GeoERA

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

Technical review report for project HOVER

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:	Hydrogeological processes and Geological settings over Europe controlling dissolved geogenic and anthropogenic elements in groundwater of relevance to human health and the status of dependent ecosystems
Project acronym:	HOVER
Project reference number:	GeoE.171.013
Project topic:	Groundwater
Project specific topic:	GW1-Drinking water, human and ecosystem health
Lead partner:	BRGM Bureau de Recherches Géologiques et Minières (The French Geological Survey)
Project website:	https://geoera.eu/projects/hover8/

☐ Technical review report
☒ Final review report

Period covered	01/01/2020 – 31/10/2021
Review meeting date	07.12.2021, start at 13:30

Contributor:	Role:	Approved on:
Barbara Simić	Monitoring and reporting officer	7.12.2021
Aleksandra Trenchovska	Monitoring and reporting officer	8.12.2021
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
Marco Petita	GeoERA Stakeholder	28.12.2021
Tibor Stigter	GeoERA Stakeholder	7.12.2021

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)	☐	See comment no. 3	☒
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?	☐	NA	☐

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 project HOVER addressed groundwater management issues related to drinking water, human health and ecosystem health across Europe in relation to geogenic elements and anthropogenic pollutants through data sharing and technical and scientific exchange between European GSOs. The project was very ambitious. The consortium consisted of 31 project partners linked by technical and scientific exchanges, working together on more than 20 pilot studies to apply more than 10 environmental tracers and supporting parameters to assess the age distribution of groundwater in Europe. The assessment of the vulnerability of the upper aquifer to pollution using the proven method DRASTIC and COP for specific karst areas covers a large part of the EU and will be made available for further studies. The project results have shown that there is a need for further development and improvement, such as a global standard for a structured database for environmental tracers and inferred groundwater age distributions, and the vulnerability of water supply wells to pollution from the surface. Overall, the project has produced several case studies, guidelines, thematic maps, web service tools at pan-European level and for pilot studies, and databases available through the Information Platform / European Geological Data Infrastructure (EGDI).

The Covid 19 epidemic has impacted the progress of the project HOVER. 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 has reviewed and approved the changes in terms of achieving the project outcomes. A detailed list of changes is part of the project documentation in the project Project plan History of changes.

The project management structure was well defined, especially considering the numerous partnerships. The pandemic situation required a high degree of flexibility of the partnership and adaptability of their participation in the project activities. In order to ensure the achievement of the set objectives, after the closure of laboratories due to the pandemic and closedowns stopping the partners to work in the field, the partners increased their efforts and added 2 deliverables to their already existing list. The project budget was slightly exceeded. Some partners changed their overall budget in response to external changes. Overall, partners GSI, GTK, LEGMC and LNEG increased their budget and partners GEOINFORM, GSD and GSS decreased it. The project did not identify any underperforming partners that could affect the quality of the project outputs. Only one partner, GEOINFORM, ceased its activities in the second reporting period, with no impact on the project work.

Communication and dissemination activities focused on the scientific community, reaching them through publications, presentations at conferences and also through social media. The project results are also used in an ongoing PhD thesis. The project has mainly collaborated with other projects under the GeoeRA Groundwater theme

and the GIP -P project. Outside GeoERA, the project partnership has reached out to organisations such as USGS, IAEA, JRC, EEA, CIS /WGGW.

Comment no. 1: The Final Project Progress Report was submitted on time in draft form. Partners still have the opportunity to recalculate their financials 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 there were changes in the partnership: the partner IGME-Gr Institute of Geology and Mineral Exploration, which was added during the implementation, was renamed to partner HSGME Hellenic Survey of Geology and Mineral Exploration. Later, partner IGME-Sp Geological Survey of Spain was integrated into 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. None of the above changes affected the ability of the project to achieve its objectives and outputs.

Comment no. 3: Due to the pandemic situation, some activities were delayed, and deliverables had to be submitted later than planned. The revised dates were communicated to the Monitoring team and the GeoERA Secretariat by amending the project plan.

