Early Warning System Concept and Technical Description

Deliverable 1.3.2 – SMART MOVE

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Produced in the Framework of the
SMART-MOVE Project

Management of Highly Variable Water Resources in semi-arid Regions - Israel (ISR), Jordanien (JOR), Palästinensische Gebiete (PSE); Teilprojekt 5: Geodateninfrastruktur zum nachhaltigen Datenmanagement

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Change Log

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0.5	06/2016	Initial creation of the Document	Vanessa Rojas
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1.1	03/2019	Adding Disclaimer	Dr. David Riepl

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0 Disclaimer

This report represents the project deliverable **D1.3.2** of the SMART-Move Project and should be understood in the context of the full activity of the Workpackage **1.3: Data Management.**

Since the relevant scope, and thus the necessary tasks, changed in parts during the project phase the following table gives an overview of the activities and results this Workpackage:

Tab. 0: Planned and conducted activities and results in Workpackage 1.3: Data Management.

Activity	Planned	Conducted	Results
1.3.1	Requirement Analyses of Data Management and Data Model	Requirement Analyses of Data Management, Integration of Data	D1.3.1: **This report:** Requirement Analyses of Data Management, Integration of Data
1.3.2	Design and implementation of Data Import Interface for large data sets and telemetric sensors of climate and water quality stations	Design and development of ETL-processes to retrieve and load telemetric Sensor data of SEBA and PESSL Stations into a centralized Data Repository. Design and implementation of business logic of the Spring water early warning system	D1.3.2: **This Report:** Early Warning System Concept and Technical Description **Software:** EWS-Prototype with focus on backend functionality (ETL and Database)
1.3.3	Design and Realization of an online dataportal and geodata warehouse for measurement data search and export (WEAP). Documentation.	Realization of an online portal with integration of data layers from previous projects. Full realization of Production-Ready EWS with Technical adaption iterations during 1-year testing phase of the EWS at Wadi Shueib springs.	D1.3.3: **Software:** Full realization of Production-Ready EWS Online information portal for project partners.
1.3.4	Capacity Development for transboundary Data Management in the region; Documentation; Training Material;	Adaption of the EWS for Cluster West springs (Auja) Official Inauguration of EWS in Wadi Shueib Jordan EWS Technical Training Workshop with Employees of the WAJ in Jordan	D1.3.4: **Report:** Early Warning System Installation Guide

1 Preface

This document describes the technical concepts and configuration of the system components of the Early Warning System (EWS) for the spring contamination.

The EWS was developed for the SMART-MOVE Project and is inspired by an estimate of contamination risk in karstic spring water sources. The estimate is based on an empirical correlation of continuously & automatically measurable observation parameters. The goals of the EWS are:

- Fast & reliable integration of monitoring data from variable sources
- Live calculation of contamination risk from input measurement data
- Push information on contamination risk to relevant decision makers
- Provide stakeholders with easy access to all relevant data for analyses
- Build system by mature & robust system components

2 System architecture

The measurement data of the monitoring stations are transferred online to a data-base, where automated combined signal analyses are performed. A database algorithm calculates continuously the risk potential in near real time and warns about a possible contamination of the spring water. The system sends a warning via email in case of a large rain event combined with increased turbidity or electrical conductivity in a specific time sequence at a spring. Thus, affected drinking water suppliers can be informed about a high microbial contamination risk.

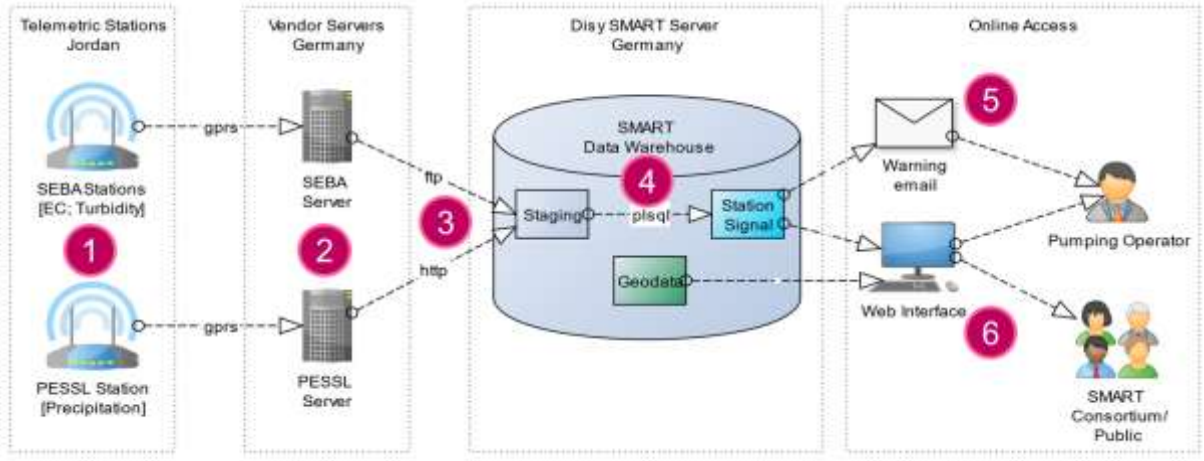

Figure 1 Functional components of the EWS

Figure 1 describes the functional components of the EWS:

1) Observation data is acquired at different stations (Rainfall & Hydro)
2) Stations send data to vendor-specific measurement Databases
3) Measurement data is integrated every 15min in SMART database (near real time)
4) New measurement data triggers updates of “Warning Levels” by EWS-algorithms
5) Changes of “Warning Level” trigger email-notifications to defined recipients
6) All available information can be accessed via a web interface

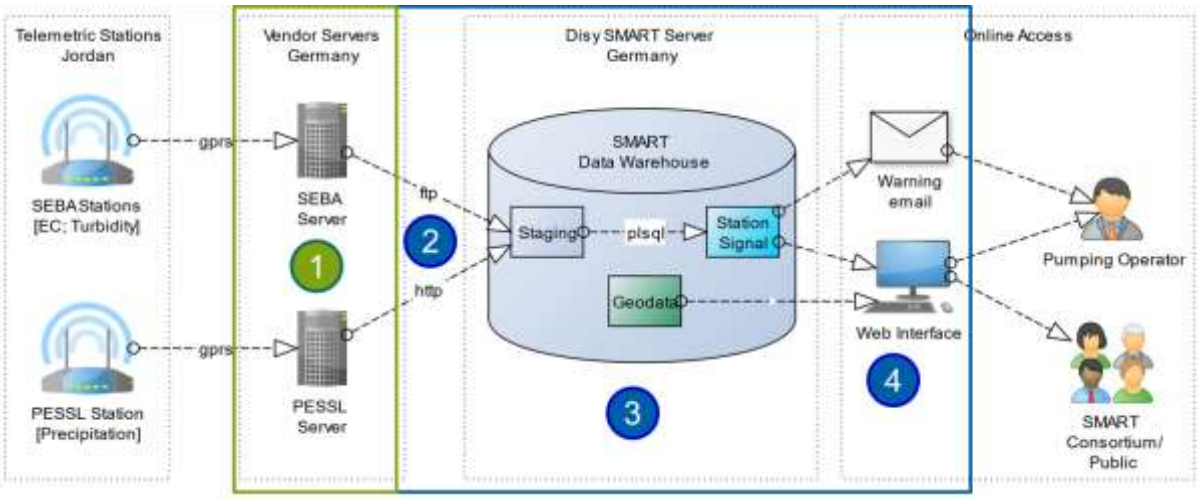

Figure 2 Technical components of the EWS

Figure 2 describes the technical components of the EWS:

7) Vendor-specific measurement databases (out-of-the-box). Data is transmitted telemtrically. These databases are not within the scope of this document.
    a. SEBA measures physiochemical parameters of spring monitoring stations and provides data in 15min-intervals as csv-files on an FTP-Server.
    b. PESSL measures precipitations and provides data on an http-URL-interface in a JSON format.
8) Measurement data import interfaces (java based). The data is
9) SMART database & EWS-procedures (Oracle DB)
10) Web interface (Disy Cadenza)

There are two general scenarios triggering a warning signal.

11) Combination of rainfall amount and turbidity
12) Combination of rainfall amount and electrical conductivity

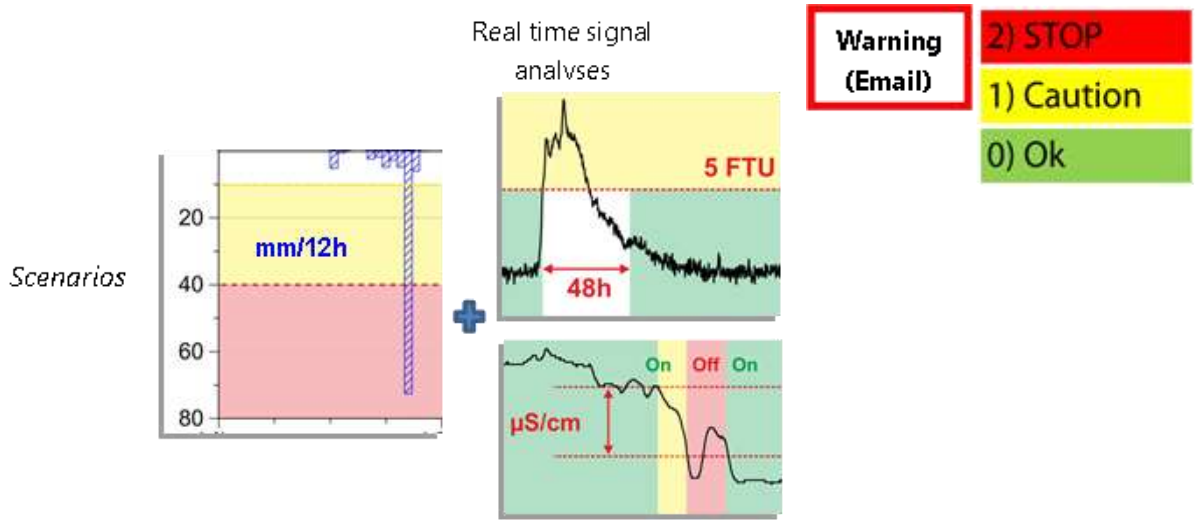

Figure 3: Two different scenarios can trigger a warning signal, whereby Rainfall is the hierarchical top parameter

3 Data Model

The EWS database consists of different objects whose properties and relationships can be represented in the Entity-Relation-Model (Fig. 4).

