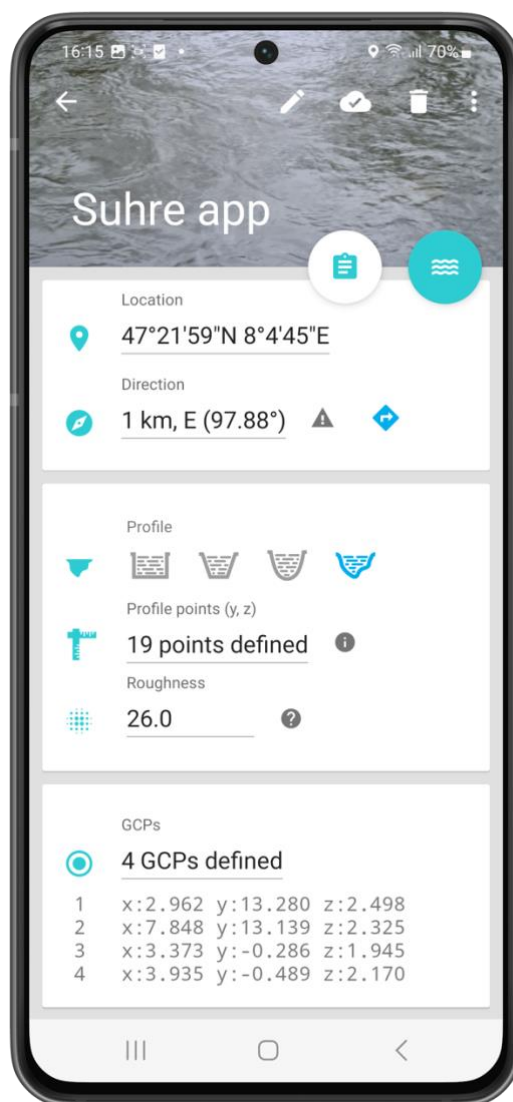


DISCHARGE

USER MANUAL 2024-05-02



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WHAT DOES THE DISCHARGE APP DO?

The Discharge app is a non-intrusive, optical flow measurement tool, suited for natural water streams, irrigation furrows and water channels. The app is fully integrated in the web platform discharge.ch. At dedicated measurement sites the app can accurately determine water level and discharge. The discharge is calculated either via rating curve or via surface velocity that is measured by the app. All calculations are performed directly on the smartphone, such that the app can operate in offline mode. An operational site requires 4 reference Ground Control Points (GCPs) and a known cross-sectional profile.

The Discharge web platform discharge.ch is designed for large scale acquisition of hydrometric and meteorological data. The user can navigate through measurements, timeseries and proof images. Site properties can be edited either via app or web platform and updates are pushed immediately to all registered devices. Sites may be grouped into organizations. State of the art tools and intuitive usability facilitate administrative aspects, user, and organization management.

GETTING STARTED

SMARTPHONE REQUIREMENTS

The application Discharge is available on Android devices with the following requirements:

- Android 6.0 or higher
- Smartphone Camera: 25 fps video
- ARM processor

Tested devices:

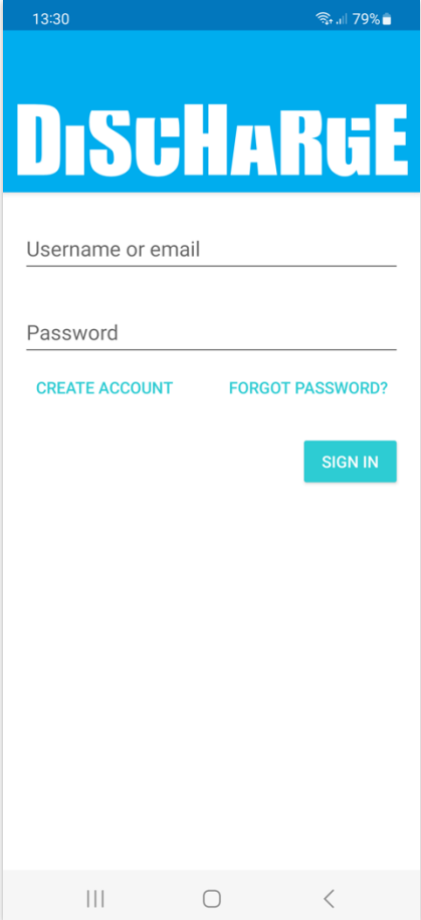
- SAMSUNG A 51
- SAMSUNG GALAXY A14
- SAMSUNG GALAXY S4
- SAMSUNG GALAXY S5
- SAMSUNG GALAXY S7
- SASMSUNG GALAXY S20
- Fairphone 2 and Fairphone 3
- SONY Xperia Z1 compact
- HTC 10
- HUAWEI Y5
- HUAWEI Y6 Pro

DOWNLOAD

Discharge is available on Google Play Store. Search for “Discharge river” and download the application (<https://play.google.com/store/apps/details?id=ch.photrack.discharge&hl=en>).

CREATING AN ACCOUNT

Upon opening the application on your Android device, the application will ask for your sign-in information. New users may simply click ‘create account’, which will trigger the registration process. The password must be at least 6 characters long. Please make sure to enter a valid email address in case the password needs to be reset.



The screenshot shows the sign-in screen of the Discharge app. At the top, the status bar displays the time 13:30, signal strength, Wi-Fi, and 79% battery. The app's logo, "DISCHARGE", is prominently displayed in white on a blue background. Below the logo, there are two input fields: "Username or email" and "Password". Underneath these fields, there are two links: "CREATE ACCOUNT" and "FORGOT PASSWORD?". A blue "SIGN IN" button is located at the bottom right of the form area. The bottom of the screen shows the standard Android navigation bar with three icons: a square, a circle, and a triangle.

MENUS

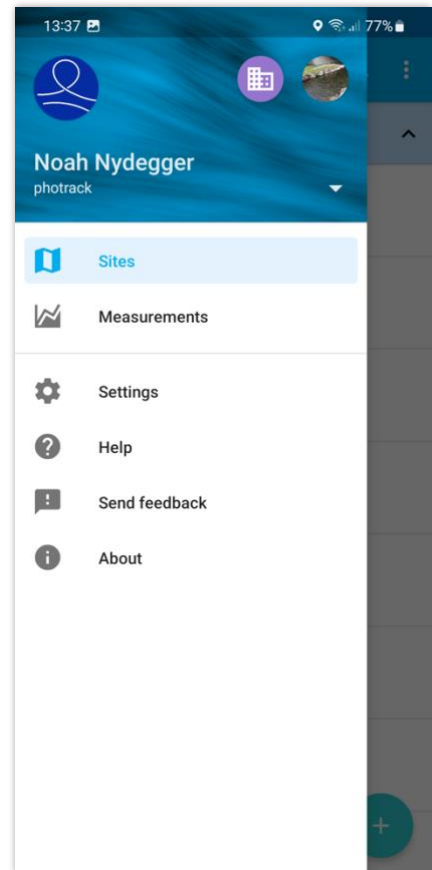
After the login the app shows all sites in all organizations for which the user has at least viewing permissions.

The organizations can be expanded and collapsed; the sites within organizations can be sorted alphabetically or by distance to the user location. Sites may also be searched for directly.

