GeoERA

Establishing the European Geological Surveys Research Area to deliver a Geological Service for Europe

Technical review report for project RESOURCE

This report is part of a project that has received funding by the European Union's Horizon 2020 research and innovation programme under grant agreement number 731166.

INTRODUCTION

Technical review report is part of GeoERA's Monitoring and evaluation process for co-funded projects (*hereinafter: project*). The aim of a technical review is to assess the work carried out under the project over a certain period and provide recommendations. Such technical review evaluates the project reports and deliverables, the proper use of resources, the management of the project and the expected impact.

Technical review report consists of four sections, each representing one level of monitoring and/or evaluation of the project:

Level	Monitor / Reviewer	Input	Aim
1 – Monitoring of progress indicators	Monitoring and reporting officer (GeoZS)	MPPR* FPPR**	Monitoring of the effectiveness of implementation of selected projects with respect to finance, time and administration.
2 – Scientific review	Reviewers (GeoZS)	Submitted deliverables MPPR FPPR	Quality review of the deliverables and review of achieving scientific and professional goals.
3 – Review of the theme progress	Theme coordinators	MPPR FPPR	Review of achieving theme objectives.
4 – GeoERA Progress evaluation	Stakeholder Council member(s)	Sections 1 and 2 of this report Review meetings	Overall project progress and general recommendations.

*MPPR = Midterm Project Progress Report (see PI doc no 2)
**FPPR = Final Project Progress Report (see PI doc no 2)

Monitoring and evaluation process:

M0 = End of reporting period
M1 = Submitted (Final) Project progress Report (MPPR / FPPR)
M2 = 1 – Monitoring & 2 – Evaluation
M3 = 3 – Evaluation of the theme progress
M3 = (Final) Review Meeting & 4 – Progress evaluation

Each project will be reviewed twice: for first project period M1-M18 – Technical review report, and second project period M19-M36 – Final review report.
Technical review report is based on Horizon 2020 templates but adopted to GeoERA needs. Technical reviews of projects shall be carried out on a confidential basis.

GENERAL INFORMATION

ERA-NET Cofund Grant Agreement:	731166
ERA-NET Cofund acronym:	GeoERA
Call identifier:	H2020-LCE-2016-2017/H2020-LCE-2016-ERA
Project full title:	RESOURces of groundwater, harmonized at Cross-Border and Pan-European Scal
Project acronym:	RESOURCE
Project reference number:	GeoE.171.004
Project topic:	Groundwater
Project specific topic:	GW3-Harmonization of groundwater resources information at cross-border to Pan-European scale
Lead partner:	TNO Nederlandse Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek (The Netherlands Organisation for applied scientific research)
Project website:	https://geoera.eu/projects/resource9/

☐ Technical review report
☒ Final review report

Period covered	01/01/2020 – 31/10/2021
Review meeting date	08.12.2021; start at 13:30

Contributor:	Role:	Approved on:
Barbara Simić	Monitoring and reporting officer	8.12.2021
Aleksandra Trenchovska	Monitoring and reporting officer	9.12.2021
Luka Serianz	Scientific reviewer	9.12.2021
Jasna Šinigoj	Scientific reviewer	9.12.2021
Matija Krivic	Scientific reviewer	9.12.2021
Klaus Hinsby	Theme coordinator	21.12.2021
Tibor Stigter	GeoERA Stakeholder	21.12.2021
Karen Villholth	GeoERA Stakeholder	7.1.2022

1 LEVEL 1 – MONITORING OF PROGRESS INDICATORS

In this section the project is monitored "remotely" on the basis of the respective reports. This part is filled in by Monitoring and reporting officer with aim to monitor the effectiveness of implementation of the selected projects with respect to finance, time and administration, based on submited MPPR and FPPR.

	Yes	Partially (comment needed)	No
PROJECT MANAGEMENT			
Has the MPPR / FPPR report been submitted on time?	☒	See comment no. 1	☐
Have there been any changes in project partnership?	☒	See comment no. 2	☐
Has the project management been performed as required?	☒		☐
Has the collaboration between partners been effective?	☒		☐
Do you identify evidence of underperforming partners, lack of commitment or change of interest of any partners?	☐ (see comment)		☒
DELIVERABLES and MILESTONES			
Have the planned deliverables for the period been submitted on time according to timeline in Project Agreement?	☐	See comment no. 3	☒
Have the planned deliverables for the period been completed (from MPPR / FPPR, sheet 4)	☒		☐
Have any changes to deliverables occurred (type/ dissemination level)? (from MPPR / FPPR, sheet 4 and 5)	☒		☐
Have planned milestones been achieved for the reporting period? (from MPPR / FPPR, sheet 4)	☒		☐
Have the project partnership identify any difficulties achieving any of the deliverables / milestones?	☒		☐
DEVIATIONS (from MPPR / FPPR, sheet 5)			
Has the project partnership identify any deviations that will not affect projects outputs?	☒		☐
Have any deviations occur on the project, with impact on project outputs?	☐		☒
In case of deviations, have the project adopted corrective measures?	☒		☐

