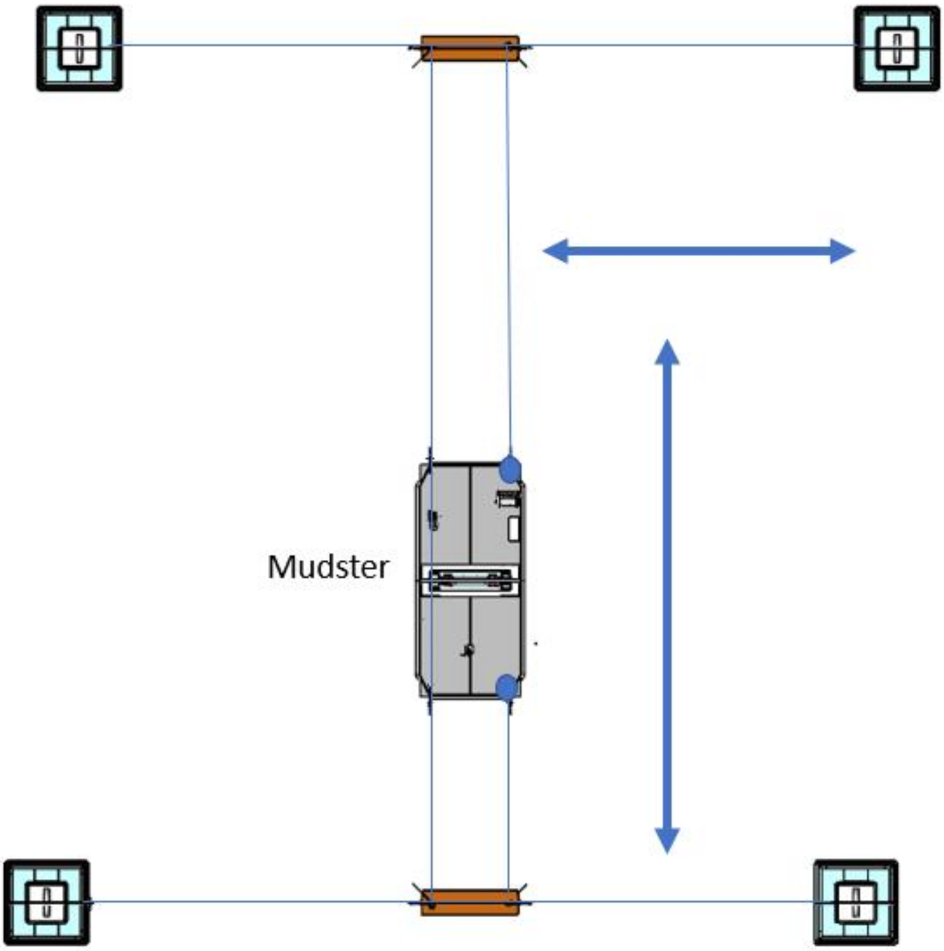

Figure 1: Mudster, wires and floating devices

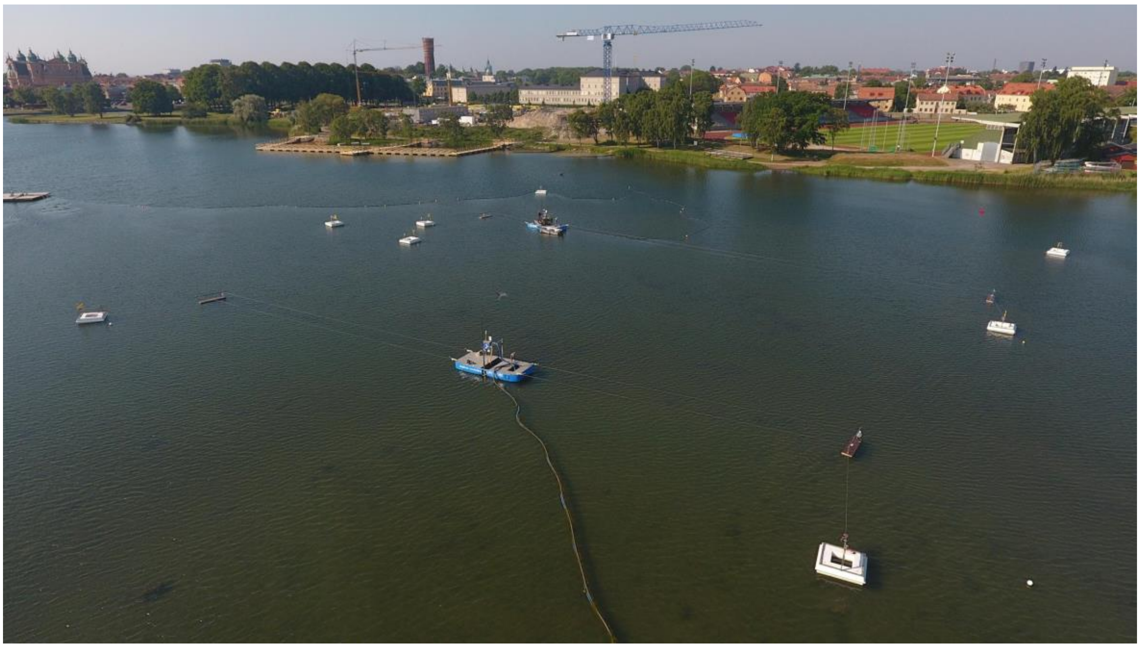

Figure 2: Two Mudsters in action, spring 2021

Mudster has a motor that moves Mudster in automatic mode back and forth in the area until its manually stopped. The sediment is pumped through hoses to a pump island where another “boost-pump” is located.