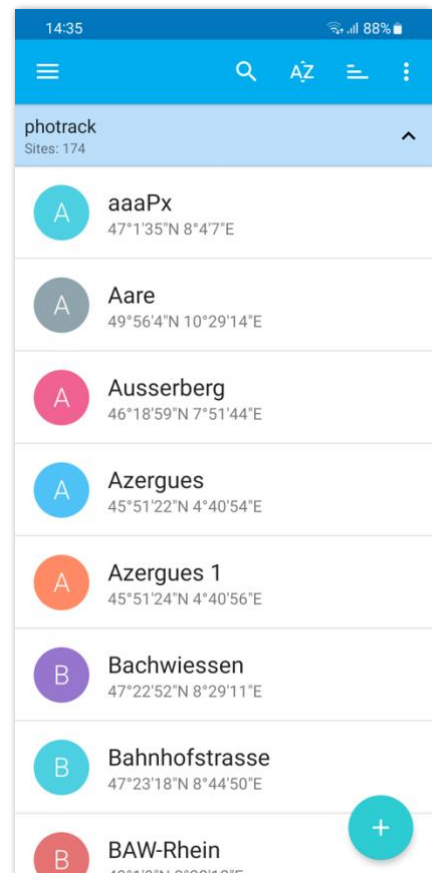
Each time the app is started, the app is synced with the cloud.

IMPORTANT NOTE: To force **synchronization with the cloud**, the screen can be 'pulled' downwards. A spinner appears, indicating that the synchronization process is ongoing.

With a swipe from the left or by clicking the menu icon on the top left the menu appears. The top section is showing in which organization context the user is and it lets the user switch between available organizations.



The menu items allow navigation through the app functionalities. The main item is 'Sites', from which a particular site can be chosen to edit it, find it, or to take a measurement.



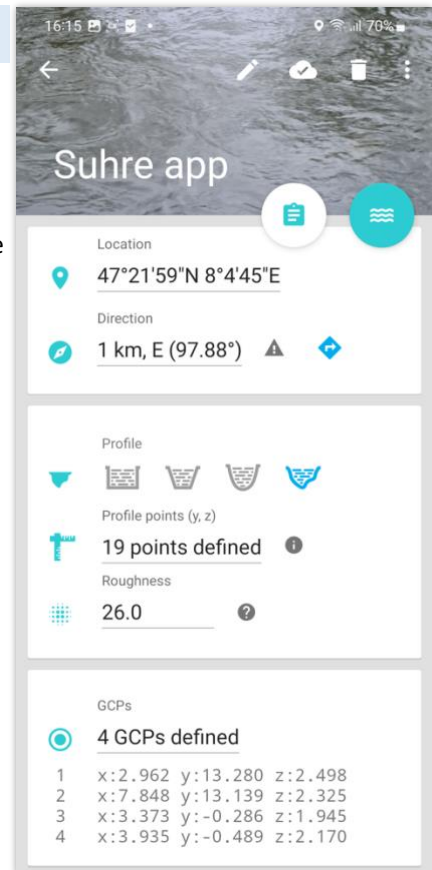
HOW TO MEASURE ON AN EXISTING SITE

RECORDING

By clicking on any particular site, a view opens that contains site specific information and properties, all of which may be edited if the user has respective permissions.

Assuming a site is setup and ready for usage there are two ways to make a measurement via the two icons 'collect' and 'measure'.

The first way will open a view 'collect discharge data'. The user can type in a metric gauge reading and submit it to the cloud by pressing the icon at the bottom of the view.



PROCESSING

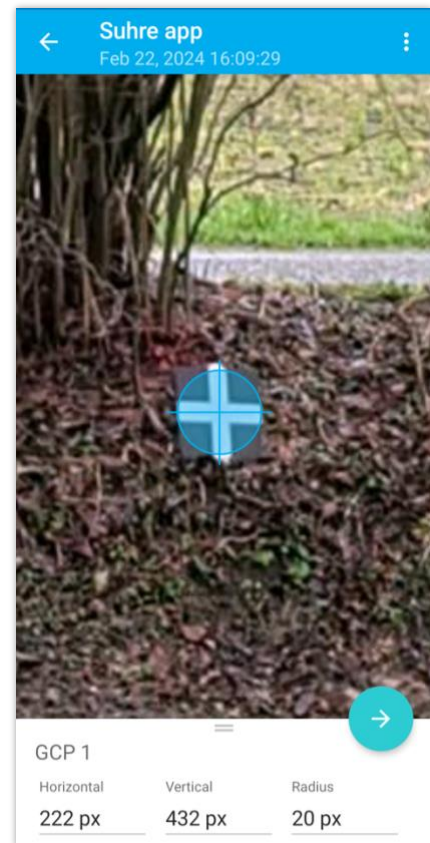
For the measurement, the user must click the 'measure' button on the top right of the screen. This starts the camera preview, and the user should hold the device such that the four reference Ground Control Points (GCPs) are all visible and placed inside the four quadrants of the view.

When the user is satisfied with the view, he presses the camera icon at the bottom of the screen. This will trigger the actual recording that takes about 5 sec. During this time the device needs to be held as steady as possible.



After the video is recorded, the app shows the screen which asks the user to select the location of the GCPs. For each GCP the user needs to move the blue hair cross exactly over the site GCP.

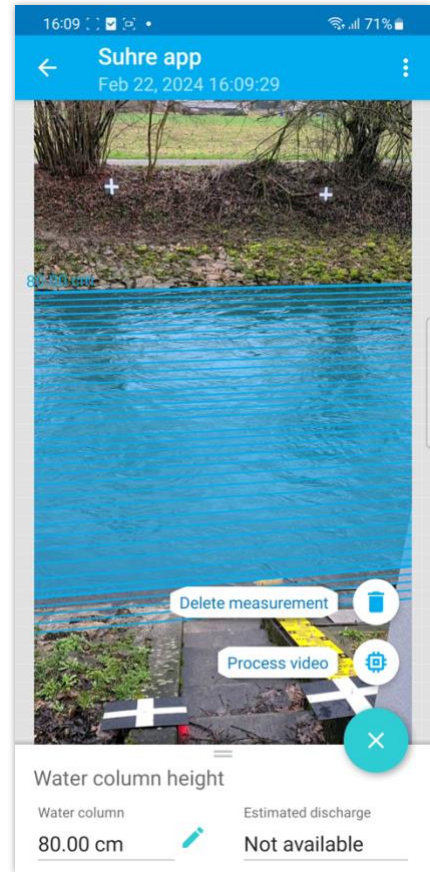
IMPORTANT NOTE: If the user wants to postpone the processing, the app or phone may just be switched off, or another recording may be taken. The user can enter processing at any point in time later, via the main menu 'Measurements'.