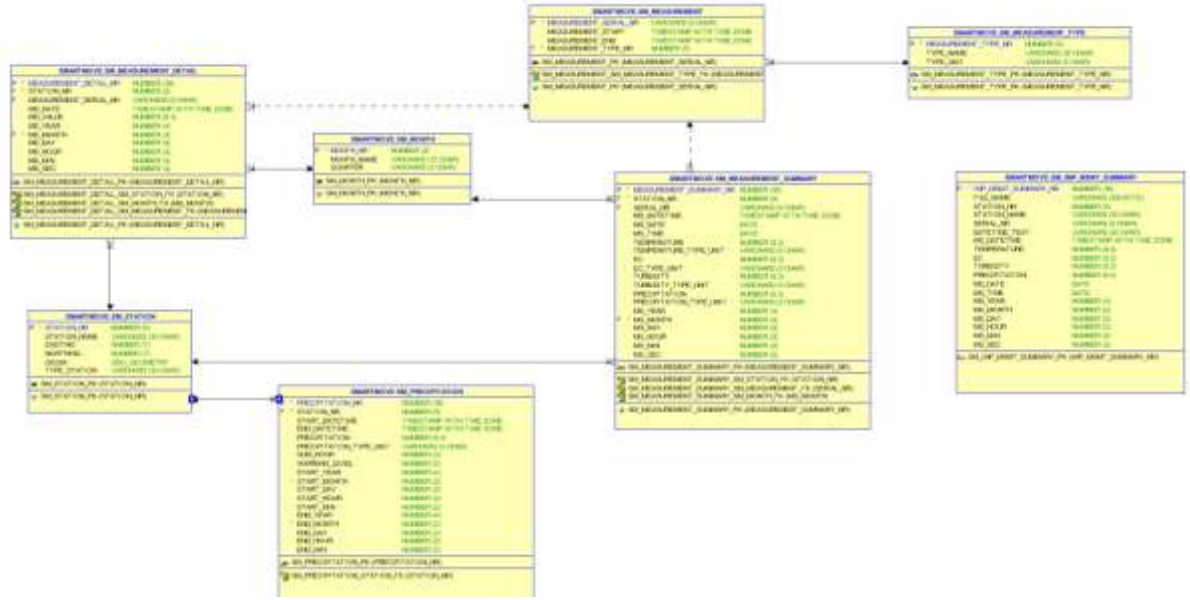

Figure 4: Entity-Relationship-Model

The **domain table** *Station* (SM_STATION) stores general information about the climate and spring monitoring stations, including name, description, location, and other relevant information. This table would store also information of limit values such as the precipitation limit for the warning levels.

Station_ nr	Station	Data Origin		Temperature	Precipitation (Niederschlag)	Turbidity (Truebung)	EC
4	Fuhais (Climate station)	PESSL Instruments JSON		Avg, min, max [°C] (hourly)	Precipitation [mm/h] (hourly)		
2	As-Salt (Climate Station) (Hazzir before)	PESSL Instruments JSON		Avg, min, max [°C] (hourly)	Precipitation [mm/h] (hourly)		
6	Hazzir (UCL10982) SENSOR_NR= 2	SEBA Hydrocenter ftp: csv	UCL10982*.csv 01_conductivity [mS/cm] UCL10982_1 02_turbidity [NTU] XX 03_water level [m] UCL10982_3 01 water temperature [°C] 02 conductivity 03 water level [m] 32 power [V]	°C (every 15min)	X	X	mS/cm (every 15min)
1	Baqquoria (UCL10981) SENSOR_NR= 1	SEBA Hydrocenter ftp: csv	UCL10981*.csv 01_conductivity [mS/cm] UCL10981_1 02_turbidity [NTU] UCL10981_2	°C (every 15min)	X	NTU	mS/cm (every 15min)

			03_water level [m] UCL10981_3 01 water temperature [°C] 02 conductivity [mS/cm] 03 water level [m] 07 pH [pH] 08 ammonium [mg/l] 09 turbidity [NTU] 32 power [V]				
3	Shoreia (UCL06320) SENSOR_NR=3	SEBA Hydrocenter ftp: csv	UCL06320*.csv -> Station Shoreia 01_conductivity [mS/cm] UCL06320_1 02_turbidity [NTU] UCL06320_2 03_water level [m] UCL06320_3 01 water temperature [°C] 02 conductivity [mS/cm] 03 water level [m] 08 Oxygen content [mg/l] 10 turbidity [NTU] 32 power [V]	X	X	NTU Measurements are incorrect	mS/cm (every 15min)
4	Sultan UCL10851 SENSOR_NR=4						

Figure 5: SM Station Table

The **domain table** *Month* (SM_MONTH) stores the number and description of the months.

MONTH_NR	MONTH_NAME	QUARTER
1	January	Q1
2	February	Q1
3	March	Q1
4	April	Q2
5	May	Q2
6	June	Q2
7	July	Q3
8	August	Q3
9	September	Q3
10	October	Q4
11	November	Q4
12	December	Q4

Figure 6: Screenshot of the domain table *Month*

Additionally, there are intermediate tables, called **Staging Tables**, where the raw data is loaded. The table *Import Measurement Summary* (SM_IMP_MSMT_SUMMARY) stores the measurements as they come from the text or excel files. The information stored in this table includes file name, station, timestamp of the measurement and the measured values for temperature, EC, turbidity or precipitation, depending on the type of station.