DISSEMINATION, COMMUNICATION			
Has the project adopted its dissemination plan?	☒		☐
Have the planned dissemination activities been completed for the reporting period? (from MPPR / FPPR, sheet 6)	☒		☐
Have the partners' disseminated project results and information adequately?	☒		☐
Is the project following dissemination plan?	☒		☐
Is the project interacting in a satisfactory manner with other GeoERA projects?	☒		☐
Is the project interacting in a satisfactory manner with national/international bodies?	☒		☐

FINANCE			
To the best of your estimate, have the resources used been utilised for achieving the project? (according to MPPR / FPPR, sheet 9)	☒		☐
To the best of your estimate, have the resources used been in a manner consisted with the principle of economy, efficiency and effectiveness?*	☒		☐
Are there any major deviations in the budget consumptions from the financial plan? (zero consumption in M18; deviation from plan exceeding 20% in M36)	☒	See comment no. 4	☐
Are there any major deviations in the Person - Months consumptions from the plan? (zero consumption in M18; deviation from plan exceeding 20% in M36)	☒		☐
Are any budget modifications for the project needed? (from MPPR / FPPR, sheet 5)	☐		☒

***The principles of economy, efficiency and effectiveness**: refers to the standard of "good housekeeping" in spending public money effectively. Economy can be understood as minimising the costs of resources used for an activity (input), having regard to the appropriate quality and can be linked to efficiency, which is the relationship between the outputs and the resources used to produce them. Effectiveness is concerned with measuring the extent to which the objectives have been achieved and the relationship between the intended impact and the actual impact of an activity. Cost effectiveness means the relationship between project costs and outcomes, expressed as costs per unit of outcome achieved.

Comments (highlighting the project progress) / deviations / recommendations:

The RESOURCE project aimed to demonstrate the potential for harmonizing information on Europe's groundwater resources through transboundary demonstration projects, through harmonized descriptive approaches for karst and Chalk aquifers, and through a first information product on a pan-European scale, compiling and integrating available data to produce a map of Europe's fresh groundwater resources. The main challenge has been to provide a coherent overview of all fresh groundwater in Europe for policy development and evaluation from the data of individual EU Member States. The project provides best practices for the transboundary provision of harmonized data and information for the assessment of the 3D structure of aquifers, available water volumes, and water flows and quality of the resource, which is also a prerequisite for any transboundary groundwater management. The information products delivered will serve as a first prototype for information that will be accessible within the framework of a Geological Service for Europe.

The Covid 19 epidemic has impacted the progress of Project RESOUCE. In December 2020, the project was extended by 4 months, from 30.6.2021 until 31.10.2021. The postponed project activities were appropriately communicated to the GeoERA Executive board, which reviewed and approved the changes in light of achieving the project outcomes. A detailed list of changes is part of the project documentation in the project plan History of changes.

The project management structure was well defined, especially given the numerous partners. From the management perspective, the main impact of the project was that 35 partners who had not previously cooperated were now working together, sharing data, working on a common interpretation of the data, and making the information available to a wider target audience. The pandemic situation required a high degree of flexibility of the partnership and adaptability of their participation in the project activities. To ensure the achievement of the set objectives, the partners increased their efforts and even added more outputs to their already exhausted list. Project expenditures remained about the same as planned at the beginning of the project. Overall, partners IGME, GBA, SGU, OPM, LEGMC and TNO increased their budget, while partners GEOINFORM and GSI decreased it. Partners that overspent can be reimbursed from the projects' GeoERA funds and partners that underspent. The project did not identify any underperforming partners that could affect the quality of the project outputs.

Communication and dissemination activities focused on decision makers and stakeholders, especially groundwater managers, and reached them through scientific publications, presentations at conferences and also through social media. Some publications will be published after the end of GeoERA. The project has mainly

collaborated with other projects under the GeoeRA groundwater theme and the GIP -P project.

Comment no. 1: The Final Project Progress Report was submitted in draft form by the deadline. Partners still have the opportunity to recalculate their finances by the end of the calendar year to include the final data, so minor variations can be expected. The changes will not affect the content of the project.

Comment no. 2: During the implementation of the project, a change in partnership occurred: the IGME-Sp Geological Survey of Spain was integrated into the CSIC Agencia Estatal Consejo Superior de Investigaciones Científicas. At the end of reporting period 1, the project partner GEOINFORM State Research and Development Enterprise State Information Geological Fund of Ukraine ended its activities and did not participate in the second period. The partner Regione Toscana left the GeoERA consortia at the beginning of the projects. Its activities were taken over by the partner Regione Umbria.

Comment no. 3: Due to the pandemic situation, some activities were postponed and deliverables were delayed to a later date. The changes in delivery dates were communicated to the Monitoring team and the GeoERA Secretariat through an amendment to the project plan.