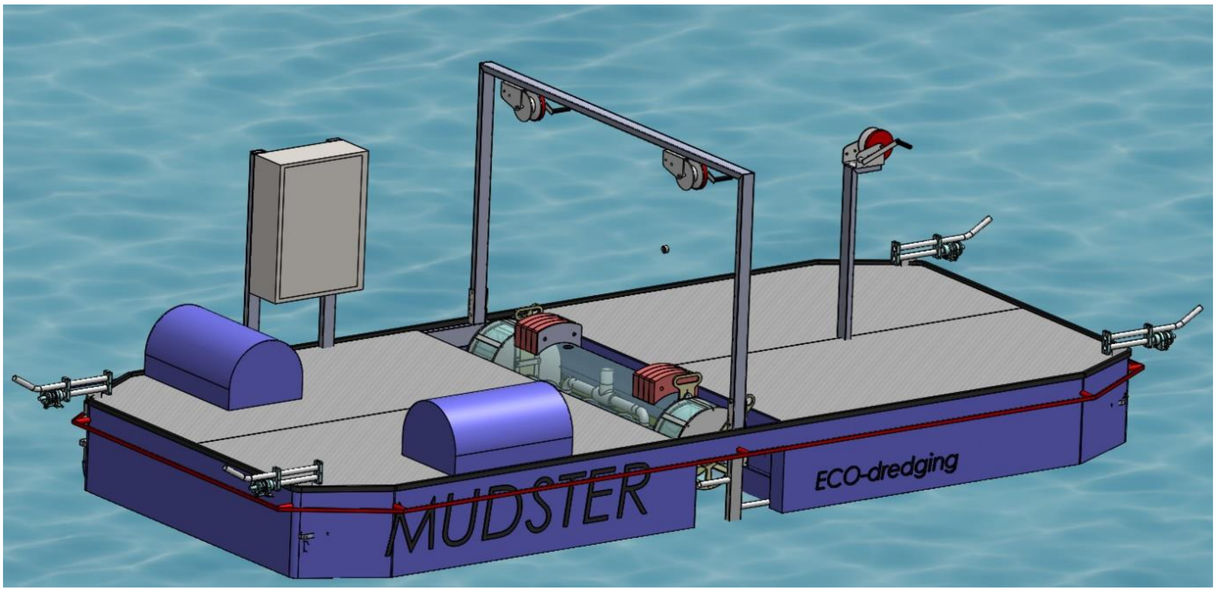

Figure 3: Mudster design

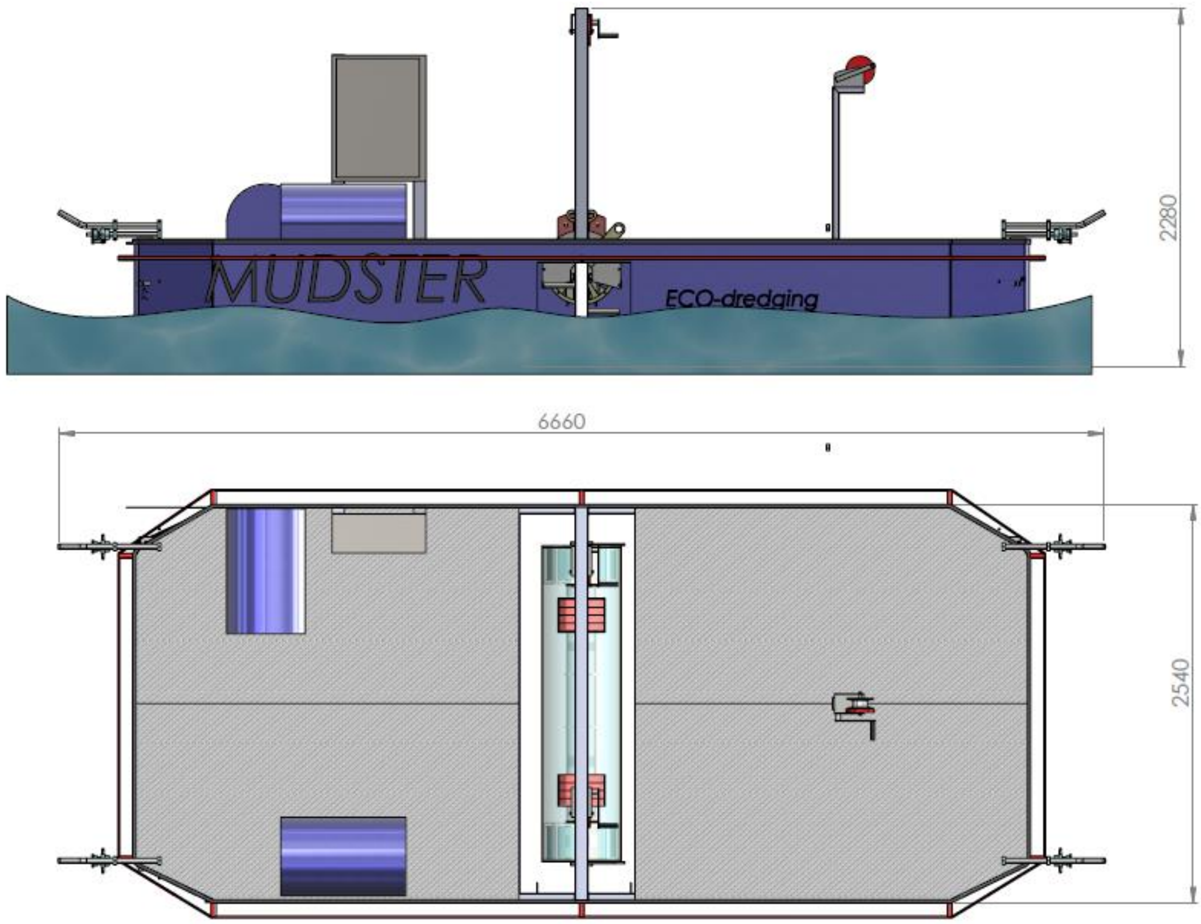

Figure 4: Mudster design

Mudster drags an underwater unit that can be set to dredge different depths into the sediment.