3.1.1 Signal for climate station - SM_RAIN_SIGNAL

Active column determines if the signal is enabled. This configuration is taken in the procedure rain_run_signal that is called from the cronjob configured in the database server.

Rain Signal NR RAIN_SIGNAL_ NR	Signal Name RAIN_SIGNAL_ NAME	Station Precipitation STTION_NR_ RAIN	Measurement Type MEASURENT_TYPE _NR_RAIN	Rain Yellow	Rain Red	Rain hour	Active
1	As-Salt	As-Salt (2)	Precipitation (1)	10	40	12	1
2	Fuhais	Fuhais (4)	Precipitation (1)	10	40	12	1

Figure 7: Signal for Climate Station

.	FILE_NAME	...	STAT...	SERIAL_NR	...	MS_DATETIME	TEMPE...	EC	TURBIDITY
25	T4L01116_Hazzir.xlsx	2	Hazzir	T4L01116	(...	14-NOV-13 12.35.00.000000000 PM...	19.176	1012	(null)
26	T4L01116_Hazzir.xlsx	2	Hazzir	T4L01116	(...	14-NOV-13 12.50.00.000000000 PM...	19.179	1011	(null)
27	T4L01116_Hazzir.xlsx	2	Hazzir	T4L01116	(...	14-NOV-13 01.05.00.000000000 PM...	19.196	1009	(null)
28	T4L01116_Hazzir.xlsx	2	Hazzir	T4L01116	(...	14-NOV-13 01.20.00.000000000 PM...	19.256	1006	(null)
29	T4L01116_Hazzir.xlsx	2	Hazzir	T4L01116	(...	14-NOV-13 01.35.00.000000000 PM...	19.4	1001	(null)
30	T4L01116_Hazzir.xlsx	2	Hazzir	T4L01116	(...	14-NOV-13 01.50.00.000000000 PM...	19.413	998	(null)
31	T4L01116_Hazzir.xlsx	2	Hazzir	T4L01116	(...	14-NOV-13 02.05.00.000000000 PM...	19.269	1004	(null)
32	T4L01116_Hazzir.xlsx	2	Hazzir	T4L01116	(...	14-NOV-13 02.20.00.000000000 PM...	19.229	1004	(null)
33	T4L01116_Hazzir.xlsx	2	Hazzir	T4L01116	(...	14-NOV-13 02.35.00.000000000 PM...	19.276	993	(null)
34	T4L01116_Hazzir.xlsx	2	Hazzir	T4L01116	(...	14-NOV-13 02.50.00.000000000 PM...	19.236	998	(null)
35	T4L01116_Hazzir.xlsx	2	Hazzir	T4L01116	(...	14-NOV-13 03.05.00.000000000 PM...	19.229	999	(null)
36	T4L01116_Hazzir.xlsx	2	Hazzir	T4L01116	(...	14-NOV-13 03.20.00.000000000 PM...	19.226	1000	(null)

Figure 8: Screenshot of the staging table Import Measurement Summary

In the **Attribute Table** *Measurement Summary* (SM_MEASUREMENT_SUMMARY) the processed information are stored, coming from the measurement staging table. The table includes additional information such as IDs (station number, month number), year, units and other relevant information to be used in the diagrams.

ME...	STATION_NR	SERIAL_NR	MS_DATETIME	MS_DATE		TEMPERATURE	T...	EC	EC_T...	TURBIDITY	TU
322	2	T4L01116	14-NOV-13 12.35....	14-NOV-13	..	19.176	°C	1012	mS/cm	(null)	FTU
323	2	T4L01116	14-NOV-13 12.50....	14-NOV-13	..	19.179	°C	1011	mS/cm	(null)	FTU
327	2	T4L01116	14-NOV-13 01.50....	14-NOV-13	..	19.413	°C	998	mS/cm	(null)	FTU
325	2	T4L01116	14-NOV-13 01.20....	14-NOV-13	..	19.256	°C	1006	mS/cm	(null)	FTU

Figure 9: Screenshot of the attribute table Measurement Summary

In the Attribute Table *Accumulated Precipitation* (SM_PRECIPITATION) the information of the accumulated precipitation per station is stored. It also stores information of the warning levels according to the accumulated precipitation.

STATION_NR	START_DATETIME		END_DATE...		SUM_PRECIPI...	PR...	SUM_HOUR	WARNING_LEVEL	OPERATION_OFF
4	01-NOV-13	...	01-NOV-13	..	0	mm/h	12	0	0
4	01-NOV-13	...	02-NOV-13	..	0.6	mm/h	12	0	0
4	02-NOV-13	...	02-NOV-13	..	0	mm/h	12	0	0
4	02-NOV-13	...	03-NOV-13	..	0	mm/h	12	0	0
4	03-NOV-13	...	04-NOV-13	..	0	mm/h	12	0	0
4	04-NOV-13	...	04-NOV-13	..	0	mm/h	12	0	0
4	04-NOV-13	...	05-NOV-13	..	0	mm/h	12	0	0
4	05-NOV-13	...	05-NOV-13	..	0	mm/h	12	0	0
4	05-NOV-13	...	06-NOV-13	..	0	mm/h	12	0	0

Figure 10: Screenshot of the attribute table Accumulated Precipitation

The table Combined signal - SM_COMBINED_SIGNAL lists the parameter combination as well as the limit values for triggering the warning signal.