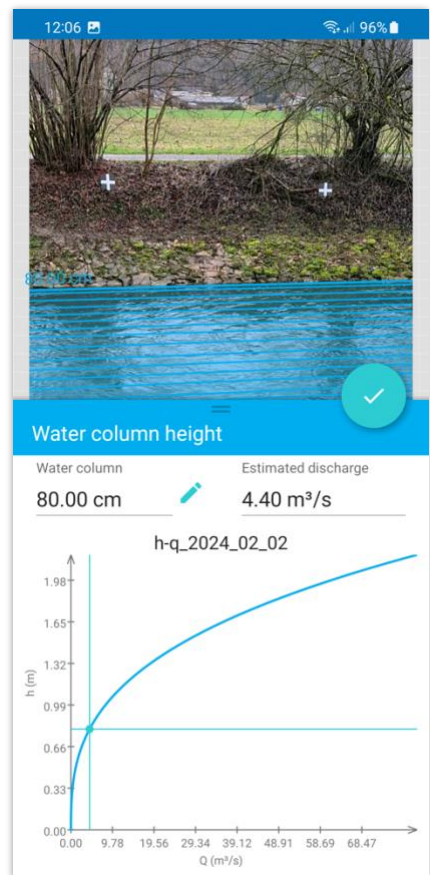
After positioning the four GCPs, a last control view appears and by pressing the checkmark the app will calibrate the view, i.e. it will determine the device position and orientation relative to the site. This will take only an instant and then the menu will move on to the level picking step.



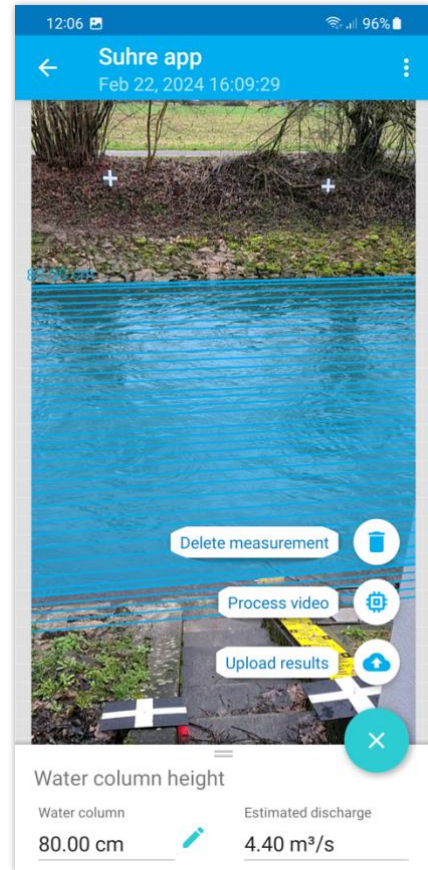
The water level is picked by moving the blue line to the actual water level. Pinching will zoom into the image, making it easier to click the water level accurately. As the user slides the water level up and down, in the lower part of the image the water level in metric units is shown.



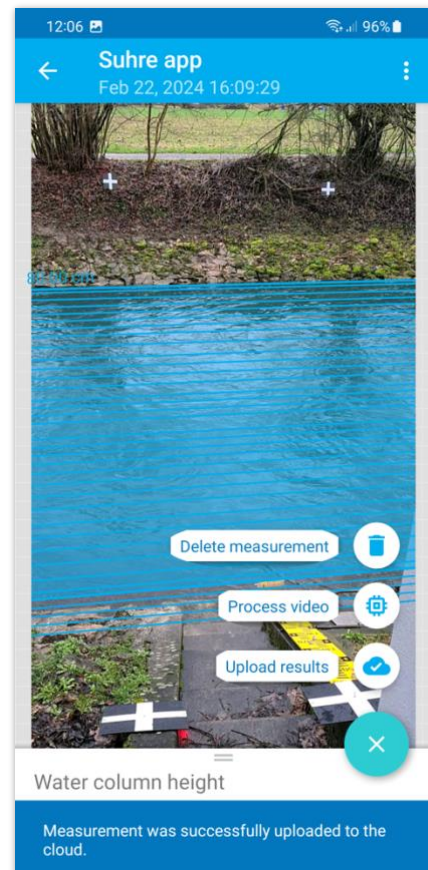
If the site has a calibrated rating curve, the estimated discharge will be shown and adapted directly on the displayed rating curve.



After tapping the check mark, the user has a choice to make. The measurement can be deleted, processed for velocity and discharge, or, if a rating curve is available, the result can be uploaded to the cloud directly, without processing the video for surface velocity.



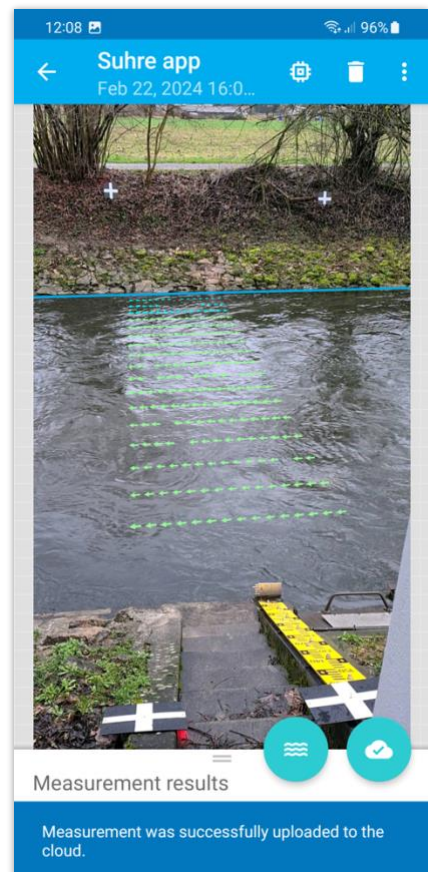
After pressing 'upload results' the app will report that the measurements have been 'successfully uploaded to the cloud'. If successful, the app is receiving a confirmation from the server. Should the upload experience some problem, the measurement will be stored with the pending cases. Those cases can be treated from the menu 'Measurements'.



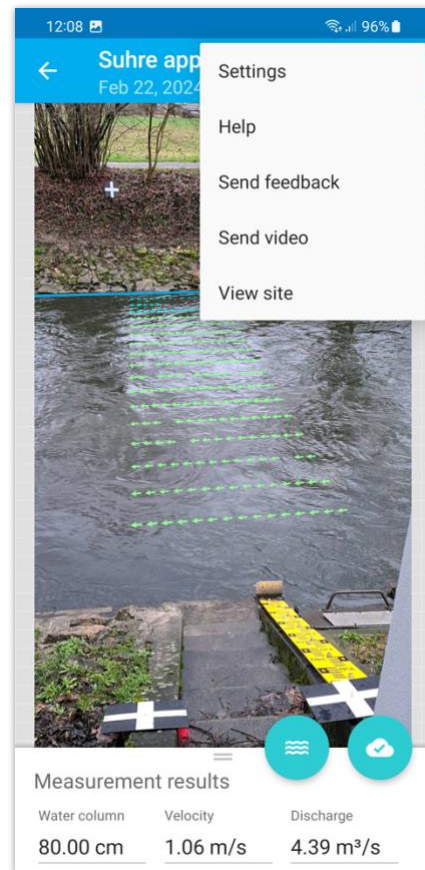
If the button 'process video' is pressed, the app will start calculating the velocity, and successively, the discharge.



After the processing is done, the velocity vectors are rendered, as well as the calculated discharge, velocity, and water column. By clicking the cloud button, the measurement is sent to the web-platform.



If the user wants to reprocess the video later or has questions about the measurement that requires back stopping services of the Discharge team, an option exists to upload the complete measurement (recorded movie) to the Discharge server. This is done via settings, by clicking the button 'Send video'.