The deliverable changes in the project implementation period are:

Reporting period 1:
D2.2a postponed from M8 (28.2.2019) → M9 (31.3.2019)
D5.1 postponed from M12 (30.6.2019) → M13 (31.7.2019)
D6.1b postponed from M12 (30.6.2019) → M15 (30.9.2019)
D8.1 postponed from M12 (30.6.2019) → M17 (30.11.2019)
D6.1a postponed from M18 (31.12.2019) → M40 (31.10.2021)
D6.2 postponed from M18 (31.12.2019) → M29 (30.11.2020)
D2.2 postponed from M18 (31.12.2019) → M22 (30.4.2020)

Reporting period 2:
D3.3 postponed from M24 (30.6.2020) → M32 (28.2.2021)
D3.4 postponed from M24 (30.6.2020) → M32 (28.2.2021)
D3.5a postponed from M24 (30.6.2020) → M29 (30.11.2021)
D4.2 postponed from M24 (30.6.2020) → M40 (31.10.2021)
D6.1c postponed from M24 (30.6.2020) → M34 (30.4.2021)
D6.3 postponed from M24 (30.6.2020) → M29 (30.11.2021)
D7.2 postponed from M24 (30.6.2020) → M29 (30.11.2021)
D8.2 postponed from M24 (30.6.2020) → M40 (31.10.2021)
D5.4 postponed from M28 (31.10.2020) → M29 (30.11.2021)

D5.3 postponed from M28 (31.10.2020) → M29 (30.11.2021)
D6.4 postponed from M30 (31.12.2020) → M40 (31.10.2021)
D7.3 postponed from M30 (31.12.2020) → M34 (30.4.2021)
D7.4 postponed from M30 (31.12.2020) → M34 (30.4.2021)
D8.4 is added and postponed from M32 (28.2.2021) → M40 (31.10.2021)
D3.5b postponed from M33 (31.3.2021) → M38 (31.8.2021)
D3.5c postponed from M33 (31.3.2021) → M38 (31.8.2021)
D5.5 postponed from M34 (30.4.2021) → M39 (30.9.2021)
D4.3 postponed from M35 (31.5.2021) → M40 (31.10.2021)
D8.3 postponed from M35 (31.5.2021) → M40 (31.10.2021)
D8.5 postponed from M35 (31.5.2021) → M40 (31.10.2021)
D1.2b postponed from M38 (31.8.2021) → M42 (31.12.2021)
D5.5b is added M36 (30.6.2021)
D1.3d postponed from M39 (30.9.2021) → M42 (31.12.2021)
D7.5 is deleted

Comment no. 4: Some project partners spent 20% more than their planned budget, others spent less than 80%. The partners that have exceeded their budget are BGR, IGME-Sp and HSGME. Partners that spent less than their planned budget are: CGS, GBA, GSD, GSS, ISOR, LGT, SGU and VMM. 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	8255	50	147	8		10	11				8481
MEETINGS	550		10		1						561
ONLINE_MEDIA	32000	22000	2000	20	50	50	100	50	100	50	56420
PUBLICATIONS	9000						10				9010
Total	**49805**	**22050**	**2157**	**28**	**51**	**60**	**121**	**50**	**100**	**50**	**74472**

	ABSTRACTS	BLOG	CONGRESS	FACEBOOK	INTERNAL PROJECT MEETING	LINKEDIN	MEETING	OTHER	RESEARCHGATE	SCIENTIFIC PUBLICATION	TWITER	WEBINAR	WEBSITE	WORKSHOP	Total
EVENTS			16									3		1	20
MEETINGS					34		1	1							36
ONLINE_MEDIA		1		1		1			1		1		1		6
PUBLICATIONS	4									7					11
Total	**4**	**1**	**16**	**1**	**34**	**1**	**1**	**1**	**1**	**7**	**1**	**3**	**1**	**1**	**73**

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	**505,23**	**3.028.829,34**	**29,7 %**	**899.561,77**	**2.129.267,57**
1st period consumption	85,02	1.063.736,63	29,7 %	315.929,78	747.806,85
2nd period consumption	401,79	1.926.819,01	29,7 %	572.265,25	1.354.553,76
TOTAL	**486,81**	**2.990.555,64**	**29,7 %**	**888.195,03**	**2.102.360,61**

Non-funded partner RBINS is not included in the budget.