The deliverable changes in the project implementation period are:

Reporting period 1:
D1.1 postponed from M7 (31.1.2019) → M19 (31.1.2020), combining 3 deliverables 1.1 into one

Reporting period 2:
D1.2b postponed from M24 (30.6.2020) → M31 (31.1.2021)
D5.2 postponed from M24 (30.6.2020) → M30 (31.12.2020)
D5.3 is added that reports on the tasks 5.2, 5.3 and 5.4 and is postponed from M30 (31.12.2020) → M33 (31.3.2021)
D3.3 postponed from M32 (28.2.2021) → M34 (30.4.2021)
D3.4 postponed from M32 (28.2.2021) → M34 (30.4.2021)
D3.5 postponed from M32 (28.2.2021) → M36 (30.6.2021)
D6.3 postponed from M32 (28.2.2021) → M34 (30.4.2021)
D3.2 postponed from M32 (28.2.2021) → M34 (30.4.2021)
D6.4 postponed from M34 (30.4.2021) → M36 (30.6.2021)
D3.6 postponed from M36 (30.6.2021) → M40 (31.10.2021)
D1.3 postponed from M37 (31.7.2021) → M41 (30.11.2021)
D3.7 is added → M31 (31.1.2021)
D5.1 is renamed into Karst Typology in Europe: state of the art. The deliverable is reporting on Tasks 5.1 and partly on 5.2 of the WP description

D2.3 was rearranged to Milestone M5.

Comment no. 4: Some project partners spent 20% more than their planned budget, others spent less than 80%. The partner that has exceeded their budget is IGME-Sp. LBEG and LBGR. Partners that spent less than their planned budget are FZZG, OPM, NERC, SCK/CEN and SGL. The consumption of man-months followed the EUR consumption.

The project has coped well with the negative external factors and has overcome its challenges in such a way that it has achieved its planned objectives and project results. For this reason, the project is rated as "excellent" at level 1 and thus receives a rating of 4 - Objectives and targets fully achieved.

Overall assessment of the project:

☐ 5 - **Overachiever** (the project has achieved all objectives and goals for the period and has even exceeded expectations)

☒ 4 - **Excellent progress** (the project has fully achieved its objectives and goals for the period)

☐ 3 - **Good progress** (the project has achieved most of its objectives and goals for the period with relatively minor deviations)

☐ 2 - **Acceptable progress** (the project has achieved some of its objectives)

☐ 1 - **Unsatisfactory progress** (the project has failed to achieve critical objectives)

Summary of dissemination activities:

	SCIENTIFIC COMMUNITY	GENERAL PUBLIC	POLICY MAKERS	EUROPEAN INSTITUTION	NATIONAL INSTITUTION	REGIONAL INSTITUTION	INTERNATIONAL INSTITUTION	LOCAL INSTITUTION	PRIVATE COMPANIES	OTHER	Total Target Group reach
EVENTS	6795	10	110	140	110	100	30	100	30		7425
MEETINGS	940	30	51	15	30	31		10	10	15	1132
ONLINE_MEDIA	41600	2350	80	80	80	80	80	80	80	80	44590
PUBLICATIONS	5550	250	30		10	10		10			5860
Total	**54885**	**2640**	**271**	**235**	**230**	**221**	**110**	**200**	**120**	**95**	**59007**

	ABSTRACTS	BLOG	CONGRESS	FACEBOOK	INTERNAL PROJECT MEETING	LINKEDIN	MEETING	MEETING WITH OTHER GEOERA PROJECTS	MEETING WITH OTHER PROJECTS	OTHER	PITCH EVENT	POSTER	SCIENTIFIC PUBLICATION	SEMINAR	TWITER	WEBINAR	WEBSITE	WORKSHOP	Total
EVENTS			15								1			1		4		10	31
MEETINGS					14		7	7	2	2									32
ONLINE_MEDIA		1		10		1									2		4		18
PUBLICATIONS	4											3	4						11
Total	**4**	**1**	**15**	**10**	**14**	**1**	**7**	**7**	**2**	**2**	**1**	**3**	**4**	**1**	**2**	**4**	**4**	**10**	**92**

Are the dissemination activities adequate?

☐ 5 - **Overachieved** (the projects dissemination activities have exceeded expectations)
☒ 4 - **Excellent** (the projects dissemination activities have fully achieved its expectations)
☐ 3 - **Good** (the projects dissemination activities are adequate)
☐ 2 - **Acceptable** (the projects dissemination activities are acceptable)
☐ 1 - **Unsatisfactory** (the project has failed to disseminate)

Cummulative financial statement:

	Person months	**Total eligible costs**	**Reimbursement rate**	**GeoERA contribution**	**In-kind contribution**
Plan	**410,43**	**2.459.557,24**	**29,7 %**	**730.487,46**	**1.729.069,78**
1st period consumption	213,52	941.866,20	29,7 %	279.734,26	662.131,94
2nd period consumtion	195,51	1.404.116,35	29,7 %	417.022,56	987.093,79
TOTAL	**409,03**	**2.345.982,55**	**29,7 %**	**696.756,82**	**1.649.225,73**

2 LEVEL 2 – SCIENTIFIC REVIEW

In this section the project is reviewed ”remotely” on the basis of the respective reports. This part is filled in by reviewer with aim to review the quality of the deliverables and review of achieving scientific and professional goals. Scientific review is based on submitted deliverables and reported Impact statement in MPPR/FPPR.