CHOOSING A LOCATION FOR A DISCHARGE SITE

The identification of a convenient measurement site along a given river, channel or furrow is of major importance as it determines the measurement accuracy and a smooth setting-up and calibration procedure. To select a channel/river section, please check the following prerequisites:

- ✓ The cross-sectional profile of the stream is constant and well defined (**IMPORTANT NOTE:** Please be aware that for now the app only supports the input of regular channel/river cross sectional profiles, such as rectangular, trapezoidal, and parabolic. So called 'free' cross sectional profiles can be entered only after point measurement processing, which may require support by the Discharge team)
- ✓ At least one side of the river section is easily accessible.
- ✓ There are enough visible structures on the moving water surface, like turbulent patches, waves, leaves, bubbles, etc.

If these prerequisites are fulfilled, continue by looking through the smartphone camera (in portrait mode!) while standing on one side shore of your candidate channel/river section and move around to find an optimal measurement position that fulfills the following requirements:

- ✓ Both shores are visible
- ✓ The waterline on the opposite side can be seen at an angle that is between ~20-70 degrees (measured from the horizontal)
- ✓ It is possible to create/place 4 artificial ground control points or (2 on each shore), which are clearly visible through the phone camera (using spray, paint, concrete etc.)
- ✓ The four GCPs should be approximately in a horizontal plane (**IMPORTANT NOTE:** it is possible to have more general GCP positions, but such positions can only be entered after point measurement processing, which may require support by the Discharge team).
- ✓ The GCPs are visible for all flow situations of interest (e.g.: high-flow, low-flow, flood)

The measurement position is not too far away from the channel/river, i.e., the water surface should expand over at least 1/3 of the image height.

CREATING A NEW SITE

From the sites menu a new site can be added by pressing the + button at the bottom right of the screen. All properties initially have some default values, which may be edited now or later. At any time, the changes may be 'saved' or 'canceled'. After 'SAVE' the local changes can be pushed to the cloud by pressing the icon with the cloud and the upward arrow. A checkmark inside the cloud indicates that the device is synced with the cloud.

IMPORTANT NOTE: The user may at any time proceed editing the site properties by using the web platform.

A site can have a site image, which may be taken by the device camera, or which may be chosen from existing images stored on the device.

Obviously, a site should have a name and a site has a location. Both properties can be edited from the app or from the web platform. If the location service is switched on, by default the GPS position is already filled in and does not require editing.

The site can have standard cross sections or 'free' cross sectional profiles (**IMPORTANT NOTE:** Please be aware that for now the app only supports the input of regular channel/river cross sectional profiles, such as rectangular, trapezoidal, and parabolic. So called 'free' cross sectional profiles can be entered only after point measurement processing, which may require support by the Discharge team). Choose the profile type and fill in its 'width' and 'depth'. Please note that the depth refers to the distance between the channel banks and the bottom of the channel and NOT the depth of water.

The roughness value k_{st} (Strickler value) is important. Very smooth surfaces have high values $k_{st} \sim 50-100$ and very rough surfaces typically range from $k_{st} \sim 25-50$. More information is given on the site info panel, next to the roughness field, clicking the information icon '?', will pop up a table with roughness values.

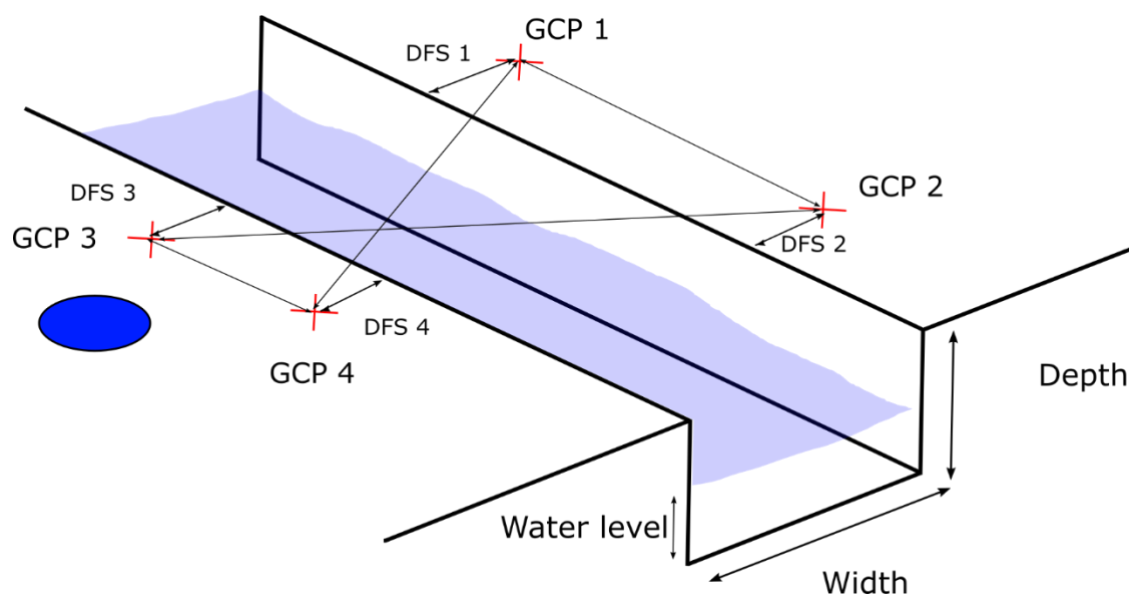
Touching the field 'No GCPs defined' will open the GCP menu, which allows to enter simple measurements of the GCP inter-distances, as well as their distances relative to the cross-section. It is explained in more detail below.

Finally, we have the card 'Discharge video resolution'. It defines the pixel resolution at which the app will attempt to record its videos for the measurements. A good default value is 1080p. More experienced users may try to reduce resolution to 480p. Processing will be much faster, and if the signal is strong enough, the accuracy for the velocity measurement will not suffer.



CROSS SECTION AND GCP CONVENTIONS

All sites need to have 4 GCPs (GCP1-GCP4) and the Discharge convention is that they are placed like shown in the schematic drawing. The four GCPs should be approximately in a plane that is parallel to the water surface (**IMPORTANT NOTE:** it is possible to have more general GCP positions, but such positions can only be entered after point measurement processing, which may require support by the Discharge team).



PLACING GCPs

The GCPs must be inside of the camera view and clearly visible by the smart-phone camera at the chosen resolution. To find a good place for the GCPs, the camera preview screen of the app can be used. This screen is accessed by clicking on the camera icon of the site view. Ideally one person is looking through the camera preview screen while guiding a second person to where the GCPs should be placed.

The requirements for a correct GCP setting are:

- ✓ The GCPs should be in such a way that they are visible on the screen of the smartphone. Ideally, they should be on the outer corners of your view window but still visible after small movements of the camera.
- ✓ Make sure the GCPs do not move.
- ✓ The GCPs should be permanent and distinguishable from the surroundings in different light conditions (sun/clouds).
- ✓ Make sure the highest possible water level does not flood the GCPs.



IMPORTANT NOTE: Involve communities and stakeholders to make sure they know the purpose of these GCPs.

COLOR AND MATERIAL FOR GCPS:

Very often it is a good solution to spray or paint the GCPs onto the wall or rocks of the channel/furrow. If there is only earth the GCPs can be buried rocks, (cemented) poles. Alternatively, if trees are next to the channel/furrow, iron sheets can be mounted (nailed) onto the tree trunks. For colors a good choice is some dark (black) background and some bright (white) clear feature, like a cross or a circle. The diameter of the features can range from 5cm (if GCPs are at small distances of 2m from the smartphone) to 50cm for distances up to 20m.