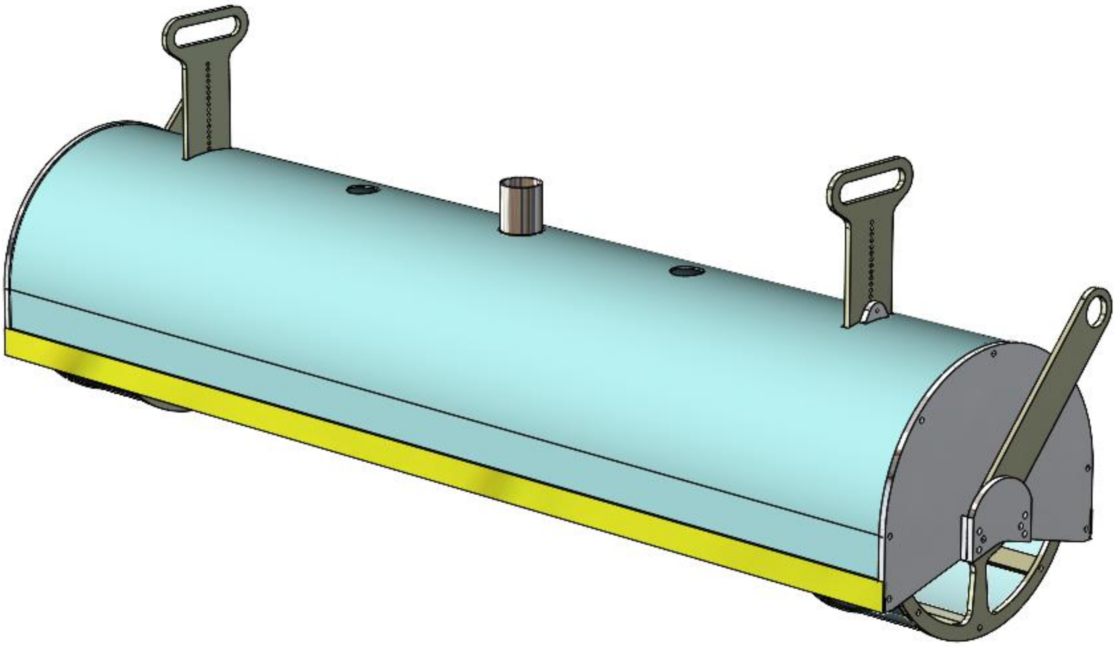

Figure 6: Mudsters underwater unit

Figure 5: Mudster put back in the water in spring 2021

LAND-BASED TREATMENT SYSTEM

The land-based system consists of the following steps: equalisation, a polymer station, simultaneous thickening (coagulation/flocculation), dewatering, and reject water treatment through infiltration. This design and choice of methods were taken from the broad physico-chemical characterization that was done within the project with the main conclusions that sediments are moderately contaminated and no further treatment other than thickening and dewatering was needed.

A previous version of this deliverable emphasized the needs for adaptation and changes that would consider the modifications the land-based site went through when the project moved from *Action B2 – Minor Scale Tests* to *Action B3 – Full scale demonstration*. Therefore, this current version is focused on the latest design that was built to increase the capacity of the dredging system.

Important to highlight that all changes are still within the main concepts of the project that is to have a simple to operate and low energy consumption treatment of sediments. The land-based system can be also moved and transported to different locations since they are built in containers.

Several possible final dewatering solutions have been investigated and discussed with the aim to find best solutions to increase the capacity of the system and based on external consultants, international dredging/dewatering experts cost calculations and expected dewatering results the decision was to continue the project with semi-passive dewatering in geo bags. Several earlier considered solutions, such a as sedimentation basins and lamella separators, will not work with our silty-clay sediments. Centrifuges will add to energy costs and will according to project external consultants, manufacturer and dredging companies demand for a full time or part time high-skilled process technician on site. Geo bags are generally considered to be the cheapest and most energy-effective dewatering and purifying solution which falls into the project concept.