Impact statement (from MPPR / FPPR, sheet 8):

The RESOURCE project aimed at demonstrating the potentials of the harmonization of information about Europe’s groundwater resources through cross-border demonstrations projects, through harmonized characterization approaches for Karst and Chalk aquifers and through a first information product at Pan-European scale where available data was compiled and integrated to produce a map of the fresh groundwater resources of Europe. WP2 provided the link of the RESOURCE project with the Information Platform project and was responsible for dissemination activities. The main impact derived from the project is that the general public and stakeholders will have access to information of groundwater resources at Pan-EU by means of the EGDI webservice. Impact was further enhanced by a dissemination strategy that is actively making use of social media, national and international conferences and reaching out to the scientific community, policy makers and regional and national stakeholder and the general public. WP3 built on the established 3D transboundary geological structure that was inherited of previous Flemish-Dutch-German projects, but extending those with harmonized information on hydraulic properties, groundwater heads, groundwater quality and age, in strong cooperation with regional stakeholders that play an active role and provide guidance to the work process and will have access to a new cross-border visualization tool. The stakeholders hope to use the provided information new transboundary groundwater management and the project provides independent information that forms the basis for such groundwater planning. WP4 established the first- Polish-Lithuanian hydrogeological transboundary harmonization in order to assess cross-border flow and flux patterns. The work performed included the harmonization of available geological information and schematization, but also assessed field data on cross-border surface water flow for calibration purposes. WP5 worked towards a common tool for the interpretation of data time series from karst aquifers. The tool allows sharing a common, harmonized and up to date way of classifying karst aquifers regarding several management issues such as (i) water reserves evaluation, (ii) flow regulation and (iii) vulnerability assessment. WP6: The project has delivered a first harmonized pan-European assessment of the 3D structure of aquifers and the volumes of water involved. The surveys that participate in RESOURCE found a common language and developed a common tool to collect the data on the fresh groundwater resources, The result of this work will be distributed through EGDI and the general public will be able to assess volumes and depths of groundwater resources using the map viewer. The results of the panEU assessment was inrerpreted in the framwork of substainable groundwater management, estimating water balance terms and ratios between groundwater

recharge, groundwater volumes and abstractions.This will help to appreciate the possible role of groundwater in water supply, while making the public community aware of the protection measures necessary for sustainable use of the resource.

Expected impact (from Project Agreement):

Groundwater is the most important resource for fresh water for human consumption, irrigation and industrial and other uses and delivers base flow to river systems with associated ecosystems. Although EU member states deliver information about their "groundwater bodies" to the EU for the Water Framework Directive, this does not yet lead to a harmonized pan-European assessment of the 3D structure of aquifers, the volumes of water involved and its quality. This predicament was also identified at the EU Working Group C on Groundwater, dedicated to the Common Implementation of the WFD and GWD, but the EC Directives offer a lot of responsibility and flexibility to its member states. However, harmonisation of geological and hydrogeological information and harmonized 3D characterization of aquitards and aquifers is a prerequisite for any transboundary groundwater management and RESOURCE strives to stimulate advanced cross-border demonstration projects that establish such a 3D cross-border harmonization, in order to eventually harmonize data and information at a Pan-European scale. To date there has been no attempt to make pan-European harmonized compilations of available groundwater and hydrogeology data. Key aim of this the approach followed under RESOURCE is to deliver stakeholder access to relevant harmonized groundwater data for sustainable and integrated management of the subsurface and integrated surface and subsurface spatial planning in accordance with EU policies. This will benefit not just the groundwater research community, but also public and private partners and public-private partnerships developing sustainable water policies and innovative water and environment solutions. Innovative and broadly applicable solutions and products for sustainable water management will support and preserve Europe's leading role in this area. We intend to deliver synchronized information that can be used for cross-boundary aquifer management and subsurface spatial planning, in areas where many subsurface activities strive for prioritization. The proposed project yield information and methods for water managers to balance the pressure of the many activities demanded and the ecosystem services that the groundwater/subsurface can provide, both at cross-border scale and EU scale. Therefore, the results will be relevant for regional authorities responsible for groundwater management in the greater cross-border area, to drinking water supply companies and to the member states governments that perform groundwater management at national and supranational level, including the definition of national strategic groundwater reserves, as in the Netherlands (Broers et al. 20157). Additionally, the EU scale maps will help member states and the commission to obtain an up to date overview of groundwater resources and special groundwater at an appropriate scale for policy development and evaluation. The project will yield considerable progress beyond the current state-of-