SET UP A REGULAR SITE: MEASURE INTER GCP DISTANCES AND POSITIONS

Once the GCPs have been placed, they need to be measured in. For the standard cross-sections 'rectangular', 'trapezoidal', and 'parabolic' the measurements can be entered directly via app (**IMPORTANT NOTE:** we repeat also here that it is possible to have more general GCP positions, but such positions can only be entered after point measurement processing, which may require support by the Discharge team).

The 'measuring in' involves measuring four distances *between* the GCPs and 4 distances of the GCPs *relative* to the cross-sectional profile. Please read, understand, and follow the conventions described above before following these simple steps guideline:

- ✓ The length unit is meter
- ✓ Measure the distances between the GCPs on each shore, 1-2, 3-4.
- ✓ Measure the diagonals between the GCPs 1-4 and 2-3.
- ✓ In the fields DFS 1,2,3,4 please fill in the respective distances from the GCPs to the channel, as indicated in the above sketch. Note that all values need to be positive.

IMPORTANT NOTE: Save the site after you press 'SET' and publish the site by pressing the icon with the cloud and the upwards arrow.

13:43 76%

CANCEL SAVE

Name

New Site

Location

Distance between GCPs ?

GCPs 1 - 2: GCPs 3 - 4:

Dist. [m]: 1.0 Dist. [m]: 1.0

GCPs 1 - 4: GCPs 2 - 3:

Dist. [m]: 1.414 Dist. [m]: 1.414

Distance from shore

DFS1 [m]: 0.0 DFS2 [m]: 0.0

DFS3 [m]: 0.0 DFS4 [m]: 0.0

CANCEL SET

Discharge video resolution

1080p

Parameters



SET UP AN IRREGULAR SITE: MEASURE INTER GCP DISTANCES AND POSITIONS

When the different conditions required for regular sites are not met (GCPs not in same plane, large width, irregular cross-section) it is necessary to set up irregular sites.

Here any tool allowing to perform a survey of points with an accuracy of 1 cm can be used. However, we strongly recommend the use of the Leica Disto S 910 or the follow-up device, which is a laser distance-meter allowing to measure distances and angles at cm precision. Additionally, along every measurement performed with the Disto comes a proof image, which allows to check that the measurement went well. Among several systems tested, this product seems to be an interesting solution producing decent results at a correct price, but any other system can be used.



What is important is that the system chosen allows to produce data in a right-handed Cartesian coordinate system (see figure below). The x-axis of this coordinate system should be aligned with the direction of the flow. As a convention, the x-axis should always go from left to right from the perspective of the user. This being, said, it is possible to proceed with the survey, namely:

- of 2 points on the shoreline on the far shore that define the x-axis
- of the position of the 4 GCPs
- of the position of points along the cross-section
- of 3 points along the shoreline on the far shore (this step is optional)

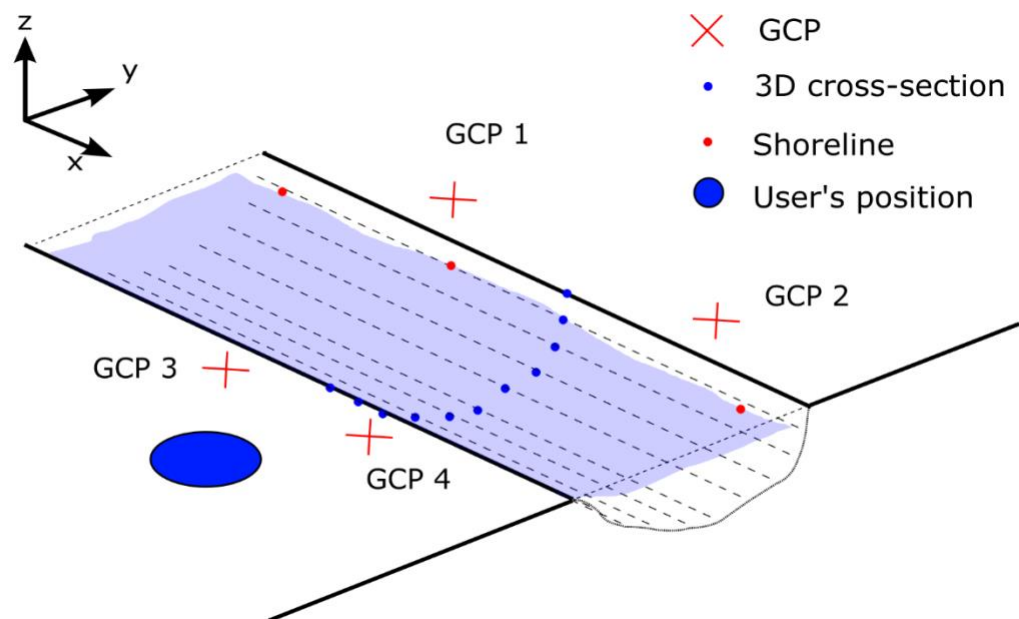
Again, similarly to the setup of regular sites, before deciding where to install the GCPs, it can be convenient to use the DischargeApp from a realistic user position to ensure that all GCPs fit well within the field of view of the camera.

Measuring the cross-section is also necessary. Thereby, the distance between the points of the cross-section needs to allow to capture the shape of the cross-section. If possible, the cross-section should be measured between the GCPs, as shown in the sketch below. During the cross-section measurement, it is good practice to remember the deepest point measured, as it will correspond to the water column. Finally, three points along the shoreline of the opposite shore can additionally be measured as well. Note that it may be necessary to use

a pole to perform the cross-section measurements (see images below). If the measurements are performed with the Disto S910, please note that the first point will be the origin of the Cartesian coordinate system and that the direction of the x-axis will be defined by the vector formed by the first two points. The Disto only allows to measure 30 points. This should be remembered during the surveying of the cross-section.



Disto proof images of a measurement performed for a GCP and during the measurement of the cross-section.



Data necessary for the setup of sites with irregular cross-section, namely the position of the Ground Control Points, points along the cross-section and optionally the position of three points along the shoreline on the far shore.

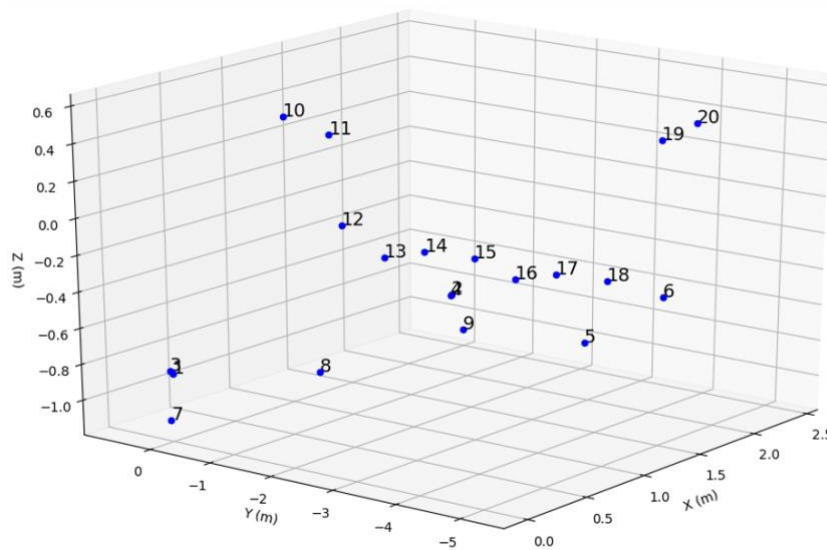


Image of a channel (top) where Disto measurements (bottom) were performed.