Comb Signal NR	Signal Name	Rain Signal NR	Station NR Sensor NR	Signal	Meas Type	Limit	Hours	Active	Def
2	Baqqouria (Turbidity) As-Salt	As-Salt (1)	Baqquoria (1) UCL10981 (1)	Precipitation + Turbidity	Turbidity (2)	5	1	Y	Y
3	Hazzir (EC) & Fuhais	Fuhais (2)	Hazzir (6) UCL10982 (2)	Precipitation + EC	EC (3)	30	24	Y	Y
4	Sultan (Turbidity) As-Salt	As-Salt (1)	Sultan (7) UCL10851 (4)	Precipitation + Turbidity	Turbidity (2)	5	1	Y	Y
5	Shoreia (EC) & Fuhais	Fuhais (2)	Shoreia (3) UCL06320 (3)	Precipitation + EC	EC (3)	20	24	Y	Y
6	Baqqouria (EC) & Fuhais	Fuhais (2)	Baqquoria (1) UCL10981 (1)	Precipitation + EC	EC (3)	20	24	Y	N
7	Sultan (EC) & Fuhais	Fuhais (2)	Sultan (7) UCL10851 (4)	Precipitation + EC	EC (3)	20	=24*7 =168	Y	N

Figure 11: SM_Combined Signal Table

The internal processes done in the database are stored in **Work Log Tables.** Information include starting and ending time of the process as well as log information of data processing errors.

	PROCESS_NAME	START_DATE	END_DATE	ERROR_DATE	ERROR_MESSAGE
41	scenario_rain 4	30-SEP-15 12.21.11.134275000 PM	(null)	30-SEP-15 ...	Error code -1400: ORA-01400: cannot insert NULL
23	precipitation_sum 4	17-SEP-15 10.53.56.407632000 AM	17-SEP-15 10.56.09.467916000 AM	(null)	(null)
21	precipitation_sum 4	17-SEP-15 10.50.07.494379000 AM	17-SEP-15 10.50.08.000483000 AM	(null)	(null)

Figure 12: Screenshot of the table Work Log

4 Data Import

A suggested workflow for the data import is having a batch process that loads the data periodically. The data would be loaded using Talend Open Studio for Data Integration. This is an open source software for data integration and can be used to process and load the data into the database (for further information see also https://en.wikipedia.org/wiki/Talend_Open_Studio_for_Data_Integration).

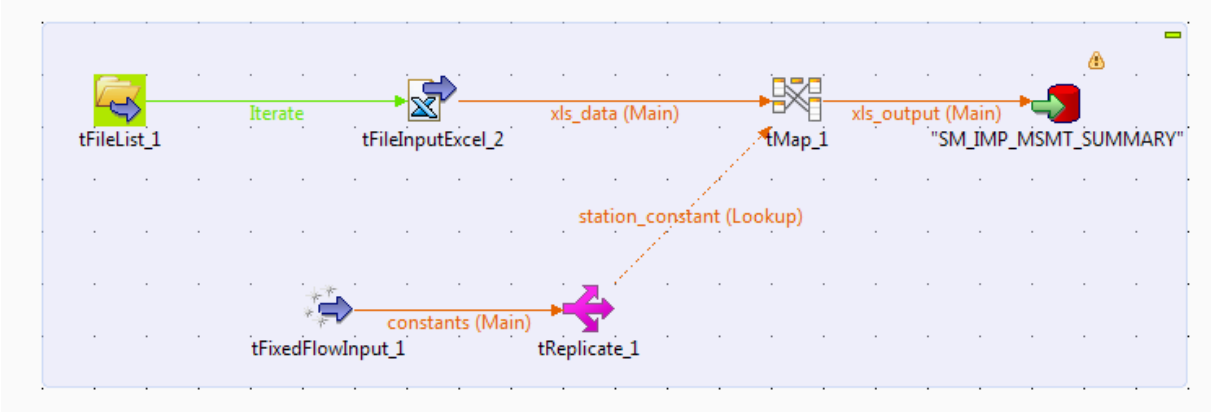

Figure 13: Scheme of the data import

In this example the process loads all Excel files (or .csv files) into a staging table called SM_IMP_MSMT_SUMMARY. The tMap_1 component matches the input Excel columns with the output columns in the table and also does any additional data conversion.