the-art in demonstrating the merits of 3D cross-border geologic and hydraulic and chemical characterization, as such enabling groundwater managers of cross-border regions to manage their resources with a good understanding of geological structure, groundwater flow and age patterns in order to prioritize competing uses of the subsurface and effectively protect their resources. Stakeholders will be involved in the two cross-border projects in order to support and promote cross-border discussions, decisions and policymaking, regarding subsurface resource management, exploitation and associated impacts. As such, the RESOURCE project aims to provide a strong impulse to consolidate the cooperation and communication between national/regional subsurface surveys and national and EU stakeholders that deal with groundwater management and protection. The overview of European groundwater resources that we strive to achieve (Figure 8) will yield useful information to derive information on the depletion of groundwater resources in relation to the recharge to the groundwater systems, and the well-protected deeper paleo resources that may be used as strategic reserves. This would promote a more integrated approach towards realizing national and EU societal challenges that are linked with the protection and sustainable management of EU's fresh groundwater resources, supporting the interfacing between DG's (e.g. GROW, ENER, ENV, RTD) and various policy departments.

Through the cooperation with the GeoERA Information Platform, the results will be accessible through easy-access tools for regional authorities responsible for groundwater management in the greater crossborder area, drinking water suppliers and member state governments that perform groundwater management at national and supranational level. Open access to these results will enable private companies and/or research institutions to develop new groundwater services on top of the integrated climate, groundwater-surface water models and results e.g. in public-private partnerships and competitive and collaborative environments. The work will provide improved access to downloadable hydraulic and (hydro)chemical parameters of main European aquifers and aquitards (or groundwater bodies) that can be implemented in groundwater models and coupled surface water - groundwater models at regional and EU scale, and can be applied to the assessment of trends in groundwater quantitative and chemical status based on both human health and well-being and good status objectives for groundwater dependent or associated ecosystems. At EU scale, the Pan-EU mapping effort yields an information product that visualizes the extent and importance of Europe's main aquifer systems including important characteristics such as volumes, depths of confining and permeable layers and the depth of the salt-fresh water interface. This adds considerably to the current information delivered by member states, as in practice the WFD groundwater bodies are administrative units and have been delineated and analysed in diverging ways across Europe. Often depths and volumes are not registered for the WFD. By providing a harmonized map of depth and volumes of European groundwater, together with first estimates of abstracted volumes, groundwater recharge and surface water discharge, we can make a major step forward. The maps to be provided do not intend to break up groundwater systems into administrative groundwater bodies, but rather

emphasize the connectivity across borders and thus gives insight in transnational important systems. By creating the maps, we will use the experiences gained by the cross-border demonstration projects that are part of RESOURCE. A map of the depth and volume of fresh groundwater as a principal resource of water for the EU can be considered as a basic information layer, needed for almost all attempts to manage groundwater at a scale larger than member states and to formulate policy goals for groundwater within the EU. Indirectly, the map of the depth of freshwater resources gives information about residence times of groundwater in the subsurface, which yields information about the long-term susceptibility of groundwater systems. The maps and water balance estimates also form the basis for more thorough analysis of the development of groundwater systems in time, for example in modelling Figure 8 Spatial extent of the pan-European groundwater resources map to be created under WP6. Green: participating surveys, dashed green: country covered partially through contribution of regional surveys, yellow: survey not yet contributing, grey: not a GeoERA partner. 11 studies that address global change effects on water demands or the long-term effects of groundwater contamination by diffuse agricultural use or by local industrial spills. As such, the cooperation and exchange of information with the other groundwater projects that will be funded under GeoERA, will be stimulated by organizing central Consortium Assembly meetings together with the other projects, in order to collectively exchange ideas within the whole groundwater community within the geological surveys in GeoERA

Evaluation of deliverables

No.	Title	Status (Approve / Reject)	Comments
D1.1	Midterm activity report and financial and management report	Approved	Level 1 MT
D1.3	Final management report and financial report following overall GeoERA rules	Approved	
D3.2	Report with associated database of hydraulic	Approved	
D3.3	3D visualisation of groundwater composition and age	Approved	
D3.4	Report describing the water balances, recharge and discharge fluxes and routes	Approved	
D3.5	3D visualisation of cross-border patterns of groundwater depletion and recharge	Approved	
D3.6	Report with overview of groundwater management strategies on different sides of common borders	Approved	
D4.3	Harmonized hydrogeological dataset and model input	Approved	
D4.4	Report describing the hydrodynamic model for the Polish-Lithuanian cross-border area	Approved	

	and map showing the transboundary groundwater flow directions and fluxes in the multi-aquifer system		
D5.2	Detailed conceptual hydrogeological models for pilot areas and case studies	Approved	
D5.3	Karst aquifer typology tool	Approved	
D5.4	Water management recommendations in relation with the typology	Approved	
D5.5	Database with time series data of the pilot areas	Approved	
D6.2	Database with information on volumes and depths at 10x10 and/or 25x25 km grids	Approved	
D6.3	Maps showing the depth and volume of fresh groundwater	Approved	
D6.4	Dataset to be included in the Information Platform	Approved	
D6.5	Report describing water balance terms for the EU fresh groundwater grid	Approved	

Has the quality as a whole been achieved according to the objectives? Has the project as a whole been making satisfactory progress?