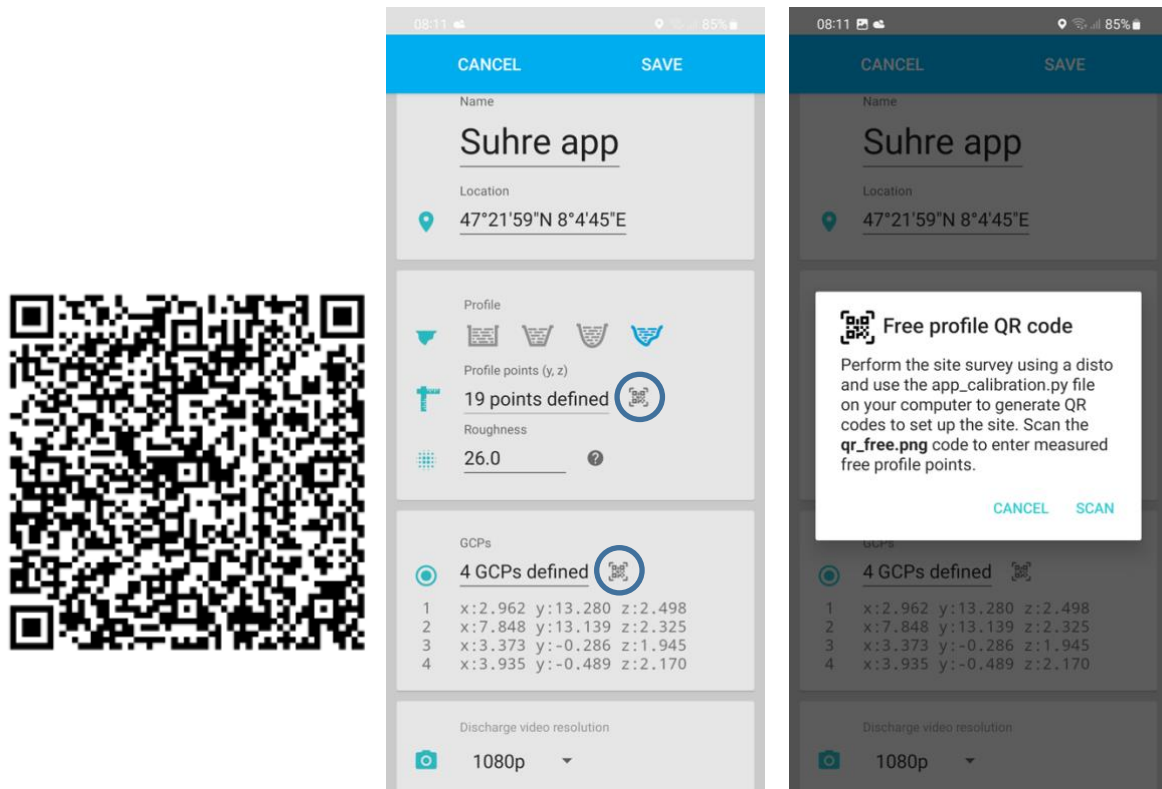
The figure above shows a location where the Disto was used to set up an irregular site. The GCPs were marked with paint on different stones on the shores. The points measured with the Disto are shown on the last panel of the figure above. Note how points forming the cross-sections have an offset corresponding to the length of the 1 m long pole used to perform the survey of the cross-section.

In order to visualize the data measured with the Disto, it is necessary to extract them from the “.dxf” file in which they are stored. For this, connect the Disto to a PC, access the local storage and retrieve the folder containing the “3D_xxx.dxf” file. Copy this file to your working folder.

There are two workflows for processing the point data, depending on whether the GCP points and cross-section points are part of the same measurement. Both workflows are implemented in a jupyter notebook which guides the user step by step through the processing sequence. The jupyter notebooks can be downloaded from the website discharge.ch together with the calibration python-scripts and the README.pdf document that explains how to open the jupyter notebooks. For the case that the GCP points and the cross-section points are in the same disto-file, use the jupyter notebook named “DApp_free_site_1_point_set.ipynb”. If the cross-section points are part of a separate disto measurement, or

provided as a separate .txt file use the jupyter notebook named “DApp_free_site_2_point_sets.ipynb”. In the jupyter you can enter the point nr. of the GCP and cross-section points and if used the length of the offset pole. If the GCPs and cross-section points are not in the same measurement you can select the option of how the two point sets are combined. The jupyter then creates two QR codes and the files “GCPs.txt” and “cross_section_2D.txt” that contain the data required to set up a new site with irregular cross-section.

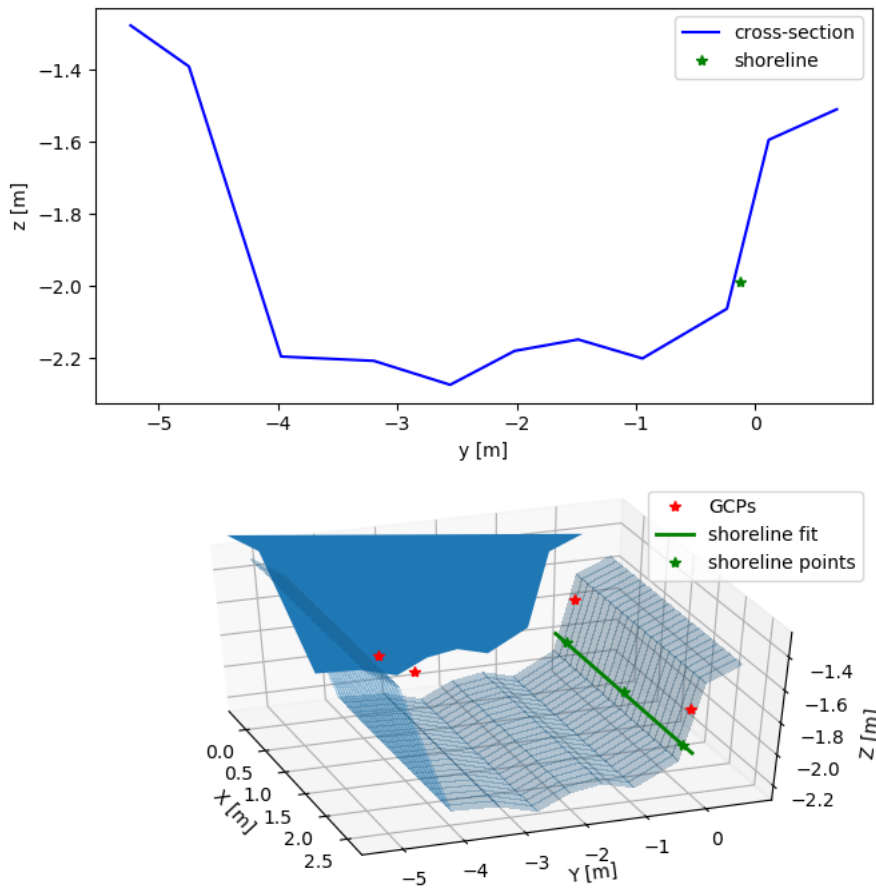
Both QR codes can be used to provide the GCPs and cross-section data to set up sites with the DischargeApp. The QR codes can be scanned within the App directly on the computer screen (see figure below).