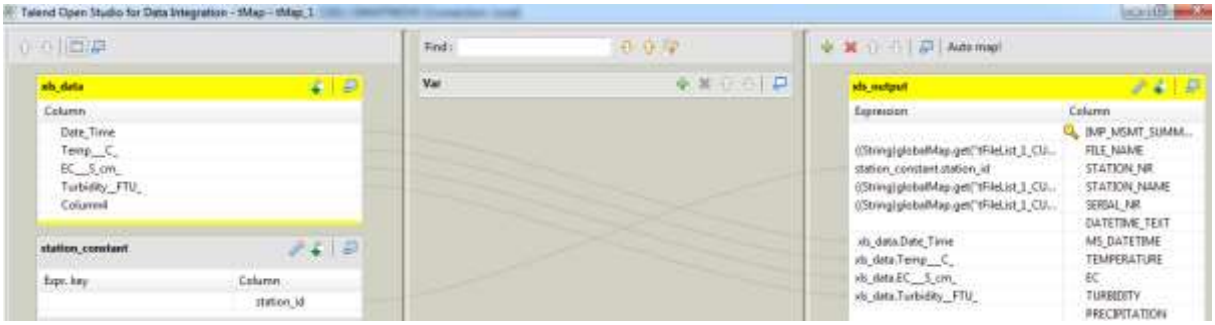

Figure 14: Matching and conversion process of the tMap_1 between the input and output Excel columns.

After loading the data in the table, a database trigger will execute procedures to load the data in the corresponding tables and trigger a condition.

5 Database Algorithms

The Early Warning System is based on three different concepts, whereby RAIN is the hierarchical top parameter:

1. RAIN only (*all three springs*)
2. TURBIDITY and RAIN (*Baqqouria & Hazzir Spring*)
3. EC and RAIN (*Shoreia*)

5.1 Concept 1 – RAIN only

Precipitation [mm/hour] as single early warning parameter, recorded at climate stations in (1) As-Salt and (2) Fuhais

(1) **IF** Rain **> 10mm in 12h** → **THEN** Warning Level **YELLOW**

or

IF Rain **> 40mm in 12h** → **THEN** Warning Level **RED**

→ **Operation Off for 48h**

(2) **IF** Rain after 48h **< 10mm in 12h** → **THEN Level GREEN**

→ **Operation On**

or

IF RAIN **> 10mm in 12h** or **> 40mm in 12h** → **THEN** back (1)

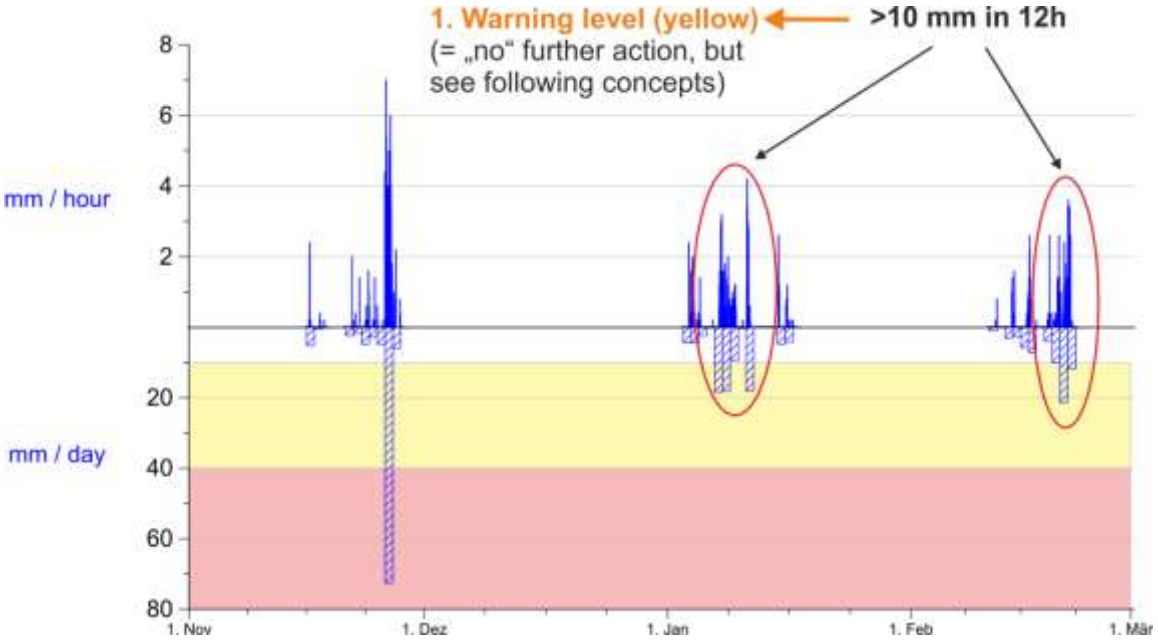

Figure 15: Illustration of Concept 1 (RAIN only)

5.2 Concept 2 – TURBIDITY and RAIN

(1) **IF TURBIDITY > 5 FTU** → **THEN** Warning Level **YELLOW**

and

IF RAIN = 1. Warning Level* → **THEN** Warning Level **RED**

→ **Operation Off for 48h**

(2) **IF RAIN** after 48h **< 10mm in 12h**

and

IF TURBIDITY < 5 FTU → **THEN** Level **GREEN**

→ **Operation On**

(3) **IF RAIN = NO** Warning Level → **THEN NO** action

*RAIN any warning level (yellow or red)