☐ 5 - **Overachiever** (the project has achieved all objectives and goals for the period and has even exceeded expectations)

☒ 4 - **Excellent progress** (the project has fully achieved its objectives and goals for the period)

☐ 3 - **Good progress** (the project has achieved most of its objectives and goals for the period with relatively minor deviations)

☐ 2 - **Acceptable progress** (the project has achieved some of its objectives)

☐ 1 - **Unsatisfactory progress** (the project has failed to achieve critical objectives)

Comments (highlighting the project progress) / deviations / recommendations:

The RESOURCE project aims to demonstrate the potentials for harmonizing information about Europe's groundwater resources through transboundary demonstrations projects, through harmonized descriptive approaches for Karst and Chalk aquifers, and through a first information product at Pan-European scale compiling and integrating available data to produce a map of the fresh groundwater resources of Europe. The project comprises 6 work packages, two of which are coordination based (WP1 and WP2), while the other 4 are technical WPs.

Most of the WPs develop specific deliverables. 15 technical and 2 coordination deliverables have been subbmited and are included in the scientific review. In general, it can be conculded that the deliverables reports are very good and clear and comply with the project agreement. Based on the review of the submitted reports, we can assess the progress of the project as excellent.

According to the objectives in the project proposal and the deliverables submitted, we believe that all work packages have been developed in a way that they can be approved. Therefore, we have no further comments or revisions that would affect the scientific part of the overall project. We would only suggest to double check the content of deliverables reports before the final submission.

3 LEVEL 3 – REVIEW OF THE THEME PROGRESS

In this section the project is reviewed ”remotely” on the basis of the respective reports. This part is filled in by Theme coordinator with aim to review the achieved scientific goals in accordance with theme objectives, on the basis of Sheet 3 in MPPR / FPPR – Project contribution to GeoERA project.

Project contribution to GeoERA project (from MPPR / FPPR, sheet 3):

The RESOURCE project addressed the Specific Research Topics of the call, such as addressed under GW3 (GeoERA 2017). The set of deliverables provides good practices in providing harmonized data and information across borders for proper assessments of water volumes, fluxes and water quality at a cross-border scale, which were nearly absent but are needed for successful water planning and management in Europe, especially in a transboundary setting. The Pan-EU mapping approach and the cross-border demonstration projects under RESOURCE have led to example products of a harmonized pan-European assessment of the 3D structure of aquifers and the volumes of water involved. Harmonization of hydrogeological information and harmonized 3D characterization of aquitards and aquifers is a prerequisite for any transboundary groundwater management. The RESOURCE proposal included the following elements of research and development that address the scope of the call:

- Two cross-border demonstration projects that set a new standard for harmonization across borders, not only for 3D geological structures but also for hydrological characteristics such as groundwater heads, fluxes and water quality; these demonstration projects may be considered as a first step towards harmonization at European scale.
- Involvement of stakeholders in the cross-border demonstration projects in order to show and evaluate how synchronized cross-border information adds value to cross-border aquifer management and promotes sustainably prioritizing of different uses of shallow and deep groundwater resources.
- A truly pan-European effort to create a consistent pan-European information product that yields a spatial overview of the volume and depth of Europe’s fresh groundwater resources, including a first estimate of the water balance terms from the resource at NUTS level and the identification of deep paleo waters that may function as strategic reserves
- Creation of a common methodological framework for characterization of karst aquifers and their vulnerability, with a guidance for managing and protecting various karst aquifer types.

Theme objectives:

The main objective of the GeoERA groundwater theme is to provide data, information and decision-support tools for the long-term protection, sustainable management and improvement of groundwater resources across Europe, within the framework of

societal challenges and EU policies. These include the European Green Deal, the Water Framework and Groundwater directives, and the UN Sustainable Development Goals. Innovative methodologies and digital map viewers and information products are developed to tackle the diversity of hydrogeological settings at a range of scales from points or boreholes to the whole of Europe; primarily visualized in two or three dimensions providing access to all the compiled data and information including 3D hydrogeological models. By jointly developing effective and harmonized tools and methodologies for monitoring, modelling, data management and visualization, in close collaboration with the other GeoERA themes, this work will improve our understanding of groundwater chemical and quantitative status across Europe and how this is affecting or affected by groundwater legitimate uses and nature. "Legitimate uses" include e.g. drinking water abstraction, irrigation, heating and cooling of buildings and mining; and "nature" include the ecological status and biodiversity of groundwater dependent terrestrial and associated aquatic ecosystems as well as groundwater ecosystems. The mission of the GeoERA groundwater projects is to contribute to and initiate the development of a world leading digital groundwater and subsurface information platform with free and easy access (FAIR data) to groundwater data across Europe relevant for assessing groundwater chemical and quantitative status according to EU directives and support sustainable management of groundwater and other subsurface resources in a changing climate.