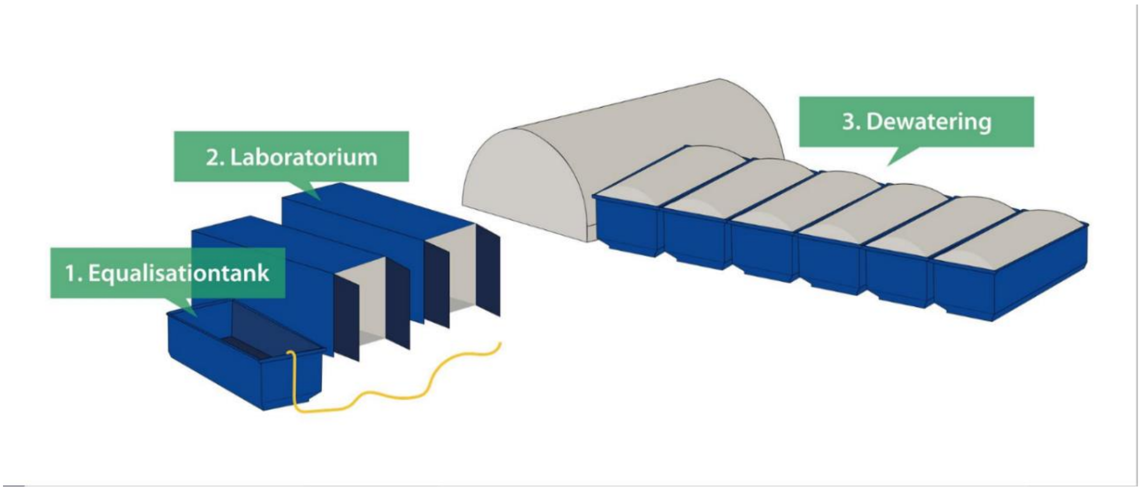

Figure 7: design of the land based system in Action B3

Figure 8: Areal view of the land based system in Action B3 (autumn 2020)

Equalisation tank

The first unit is an equalization tank that is used to equalize the incoming flows and homogenize the quality of dredged masses mainly regarding dry matter content. The homogenization of sediments and as less variability as possible is important to not disturb the efficiency of the coagulation/flocculation process (thickening). An optimal polymer dosing rate means cost-effectiveness besides efficiency and this is an important aspect in the project. The equalization tank has submerged pumps to keep the liquid phase in constant movement to avoid settling/sedimentation.

The sediments are pumped from Malmfjärden with a flow of approximately 250 l/min from Mudster which gives an approximate flow of 15 m^3/h for each. The equalization tank has a total volume of V=22 m^3 and has some submerged pumps to avoid settling/sedimentation. The incoming dry matter content (DM) of sediments in the equalization tank ranges between 1 and 5 although operators have observed most of time a concentration of 1% DM. The amount of incoming dry matter and its variability is a consequence of the dredging locations and differences in the characteristics of the Malmfjärden sediment.

Figure 9: Equalization tank as the first step in the land-based treatment.

Polymer station

From the equalization tank sediments are pumped into the dewatering step. On the way to the dewatering step there is an in-line addition of polymers to aid in thickening process. This system consists of a polymer station that prepares the polymer solution (0,5% polymer concentration) that will be further pumped into the pipe network connected between the equalization tank and the geo bags.. Dosing rates were obtained through laboratory tests that were performed by Linnaeus University. The project has even planned to optimize the dosing rates as a function of incoming dry matter although this is still under investigation.

The mixing of the polymer with sediments takes advantage of the turbulence that occurs inside the tubes and it is expected that a good mixing and contact between sediments and the polymer has already taken place by the time they are discharged into the dewatering step. This is crucial for an optimal dewatering process inside the tubes.

Figure 10: Polymer station to prepare the thickener solution prior to its in-line discharge in the bags

Thickening and Dewatering

During the test phase, action B2, the project has used custom made geo bags of 9m^3 each to dewater sediments. In the full-scale test the system has been upgraded with a higher capacity. However, the process is still much similar as in the test phase in the way the geo bags are filled in cycles until their full capacity. Filling cycles and full capacity are usually recommended by the suppliers although LIFE SURE project tests are being done to evaluate possibilities of controlling this process through pressure devices.

The full scale consists of six containers each with a 22 m^3 geo bag. When the geo bags are full and dewatered, the containers are collected, transported and the geo bags can be tipped out of the containers at the final or temporary destination.

In the test phase, action B2, the reject water was pumped into a buffer tank to be further pumped into a treatment system consisting of sand filter, activated carbon filter and polonite filter. However, based on the samples and monitoring of reject water it was concluded that water quality after geo bags has quality enough to be discharged without any further treatment with the only exception of

Zinc. Zinc content in the reject water was identified as a result of a galvanized grid that was placed under geo bags and functioned as a drainage layer. The grids were replaced by wooded grids and the reject water longer had elevated Zinc levels.