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):

On the element of natural origin in high concentrations in groundwater: The thermal and mineral water database contains various physico and chemical parameters including most of the metallic trace elements. The Web service attached to the database permit to locate the areas of “special water” presenting some common characteristics such as high temperature or high concentration in some Potentially Toxic Geogenic Trace Elements (PTGTE). Focus was given to arsenic and selenium and an overview of groundwater points with concentration higher than the recommended drinking water values (HydroGeoToxicity index, HGT) was obtained for 17 European countries. It is important to know the primary concentrated sources to be able to diagnose the distribution of PTGTE in groundwater, understand its distribution pattern and improve management policies. Also, the BRIDGE method was revised in order to improve the links between dissolved elements and main lithologies. The application of statistical tests to distinguish the influence of prevailing pressure on trace contamination helps to evaluate the dataset confidence for Natural Background Levels (NBL) calculation by discarding data when necessary. The method, applied for 8 elements (SO4, As, Cd, Cr, Cu, Ni, Zn and F) constitutes an important contribution to the definition of NBLs which should be further consolidated by regional studies and at national levels for the Water Framework Directive.
Linking aquifer microbial ecology and diversity to contaminant transforming processes at European groundwater-surface water transition zones concerned 3 case studies within two countries due to COVID restrictions.
Nitrate and pesticides transfer: Denitrification process is important as it allow a decrease of N concentration in water. This natural processes can be used in order to maintain or obtain high quality water for example building wetlands or keeping the geochemical conditions allowing this process. In the pressure-impact studies it is necessary to know where denitrification occurs in order to correctly evaluate the location of the main pressure and to differentiate dilution to denitrification. This is important as denitrification is not a permanent processes and anthropogenic activities may lead to the decrease of the denitrification process and subsequently a drastic increase of NO3 concentration in groundwater. The Redox potential map established within HOVER and published in the EGDI is therefore an important tool for stakeholder in order to analyse the apparent discrepancy between pressure and concentration of nitrate in groundwater. In some cases, knowing the extent and potential of denitrification may be a parameter taken into account in the N fertilizer management plans.

Evaluating transfer time of nitrate in the unsaturated zone is needed to explain time lag between actions and chemical quality recovery. Travel times have significant implications for management of nitrate pollution and the pilots show that there are significant time lags between nitrate losses at the base of the soil zone and receptors. Harmonised travel time maps produce in HOVER and published in EGDI will support decision makers and the EU to evaluate the efforts, in time, before a global decrease of nitrate in groundwater. Furthermore, maps of nitrate stored in the unsaturated zone established at EU scale derived in HOVER can be used as a screening to evaluate whether further regional to basin scale investigations into nitrate transport in the unsaturated zone are likely to be required. Trend (rather than threshold)-based, multidecadal scale monitoring and evaluation of the impacts of measures to reduce nitrate concentrations at receptors are required. Evaluations of measures put in place to reduce nitrate concentrations should take into consideration the diversity of hydrogeological settings.

The work performed on « groundwater age distribution » included a great diversity of actions with the aim to better use this information for groundwater management through more than 20 case studies, synthetic documents and specific studies carried out in Denmark and The Netherlands. The presented case studies presented here serve to reinforce the general principle that multiple sampling points with multiple environmental tracers (stable and radioactive isotopes including 39Ar, noble gases, groundwater temperature, and water chemistry) are needed to provide the information necessary for an adequate characterization of mean groundwater ages along flow paths together with available resources or vulnerability of aquifers. One important conclusion of the guidance document on trend estimation and age dating would be the paradox linking the concept of mean residence time and the measurable effects of any pressure change on the aquifer. As it is may appear to be urgent to see the effect of a mitigation measure, it should be kept in mind that aquifers with long residence time will have a long and delay answer to this change. In some extent, it could be think that it is more urgent to act on 'old' groundwater, as effects will be longer to be seen, and pollution would stay longer in the USZ/aquifer. Appreciation of this memory effect of the aquifer is exactly the goal of the environmental tracers, and a certainly good motivation to use them. A database structure for groundwater age tracers was proposed and made available in the EGDI for further development.