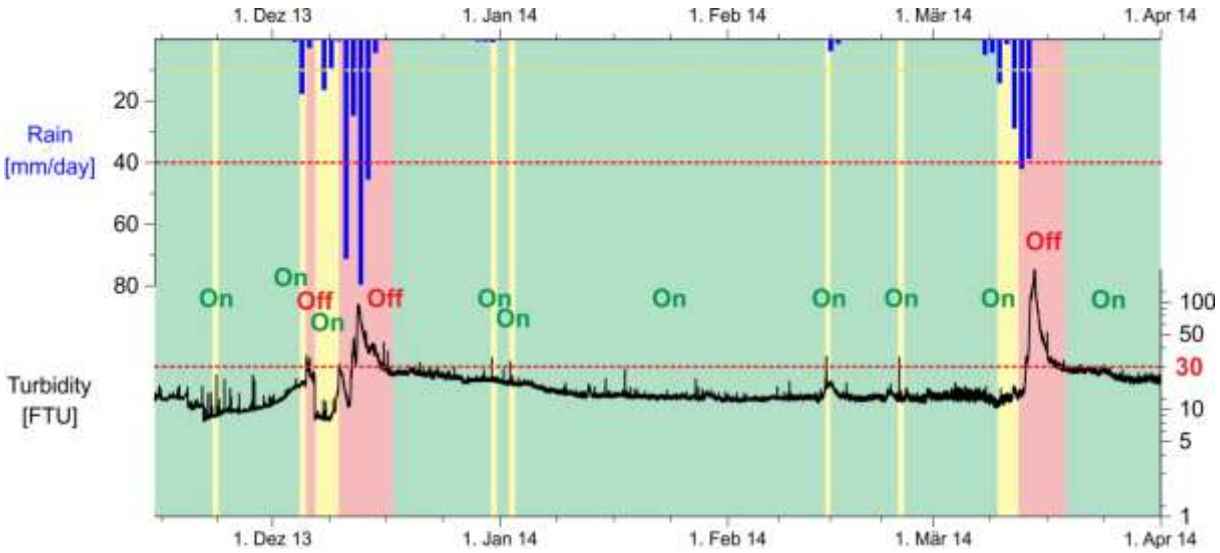

Figure 16: Illustration of Concept 2 (TURBIDITY and RAIN)

5.3 Concept 3 – EC and RAIN

(1) **IF EC-Variation > 30 µS/cm in 24h→ THEN** Warning Level **YELLOW**

and

IF RAIN = 1. Warning Level → THEN Warning Level **RED**

→ Operation Off for 48h

(2) **IF RAIN** after 48h **< 10mm in 12h**

and

IF EC-Variation after 24h **< 30 µS/cm → THEN Level GREEN**

→ Operation On

(3) **IF RAIN** = **NO** Warning Level → **THEN NO** action

Example *Shoreia Spring* → **20 µS/cm Variation-Threshold**

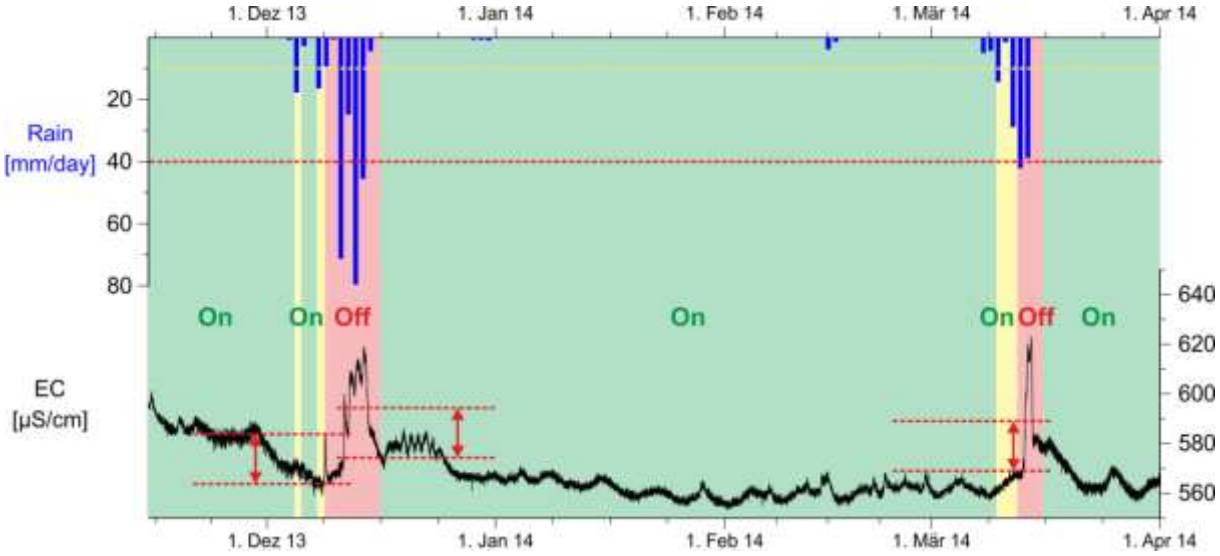

Figure 17: Illustration of Concept 3 (EC and RAIN)

6 Online Portal

The measurement data of the monitoring stations is accessible in an online portal every hour. All users of the online portal can search, analyse, and visualize the current and historical data and diagrams. Additionally the online portal provides various background geodata for the project region.

Figure 18: Example for the visualization of the station signal including background geodata of the project region

The Online-Portal provides a list of different tables where the information can be filtered. It also allows the display of the filtered data in diagrams or the comparison of measurements from different stations.