Reject water treatment

In the full scale a new treatment system was proposed by the external consultants from Sweco that consists of a final polishment of reject water through a natural infiltration basin. This infiltration basin is located beside the geo bag containers and the reject water coming out of the dewatering process can flow by gravity and further infiltrate. Monitoring is being done by Linnaeus University both on the reject water after geo bags and on the recipient to evaluate the water quality and give information on the necessity of additional preventive actions.

The infiltration basin consists of an area of approximately 450-500 m^2 and has a diffuse inlet and consequently diffuse discharge to the recipient Lindöfjärden. Reject water is treated in the infiltration area through physical processes, biological processes and it is expected that some chemical reactions by sorption take place. The image below shows an aerial view of the infiltration basin in relation to the land-based site used to dewater dredged sediments from Malmfjärden in Kalmar.

Figure 11: the land site and infiltration area

Reject water comes out from dewatering containers that are spread out longitudinally in relation to the infiltration basin which avoids high surface loading rates in specific points resulting in higher efficiency and satisfactory infiltration rates. A better understanding of the flow and variations is expected to be achieved by the end of LIFE SURE and will be part of the system evaluation.

As the system is operated with diffuse flows (inlet and outlet) the evaluation of the treatment performance and sampling at the outlet is a challenging task although constant monitoring is required and have been performed in a broad way under LIFE SURE. The way the project team established to overcome these challenges was to develop a sampling program that could evaluate the system by taking composite samples in the recipient as close as possible to the discharge area. These composite samples have been considered as an "outlet" of the system and it can give valuable insights regarding the recipient conditions and how the environmental permissions are being followed. Important to highlight that such samples are only an approximate indicator of the effects of the infiltration basin although this can be used as a good indication of the recipient status and the effects of the system.

Results from the ongoing monitoring in May 2021 show that all parameters are under the limit value when considering the recipient water quality which confirms that no major effects caused by the treatment system have been observed. It is important to highlight the high quality of the reject waters that already in most cases comply with the limit values for discharging into the recipient with the exception of oil index that has an average value of approximately 10 mg/l compared to 1 mg/l as limit value. In this case the infiltration basin has played an important role to reduce aromatics and aliphatic compounds from the reject water before its final discharge with an average concentration of 0,12 mg/l after the infiltration basin treatment system. It is expected that aliphatic and aromatic compounds are biologically transformed and in a certain range degraded in the infiltration basin if optimal conditions such as oxygen availability exist.

Figure 12: Containers where the geo bags are installed and the dewatering takes place

.

Figure 13: almost filled geo bags

REMOTE MONITORING, STEERING AND CONTROL

Our dredging robot, Mudster can be controlled on the Mudster using buttons on control panel, from the Lab or using a connection through internet.

Figure 14: the control panel on the Mudster itself

Using the control panel on Mudster:

- With setting local on first button you can move Mudster Forward or Backward with second button.
- With setting Remote on first button, Mudster is controlled using the lab or through internet
- With setting tighten on first button, the wires connected to floating devices can be tighten or loosen with second button.
- Pump can be started manually using the third button.
- Speed is controlled using the fourth button

Using the ABB interface in the LAB and remote

With the ABB interface located in the lab that also is connected to internet you can control more than one Mudster.