The well recognized DRASTIC and COP (for karst aquifers) methods were applied at the pan-EU and pilot scale for the assessment of the vulnerability of upper aquifer to pollution. The vulnerability maps obtained are important tools for groundwater management, through which specific high vulnerability areas can be identified and preventive or corrective actions can be taken at different scales for their protection. This also represents a first step to satisfy the urgent need of comparable vulnerability assessments across Europe, providing foundation for common policy and regulation implementation. This was made possible through the agreement reached regarding the DRASTIC rating scheme which is valid for all pilots and pan-EU application, ensuring comparability between pilots (and in-between them) and the PAN-EU map (and hence specific national vulnerability methods). Supplementary, the application

of a method to summarize the affected aquifer volumes per DRASTIC vulnerability class using 2D representative conceptual cross sections allows users to quantify the potentially vulnerable aquifer volumes to pollution. HOVER provided the map and related data sets through EGDI that can be reusable for further studies.
For contaminant of emerging concern it seems essential to prioritise monitoring locations in order to minimise uncertainties caused by limited sampling. As a means of achieving effectiveness of groundwater monitoring programmes, comprehensive knowledge of physical processes jointly with the purpose and objectives of monitoring are required. The first and most critical step to improve their efficiency is the elaboration of a sound hydrogeological conceptual model. In HOVER it was considered primary factors, additional drivers, features of prevalent contaminant and source area processes. Among the primary factors, Soil properties (Organic carbon content, pH and clay content), the properties of the Physical Structure (Lithology), Aquifer and Groundwater properties (Groundwater parameters, Unsaturated zone thickness, Hydraulic conductivity, Age, pH, Redox conditions, DO), Hydrological processes (Relationship river-aquifer, Climate, Flow condition and Seasonal variation) have proved to be useful for the posterior interpretation of data, so they must be considered and recorded whenever possible. Guidelines for the establishment of quality standards (threshold values or maximum contaminant levels) were also proposed. Recommendation for monitoring the contaminant of organic concern (CEC) highlighted some important points sur as i) sampling has been recognized as a key point in the measurement chain and for its quality, ii), the delay between sampling and analysis is also an important parameter. On the analytical level, new methods using high-resolution mass spectrometry and allowing the acquisition of a complete "fingerprint" of a sample are methods of the future, particularly for the monitoring of emerging pollutants. the chemical expertise of laboratory staff is necessary for a good definition of the parameters to be analyzed. Finally, the validation of analytical methods remain, for emerging pollutants as for other pollutants, important elements of the quality of the results.

Expected impact (from Project Agreement):

The results of WP3 are of importance – first of all – for water management. There will be an international exchange about different approaches concerning special groundwater. WP3 will deliver a WMS (web Map service) which is not only interesting for the water management of bottled mineral water, but also for the beverage industry (at the AQUA 2015 - International Hydrogeology Congress in Rome it was criticised by a representative of a European association of mineral water producers that there do not exist a pan European overview on mineral water). Furthermore, an overview on medical springs and spas could be of interest for tourism industry and health service.
The work package will also increase political and public awareness of health issues related to groundwater quality permitting, by developing and mapping indicators, a quick overview on a homogeneous way of the sectors with high concentration of toxic

or adverse effect dissolved elements.
Delineating the range of concentration of elements of natural origin over European aquifers will be of great support for the implementation of the water framework and groundwater directive in giving a homogeneous basis for deriving at national level the threshold values to be used in the evaluation of the chemical status and the risk evaluation.
Based on indicators and maps best practices in GW management recommendation will be proposed on i) data quality monitoring, ii) data treatment, iii) delineation of indicators in relation to geological families and case studies of specific GW exploitation in areas of high natural background level would be compiled.
The development of a framework for groundwater ecosystem assessment (WP4) will provide information on presence of degraded bacteria and potential degradation activity and reduce costly monitoring of contaminants at the GW-SW interface in future. Evaluating the potential degradation of the surface water (rivers, humid zones...) due to groundwater, requested by the WFD and helping management of drinking water wells are quite complex and need a great amount of data. Looking for indicators such as bacteria is one of the tools with good application perspectives at basin scale.
The proposed work under WP5 should lead to the development of better groundwater protection strategies through establishing travel times for nitrate and pesticides from infiltration to recharge and discharge zones, and thus the time lag between measures and trend reversal and the recovery of water quality. This will assist stakeholders in the evaluation of measures including NVZ (nitrate vulnerable zone) designations. This data is also needed at the time of making the evaluation of the efficiency of programme of measures to reduce impact of pollution pressure associated to diffuse agriculture. Indeed, delay between the application of corrective actions and the decreasing trend of contaminant concentrations in groundwater makes difficult not only the confirmation of the efficiency of measures but also the awareness of stakeholders.
Geological and hydrogeological settings will also be the entry point to classify the samples in age intervals (WP6) as an indicator of the susceptibility/vulnerability of the aquifers to contamination from human activities on the surface, elevated toxic geogenic elements in deeper aquifers and overabstraction. This information, combined with other indicators, is of great importance for better groundwater protection strategies. The project will aim at demonstrating the use of groundwater age distributions for design and assessment of monitoring programmes, pollution trends and history and the evolution of groundwater quality (chemical status).
The main outcome of the project idea developed under WP7 will be harmonized assessment products for groundwater vulnerability to pollution. The main deliverables are maps that can be used in groundwater management, subsurface spatial planning and environmental decision-making processes both at least national and regional scales, and at a cross-border scale. The project will result in methodological harmonization and the establishment of data interoperability at Cross Border, Pan European optionally national scales. More in detailed the project will