Has the project as a whole achieved the objectives and expected impact of the theme?

☒ 5 - **Overachiever** (the project has achieved greater impact on project theme and/or other themes than expected)

☐ 4 - **Excellent progress** (the project has fully achieved its objectives and goals towards the theme as expected)

☐ 3 - **Good progress** (the project has achieved most of its impact towards the theme for the period with relatively minor deviations)

☐ 2 - **Acceptable progress** (the project has minor impact)

☐ 1 - **Unsatisfactory progress** (the project has failed to achieve critical objectives and/or has no impact on the theme)

Comments / deviations / recommendations:

The reason for the high rating of the RESOURCE project is that especially WP3 and WP5 delivered considerably more information products than were planned in the original RESOURCE proposal. For WP3 this is primarily achieved with the two interactive map viewers enabling the assessment of groundwater quality and age in 2D cross sections (D3.3.), which can be defined interactively; and a similar viewer for groundwater quantity / water table variations (described and presented In D3.7 not planned in the description of WP3 deliverables) in an important transboundary

aquifer system shared by three EU member states. The two presented map viewers are beyond the current state of the art for groundwater visualization tools in any European country, and they provide very valuable inspiration to geological surveys across Europe, and most probably globally, for future developments of groundwater viewers.

In WP5 twice the original number of planned deliverables were delivered (six deliverables instead of three) including an excel based tool for hydrodynamic classification of Karst and chalk springs downloadable via the RESOURCE WP5 map viewer (link in D5.6).

The Pan European groundwater resources map developed in RESOURCE WP6 did not manage to cover all of Europe, due to the limited funding for the project, which did not allow involving all European partners and EU member states. Hence, the developed map viewer has a huge potential for further extension, and it should be further developed to include the rest of the European countries and new relevant functionality, applications and visualizations. Hence, the coordinator of the groundwater theme (the level 3 reviewer) strongly encourage the EuroGeoSurveys to find funding for completing the map and further develop it with new relevant functionality including updating it with the new improved pan European groundwater recharge map developed in TACTIC WP4. The new groundwater recharge map is based on satellite data, national monitoring and modelling estimations and machine learning to extend the data to countries without national estimates. Other additional information include information on groundwater age and travel time distributions in important aquifers and the advance of young (< 70 years) potentially contaminated groundwater in European aquifer systems (groundwater bodies). Age distribution in 39 Dutch well fields that contain groundwater in the age range of less than 100 years (potentially polluted) to more than 10.000 and even 25.000 years (paleowaters recharged during the late stages of the last ice age), were published in one of the most prestigious water research journals (Water Resources Research[1]) as part of WP3, linking this work to HOVER WP6 activities on groundwater age and travel time distributions and contributing also to the high rating of the impacts of the RESOURCE project.

[1] Broers HP, Sültenfuß J, Aeschbach W, et al (2021) Paleoclimate Signals and Groundwater Age Distributions From 39 Public Water Works in the Netherlands; Insights From Noble Gases and Carbon, Hydrogen and Oxygen Isotope Tracers. Water Resour Res 57:. https://doi.org/10.1029/2020WR029058

4 LEVEL 4 – GEOERA PROGRESS EVALUATION

In this section the project is reviewed on the Review meetings, where projects present their overall progress and achievements. This section relates to particular project, broader impact of GeoERA as a whole on policies will be covered at the Final Review meeting with questionnaire and interview with Evaluator.

Based on technical review summaries provided by Sections 1 – 3 of this report, and project presentation on the (Final) Review meeting:

Has the project as a whole been making satisfactory progress according to your own understanding and expectations of the GeoERA project?

☐ 5 - **Overachiever** (the project has exceeded expectations)
☒ 4 - **Excellent progress** (as expected)
☐ 3 - **Good progress** (minor recommendations given below)
☐ 2 - **Acceptable progress** (below expectations)
☐ 1 - **Unsatisfactory progress** (the project did not meet expectations)

Overall comments for the project (overall recommendations, modifications, corrective actions, or re-tuning the objectives to optimize the impact or keep up with the State of the Art, re-focusing, or a simple praise)

Stakeholder one evaluation:

This project made excellent progress and was able to promote communication and collaboration between geological surveys of partner countries. It produced a number of really nice outputs that should be disseminated, but also used by the public institutions in charge of groundwater monitoring. I enjoyed reading and hearing about the individual work packages of the project and have added a few comments below.

- The web tools produced were overall very interesting and useful. It was also good to see how all the partner countries were involved, with the unfortunate exception of Germany. It would be good to think about further enhancing this collaboration and possibility of training partner institutions on the further development of the produced tools.
- It would be good to provide an overview of the lessons learned and challenges to expect (e.g. in terms of data sharing, uncertainties, and impact on scenarios) when applying the work developed at a case study level (WP3, WP4) elsewhere. Good to see that there is close collaboration between the different stakeholders in both countries in the H3O Plus approach, and nice scientific results were also produced here. Perhaps this was less the case in WP4, but this could be further developed in upcoming projects.