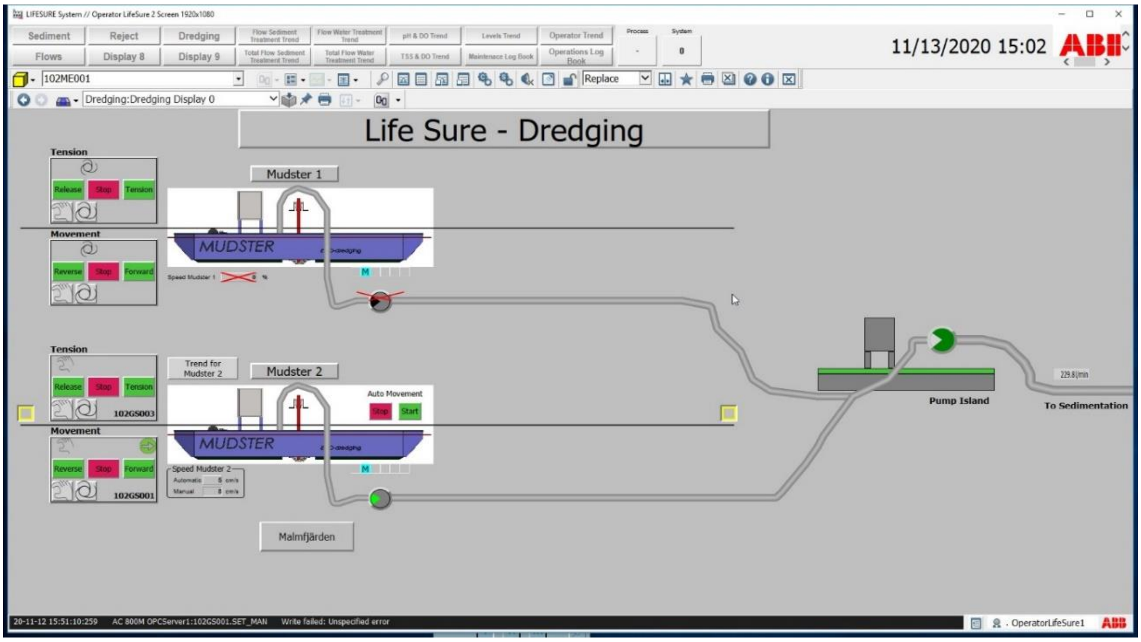

Figure 15: The interface

Tension, movement, pump on of and speed can be controlled manually. You can also press “Auto movement” that puts the Mudster in automode, dredging automatically until it manually stopped.

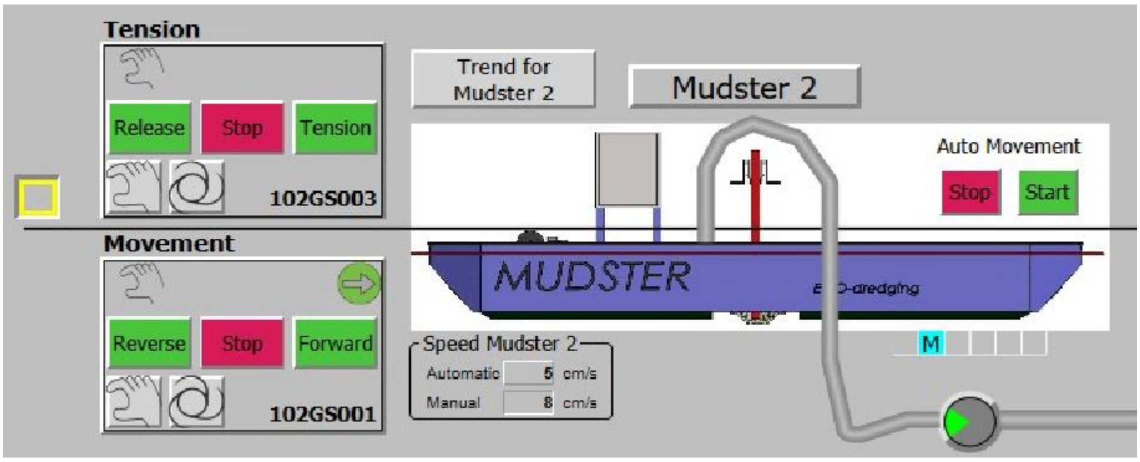

Figure 16: details of the interface

From the LIFE SURE laboratory, the flows between the different steps in the process can be monitored and controlled by an industrial PLC. The system was built in a way that samples can also be collected for further analysis of parameters either at the Linnaeus University laboratory facilities or by external laboratories. The lab-computer monitors the dredging activities from Mudster, and the flow in and between different units. Also, on-site measurements of pH, total suspended solids and turbidity are being transferred and stored every 5 minutes.

With small cameras, we can follow the dredging at Mudster and on the site. Data is stored and can be used for analysis.

The computer is connected to the internet, which makes it possible to monitor and steer from another computer or telephone. With stop and problems, an alarm message can be sent. In this way, the responsible technician can monitor the process, while doing other activities.

Figure 17. Monitoring and control room also called as LIFE SURE Laboratory.