permit to contribute to national and EU general activities in fulfilling the objectives of the WFD, and to national and regional authorities in environmental assessment and strategic and regional planning; support European-level strategic assessment, planning and forecasts and provide coherent, pan-European dataset for testing the impact of policy changes (e.g. intensified agriculture or reduced nutrient application) on groundwater.

The WP8 will help European countries to identify ECs of high concern regarding global pan-European settings and adapted to local specific contexts and knowledge and will:

 allow wide access to reliable data to support decision making such as groundwater protection

 New challenges in sampling and analytical methodologies developments regarding the increase of the number of substances of interest and the need for streamlining the ECs monitoring across Europe

 A key outcome will be an overview of GW monitoring status of ECs across Europe. Collected ECs occurrence data will be supplied to the European Commission Data Base IPCHEM.

 The development of novel methods to link EC presence with anthropogenic activities, environmental conditions and co-occurring tracers will help to identify hot spots regarding GW contamination by ECs.

 Identify what are the chemical properties that can be used to estimate the leaching potential of ECs to GW and to evaluate how to take into account usage data in risk assessment procedure

 supporting the implementation of the GW "watch list", definition of pollutants of concern and subsequent consideration for Annex I and II revision, further work is required to ensure effective monitoring is undertaken that is consistent across the EU and enables long term protection of GW, human health and GW dependent ecosystems.

Overall impact of this GeoERA initiative is the compilation and delivery of harmonized, interoperable and comparable geoscientific information, contributing to national and EU general activities in fulfilling the objectives of the WFD. The degree of harmonization depends on data availability, scale of investigation and applied methodology. The improved databases and visualization tools proposed related to thermal and mineral water distribution, natural background levels and related indicators, vulnerability assessment, on groundwater age tracers and indicators currently existing in EU member states are some of the products that will be produce at pan-European scale for supporting health and environmental issues related to the quality of groundwater.

Also, best practice guidance from demonstration projects will be proposed in different hydrogeological settings to support harmonized management strategies and most widely:

- to apply statistical data treatment related to the development and mapping of indicators
- to define the best methodology to organize and visualize data collected

- to test and develop new techniques for estimating age distributions of groundwater bodies - to monitor key parameters with reference to environmental context, geological setting and risk assessment.

Evaluation of deliverables

No.	Title	Status (Approve/ Reject)	Comments
D1.2a	Project progress report	Approved	
D1.2b	Final project report	Approved	
D1.3b	Cumulative expenditure report 2019	Approved	
D1.3c	Cumulative expenditure report 2020	Approved	
D1.3d	Cumulative expenditure report 2021	Approved	
D2.2b	Provision of data for upload and testing of GIP second version	Not provided	See comment below
Data submitted to GIP-P and published on EGDI platform: https://geoera.eu/projects/gip-p/			
D2.3b	Article(s) submitted to international peer reviewed journal(s)	Approved	
D3.3	Data set of the results of the statistical data treatment allowing the preparation of the raw elements for the tasks 4 and 5 i.e. concentrations of elements of natural origin per typologies	Approved	
D3.4	Compilation of indicators, analyses of possible use at pan-European scale and test application in countries of contrasted main litho/geology	Approved	
D3.5a	Data model and the legend of the planned web service	Approved	
D3.5b	Development of European exposure maps of selected elements (and indicators) based on GIS interpolation of measurements	Approved	
D3.5c	Support to GIP for the development of a Web Services with multi-lingual legend concerning special ground water in Europe	Approved	
D4.2	Degradation and mineralisation of selected contaminants in European GW-SW transition zones as input to task 4.3	Approved	
D4.3	The use of microbial diversity measures for monitoring contaminant transforming processes at GW-SW transition zones	Approved	