QR code (left), QR code scanning buttons (center) and QR code scanning mode (right).

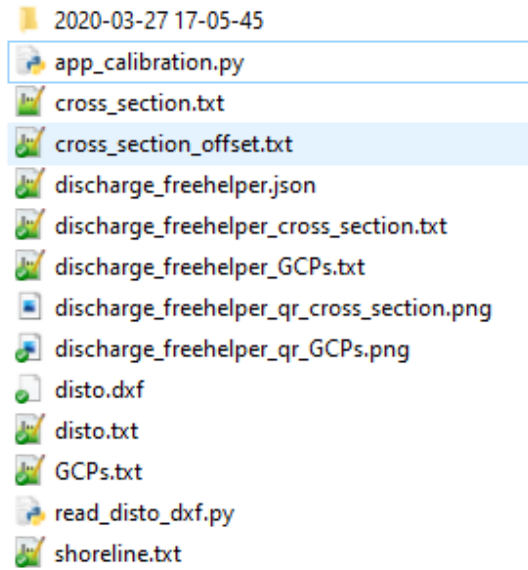
The former workflow for processing the disto data still works but is only recommended if there are problems with the jupyter notebook workflow. For this, rename the “3D_xxx.dxf” file to “disto.dxf” and copy it to your working folder. Then execute the “read_disto_dxf.py” python file available for download on <https://discharge.ch/documentation.html> which will store the coordinates under a “disto.txt” file.

In the “disto.txt” file, you need to extract the coordinates of the points forming the GCPs, the cross-section and the shoreline and paste them on new files saved under “GCPs.txt”, “cross_section.txt”, “shoreline.txt”. If the cross-section was measured with a pole, create a new “offset.txt” file, enter the length of the offset and save the file. Also write the water column recorded during the measurement to a file named “watercolumn.txt”.



2D (top) and 3D view of the cross-section measured.

Then execute the “app_calibration.py” file (also available under <https://discharge.ch/documentation.html>), which will read the data in, plot it and generate QR codes. Once this code is executed, the results will be plotted. The QR codes will be generated while closing the figure. Finally, the working folder should contain all the files shown in the figure below. The QR codes or the files can then be used to set up a new site with an irregular cross-section either within the app or on the website discharge.ch.



Files that should be contained in the working folder at the end of the data processing.

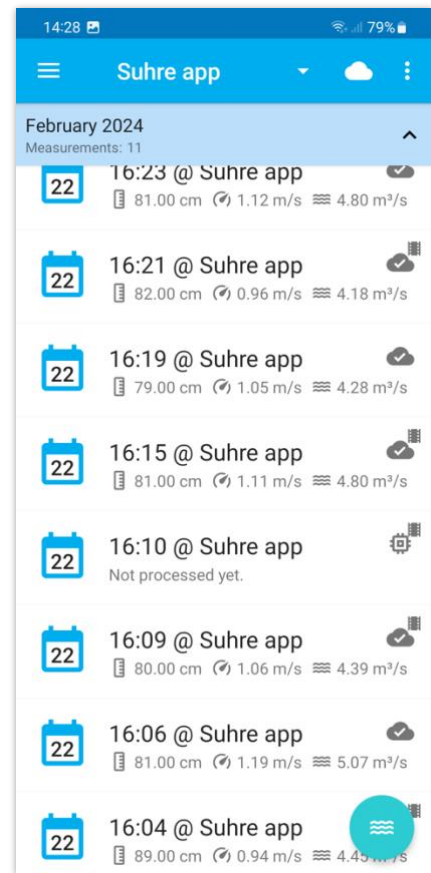
Note that the setup of both regular and irregular sites is not a difficult, but a quite cumbersome task and work under field conditions does not ease things. Therefore, some exercise under controlled conditions (e.g. in the office) could help familiarize with the workflow and the material. We therefore recommend getting some practice before going to the field, see <https://discharge.ch/documentation.html> for ideas.

MEASUREMENTS MENU

A user may wish to examine the results of a processed video. From the 'Measurements' menu all available measurements are shown by their time stamp. Clicking on a time stamp will open a screen showing the status of the selected measurement. If it has not yet been processed the user can click the 'process' icon (bottom right) and continue. If the measurement has already been processed a proof image is opened. The proof image is showing the determined velocity field and the obtained values for water level, velocity, and discharge.

If everything is looking fine, there is obviously no need for action. If something looks wrong, there are several options.

If the organization of the site is run in a mode that validates measurements, the user has the option to edit (reprocess, delete) the measurement until the measurement has been validated by an organization manager, i.e., by a user with the permission to validate measurements. The validation process is done on the Discharge web platform.



SETTINGS MENU

SETTINGS

Under settings, a user can modify the way data is transmitted to the Discharge server, i.e., 'to the cloud'. By default, data may always be transmitted if the device is connected to a Wi-Fi network. In addition, the app may communicate with the cloud over mobile data connection (set as default) or at least the measurement values may be transmitted to the cloud via SMS connection (provided that the site organization is operating in a suitable plan).

HELP & FEEDBACK

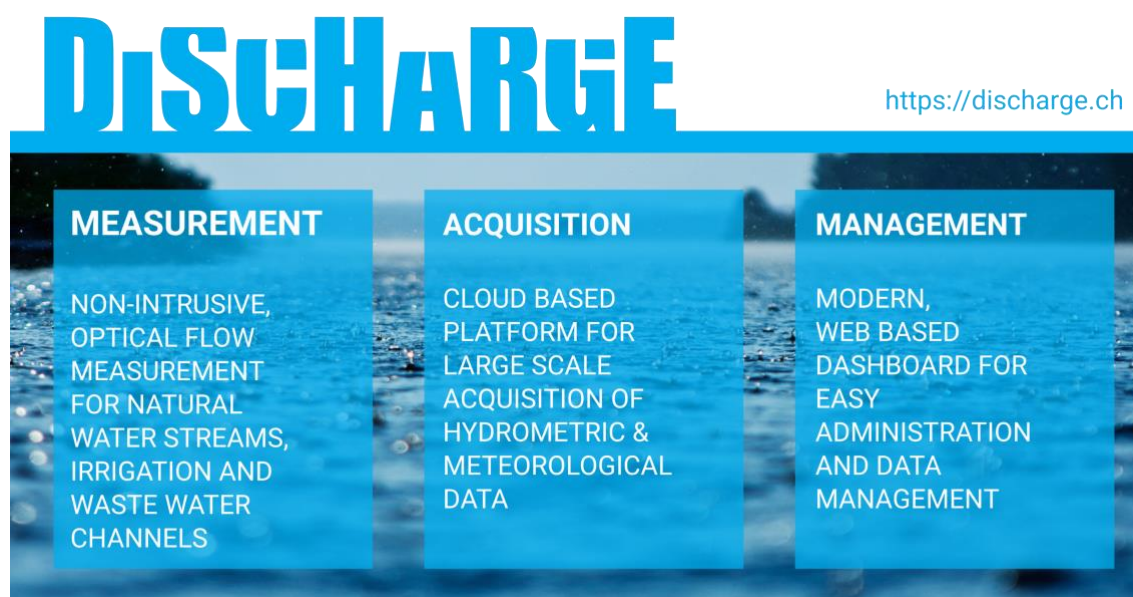
Clicking help is directing the user to a pdf download for this user manual.