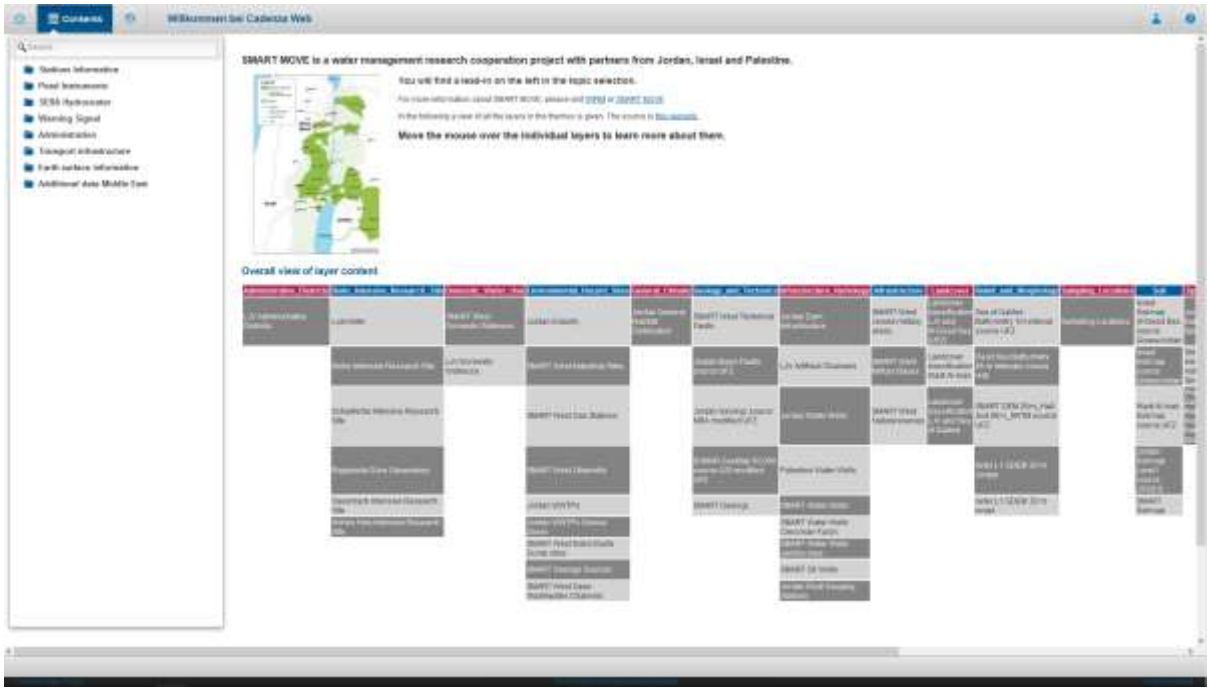

Fig. 19 Screenshot from the Cadenza Web Platform

The table *Measurement Spring Monitoring* shows the measurements per spring monitoring station. On the left side it is possible to filter the data. At the bottom a selection of different diagrams per station is possible.

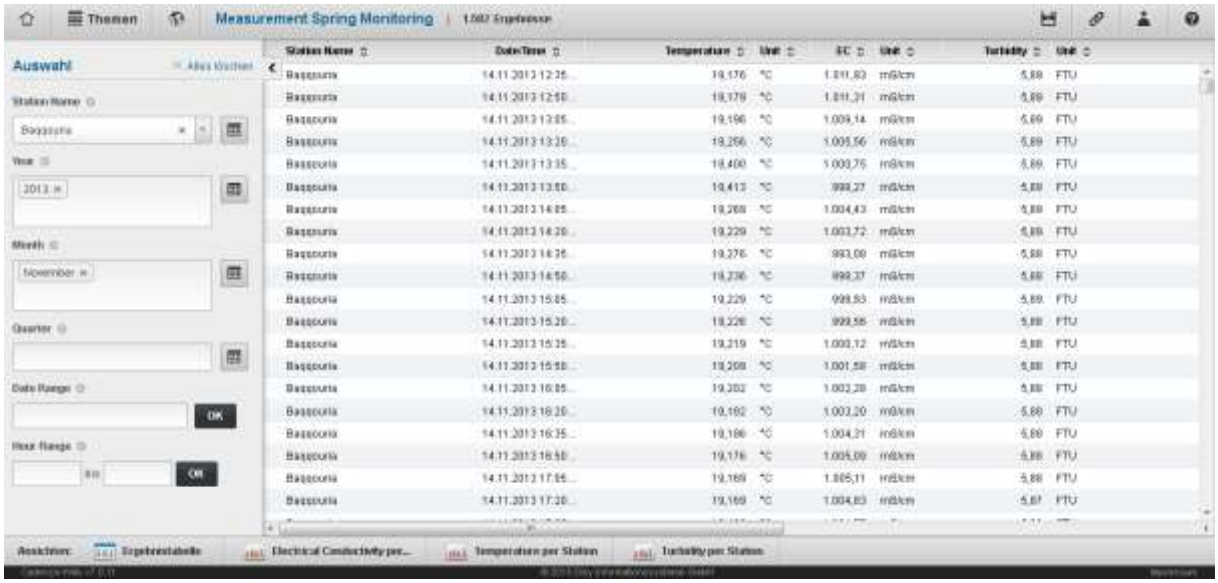

Fig. 20 Screenshot of the table *Measurement Spring Monitoring*