D5.2	Datasets with characterization of these settings relevant for agrochemical transport	Approved	
D5.3	Assessments of N travel times for a number of relevant European settings	Approved	
D5.4	Assessments of attenuation patterns for a number of relevant European settings	Approved	
D5.5	Maps of groundwater-N travel time – pan-European if there are sufficient partners	Approved	
D6.1a	Database for concentrations of groundwater age indicators, estimated mean ages and age distributions, vulnerability classes and associated guidance	Approved	
D.6.1.c	Maps and cross sections on the information platform / EGDI showing spatial distribution of groundwater age and vulnerability classes in selected European aquifers	Approved	
D6.2	Collection of use cases including good practice guidance and age indicator sampling guide	Approved	
D6.3	Recommendations for estimating groundwater age distributions and the application of these in groundwater monitoring and quality estimation (including trend assessment)	Approved	
D6.4	Investigation of age distributions in water supply wells with long screens and recommendations for application of tracers and models mainly for estimating groundwater ages between 10 and 1000 years	Approved	
D7.2	Compilation of the examination results of the data sets of input data for the respective methodologies assessing vulnerability of the upper aquifer to pollution.	Approved	
D7.3	Provision of scale and data-dependent products on the vulnerability of the upper aquifer to pollution using GIS.	Approved	
D7.4	Delivering of cross sections and maps of extend of selected aquifers in specific national pilot areas	Approved	
D8.1b	Critical review report of non-published European-monitoring results for organic emerging contaminants	Approved	
D8.2	Report with recommendations for monitoring of key parameters with reference to environmental context, geological setting and risk assessment	Approved	

D8.3	Report describing new sampling analyses and interlaboratory tests directed towards potential hotspots for emerging contaminants transport	Approved	
D8.4	GIS-layers published by a GeoERA (EGDI) web service on the selected ECs	Approved	
D8.5	Concrete proposal and design for an EU wide monitoring program customized to emerging pollutants of high concern	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 HOVER project aims to gain and improve the understanding of the groundwater quality controls as the main drinking water resources in Europe using the combined expertise and data held by member states. The project is addressing groundwater management issues related to drinking water, human and ecosystem health across Europe in relation to both geogenic elements and anthropogenic pollutants by data sharing, technical and scientific exchange. The project comprises 8 work packages, from which two are coordination based (WP1 and WP2), while other 6 are technical WPs. One WP consider natural geogenic processes and four are focousing on anthropogenic contaminants. WP6 is focused on groundwater age distribution considering both geogenic and anthropogenic water types.

Most of the WPs develop specific deliverables. 31 deliverables were subbmited and are included in 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):

HOVER is one of the four groundwater projects. The main goals were therefore towards improvement of groundwater knowledge and preparing tools for water stakeholders. The project focus mainly on relationships between geology/lithology, unsaturated zone characteristics and groundwater quality to ensure that the risk associated with high concentrations of natural origin and human activities are properly characterized to enable protection of groundwater used for drinking water or for supporting dependent terrestrial and associated aquatic ecosystems. Various web tools and maps were developed in pilot sites in a variety of hydrogeological settings over Europe and translated into useful information for decision makers and the public. This work supports the groundwater chemical status assessments required and described in the Water Framework and Groundwater directives and the related guidance documents. The project developed and provided harmonized methodologies and data on hydrostratigraphy/lithology, groundwater vulnerability, quality and age in a number of local, regional and national pilot studies and a pan-EU map as a first step towards harmonization of information at European scale. Progress beyond the current state-of-the-art in demonstrating the merits of uniform approach in lithological, travel time, vulnerability and chemical characterization enabled a European vision of some main groundwater quality problems linked to nitrate, pesticides, emerging contaminants or elements of natural origins such as As or F. HOVER developed various maps and web services in close collaboration with GIP-P in order to integrate European GSOs’ information and knowledge on water to contribute to sustainable use and management of the subsurface. Specially the following products: Web Services with multi-lingual legend concerning special ground water in Europe and visualization of data on natural mineral and thermal waters was prepared. The Web services include data on physico and chemical parameters of thermal and natural mineral waters from 13 countries. Two other maps were built in relation to arsenic and fluoride of natural origin in groundwater. The maps of nitrate travel times through the unsatured zone are based on a series of common, evidence-based conceptual models for nitrate transport in the shallow subsurface. Progress was also made in the evaluation of the state-of-the art in organic emerging compounds monitoring and need to improve sampling, analyses and data interpretation. Data and modelling collected over case studies allowed proposing a web service on the nitrate stored in the unsaturated zone from 1900 up to 2000. Based on data available and methods applied in participating countries a simple common approach was proposed to define the oxic and anoxic environment or mix condition at each sampling point and to prepare a redox potential map that provide valuable information in the