Through the 'Send feedback' function, users can communicate directly with a person from the Discharge team. Via the displayed email address (discharge@photrack.ch) text messages as well as supporting images, e.g. screenshots can be sent and the Discharge team will respond and deal with any issues as fast as possible.

WEB PLATFORM DISCHARGE.CH

The Discharge web platform is the natural counterpart of the Discharge app, it completes the Discharge system. Its purpose is to manage organizations and the sites and users that are associated with the organizations. While some operations can be performed conveniently from either the app or from the web platform, typically the web platform offers more functionality.

The web platform is designed for intuitive usage. The purpose of this section is to elaborate some underlying principles and to point out some convenient features that can only be controlled through the web platform.



SIGN IN

For the sign-in the same account credentials are valid as for the mobile app. Vice versa; an account can be created on the web platform and is valid for the mobile app.

MANAGING ORGANIZATIONS AND USERS

ORGANIZATION

It is important to realize that organizations are pivotal to the Discharge system; they comprise the backbone of the Discharge structure. Discharge organizations give home to Discharge sites and to Discharge users. Organizations can have any level of sub-organizations. Like in any other organization, also in Discharge organizations users play different roles. Some manage, some perform measurements. More particular, in Discharge a user can view, manage, create and export stuff. The user roles, and thus the structuring of any organization, are defined through a small set of permissions. Note that a user generally has different permissions for different organizations. Finally, also the different payment plans are referenced to the root of each organization structure, i.e. to the organization that does not have a parent organization.

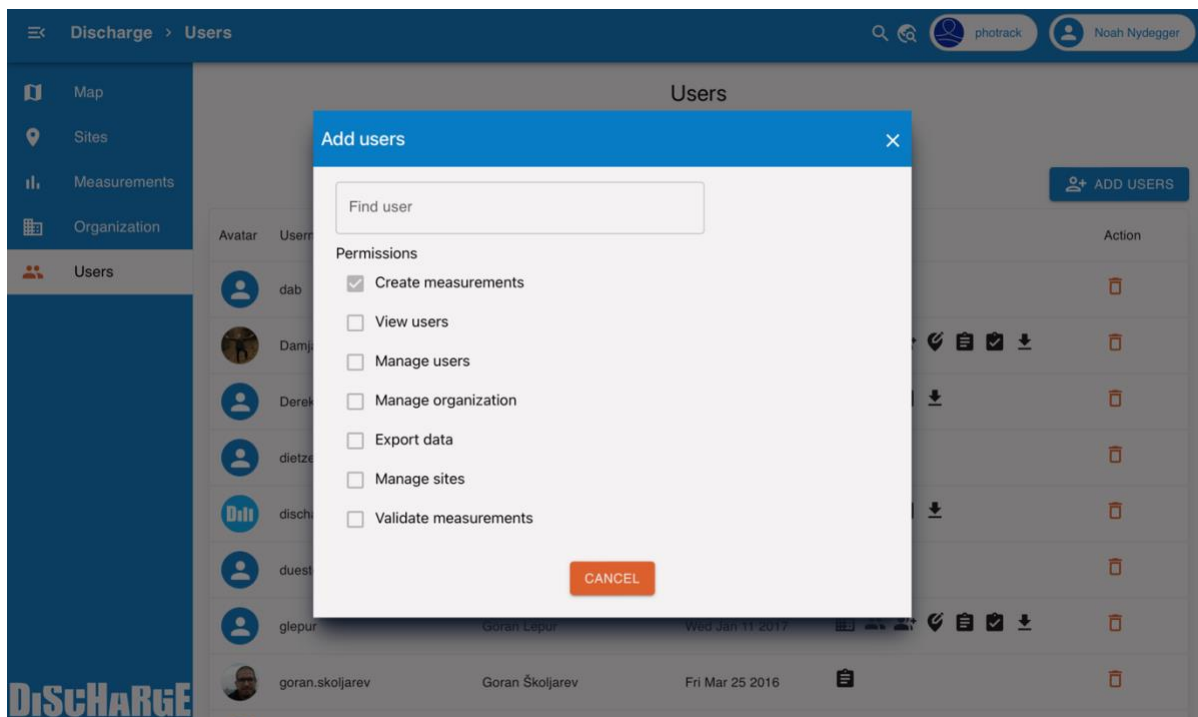
Upon login, the user is in the context of the organization he was in before logging out the last time. A first-time user will be casted into the organization 'Welcome'. At the top left of the screen the current organization is

indicated, and it may be changed by clicking onto the 'organization switcher'. The listed items show all organizations the user belongs to.

The creation of a new organization is facilitated through the + (Create organization) wizard. The important thing to realize is that the new organizations can either become a root organization, i.e. without a parent, or it can become a sub-organization of the currently selected organization.

USERS

Users are members of one or several organizations. A user can take measurements at all sites of the organizations he is member of. The only way to become a member of an organization is 'by invitation', i.e., an existing member with the permission to 'manage users' (a user manager) can invite, well actually 'add' new members, the invitation cannot be declined. Adding a user to an organization is done via the + icon (the top right of the user card). By default, the new user cannot do much besides 'create measurements'. The user manager can edit these permissions at any time. For example, if you want somebody to help you with management tasks, you need to make sure you give this new user the necessary permissions. To modify permissions later the manager needs to hover over the user field, and a 'lock' icon appears. Clicking the 'lock' icon will open again the permission menu. Clicking the entire user field will open a card where various user properties can be edited. Finally, there is a trash-icon, which allows removing a user from the current organization.



MANAGING SITES

MAP

The map view is the default starting view and the platform remembers the organization the user was switched into before the last logout. The map is showing balloons which indicate site locations. Clicking on them causes a popup that shows the name and location. And the site can be accessed by clicking on 'view site'. The option at the bottom right of the view, above the +/- zoom buttons allows to group and ungroup sites that are close together.

SITE INFOS

The site card has three views (info, measurements, rating curve) and opens showing the view 'info', which contains all the site properties. If the user has the permission to 'manage sites', a pencil is shown that allows to enter the editing mode. In the editing mode all properties can be clicked and modified in an intuitive way.

IMPORTANT NOTE: It is here where the necessary entries for 'free' cross sectional profiles can be edited.

SITE MEASUREMENTS

This view is accessed by clicking on 'view measurements' on the site info view. The user can choose the time period, the aggregation (all measurements, hourly, daily) and add filters for the measurements that are displayed. The table at the bottom of the page shows the selected data and allows the user to check measurements and proof images. The measurements can be exported to multiple data formats and a timelapse movie of the proof images can be created.

RATING CURVES

This view is also accessed by clicking on 'view measurements' on the site info view and then selecting the view 'Rating Curve' instead of 'Measurements'.

When already several measurements exist for different water levels, it is possible to fit a rating curve (discharge – water height relation) to the data. To do so click the '+ Add'-icon below the chart.



Fitting of rating curves can be done manually by adjusting the parameters of the curve type (automatic fitting is planned for a future release).

IMPORTANT NOTE: The primary rating curve is synced to the app. This means that with a defined rating curve the app can be used to 'only' measure the water level and determine the discharge via the rating curve. This feature is particularly useful for situations with low water levels where the measuring of the surface velocity can become problematic.