- For WP5 it would be good to link to the Karst vulnerability assessment approach developed in the HOVER project. This can be done through simple acknowledgement of similarities, differences and complementarities between the approached. Jointly developing a short publication on Karst system assessment could be another initiative. Strengthening the links between all GeoERA projects would be an overall recommendation.

For the PAN-EU map it is important to inform the users on the uncertainty around the thematic maps produced, in terms of data scarcity, parameter uncertainty and impact on the maps. This is particularly important where these link to critical situations of the balance between water availability and demand, for instance in Southern Europe. In addition, differentiation should be made between blanked regions because of lack of data, lack of participation in the map or absence of a specific item/characteristic of a groundwater body in that area. Moreover, you could further build on this (already very nice) product in future initiatives by including temporal aspects (seasonal storage variation for instance).

Stakeholder two evaluation:

Congratulations to the GeoERA Network and the RESOURCE project team on the significant and positive outcomes of the project. The approach, which combined harmonized pan-European distributed assessments with smaller-scale transboundary pilot studies, provided a good way to expand on data collection and harmonization and the collaboration between a large cross-section of partners and stakeholders, at a variety of scales from local, to national, to transboundary, to pan-European.

On the technical side, I was looking for the spatial resolution of the datasets/maps online, and could not easily find it. Could this be made more upfront visible/clear in the EGDI viewer for easy reference by users. This may be combined with some intro-notes and descriptions more broadly of what the system provides, in easily-read text. This could also provide links to the datasets/maps directly from within this text, so one gets a quick snapshot of what the tool can provide. This could work as an appetizer and easy induction to the system. Thinking of ways to make the tool/maps most user-friendly is a critical part of the FAIR principle. Obviously, some coordination across various GeoERA project/partners on these aspects is needed.

The Information Platform offers great opportunities for expansion, e.g. with more GW quality data, 3D visualization, and opportunities are basically endless. One observation in terms of databases is that the International Groundwater Resources Assessment Centre (IGRAC) already is collating and mapping data and information on GW/aquifers globally, and it appears there is room for coordination in order to avoid parallel systems, which may not speak to each other. However, it may appear that IGRAC has more of an extra-European focus. In any case, coordination and alignment going forward appear both feasible and beneficial.

It may be good to provide up-front the rationale and background for the selection of the two pilots. This work will definitely inform and complement the European Framework/Groundwater Directive work on shared groundwater bodies, and distilling lessons in this regard, maybe across the two pilots, e.g. in a separate paper, would be very valuable, both from a data/harmonization/tools point of view, but also how EU countries may take advantage and be motivated by the provided platform and institutional framework set up as part of the project to cooperate on their shared GW resources. Possibly, the institutional framework strengthened as part of the project, is an underestimated positive outcome of the project, as it leaves a legacy for taking up and expanding GW-related collaboration in challenging contexts in the EU, like transboundary and under climate change.

The present deliverables form a solid basis on which to strengthen scientific work and collaboration on groundwater and other sub-surface resources across Europe, to expand data/the knowledge base and to develop/retain strong partnerships. Options for building capacity in countries and regions outside Europe, where needs are high and transboundary work is becoming more pressing, is also something to consider. E.g., funding to groundwater projects at EU level could be linked to North-South cooperation and incentives/requirements for training as well as globally agreed standards and harmonization of GW information, for the overall benefit of promoting sustainable development.

In general, capitalizing on the achievements and investments made in RESOURCE will be a major measure of success of GeoERA Project going forward.

Annex 1: Review meeting list of participants

Name	Role	Organisation
Joop Hasselman	GeoERA coordinator	Netherlands Organisation for Applied Scientific Research
Karen Villholth	GeoERA Stakeholder	IWMI – South Africa
Tibor Stigter	GeoERA Stakeholder	IHE Delft
Barbara Simić	Monitoring and Reporting Officer	Geological Survey of Slovenia
Aleksandra Trenchovska	Monitoring and Reporting Officer	Geological Survey of Slovenia
Jasna Šinigoj	Scientific Reviewer	Geological Survey of Slovenia
Matija Krivic	Scientific Reviewer	Geological Survey of Slovenia
Luka Serianz	Scientific Reviewer	Geological Survey of Slovenia
Klaus Hinsby	Groundwater Theme coordinator	Geological Survey of Denmark and Greenland
Hans-Peter Broers	RESOURCE Project manager	Netherlands Organisation for Applied Scientific Research
Cis Slenter	Project member and WP3 lead	Flanders Environment Agency
Tomasz Gidzinski	Project member and WP4 lead	Polish Geological Institute
Jean-Christophe Marechal	Project member and WP5 lead	The French Geological Survey
Tano Kivits	Project member and WP6 lead	Netherlands Organisation for Applied Scientific Research