assessment of the migration of contaminants e.g. nitrate in European aquifer systems . A collection of more than 20 use cases of the environmental tracers for groundwater age distribution allowed preparing a good practice guidance, age indicator sampling guide and a database structure for storing and visualizing the distribution of age indicators and groundwater ages across Europe. Finally, the HOVER project enabled the vulnerability assessment of the upper aquifer to pollution at pilot areas and Pan European scale using DRASTIC and COP methods.

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[1] 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.

[1] Wilkinson M, Dumontier M, Aalbersberg I (2016) The FAIR Guiding Principles for scientific data management and stewardship. Sci. Data 3 (2016). Sci data 3:1–9

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 is that the project is expected to ultimately publish more than 10 scientific papers – all the technical work packages have already or will publish in total more than 10 papers within the next half a year – as no research papers were anticipated or listed as deliverables from the HOVER project this is a significant additional achievement, which increase the impact of the project and improve the chances for the partners in the consortium to get involved in other Horizon Europe proposals related to the HOVER topics e.g. In the anticipated new European Partnership – "Water4All – water security for the planet".

Several HOVER partners have already been using their new collaboration experiences and research products in new Horizon Europe proposals, which either have already been submitted or are in the pipeline.

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:

I would say that this project, given its initial goals and available budget, has exceeded the expectations in terms of what it delivered. I enjoyed reading and hearing about the project deliverables and have added a few comments below.

- The project made great efforts and was successful in combining data and carrying out studies involving so many European countries, comparing and harmonizing data bases and methods, more specifically on background level determinations, groundwater age tracers, unsaturated zone travel times, groundwater-surface water studies, vulnerability assessment and emerging contaminants, among others.
- Recommendations for policy and decision-making could be made more specific, for instance on the need to include groundwater age in the interpretation of monitoring data, or to evaluate groundwater travel times in action plans on the restoration of groundwater quality in contaminated aquifers and expected impacts of these action plans.
- Based on the results from this project, it may now be possible to recommend the improvement of national monitoring networks, in a way that observation points are as much as possible representative for the groundwater body

(from a baseline and geogenic contaminant perspective) and land use (from an anthropogenic contaminant perspective). Of course, land use changes over time, to which the monitoring network may need to react, and monitoring wells also need to represent the groundwater flow system (in terms of direction and residence time). Some of the Geological Surveys also have the responsibility of groundwater monitoring, so they could perhaps make a faster link towards improved monitoring.

- I noticed only academic partners were invited as stakeholders, it could be good to also have non-academic stakeholders involved. In particular, it would be useful to have policy and decision-makers in the field attend these presentations on project outputs, challenges and recommendations.
- Regarding the study on groundwater-surface water interactions, follow-up studies should look at: i) upscaling results obtained at the local scale, and comparing the results with other studies done in Europe and worldwide; ii) the role of groundwater discharge on greenhouse gas emissions from rivers and wetlands, considered as hotspots; it is important to compare these sources to the role groundwater plays as carbon sink.
- A note should be added to the use of DRASTIC for vulnerability assessment, in that it is mostly applicable to degradable contaminants. It will not work well for nitrate contamination in oxic conditions, as nitrate is then very stable, and its concentration will be more affected by the dilution potential of an aquifer (see e.g. Stigter et al. (2006), doi 10.1007/s10040-004-0396-3, and other studies where an attempt was made to validate the results of DRASTIC).

Stakeholder two evaluation:

The HOVER project has been developed correctly and in line with the initial program, using the available budget to reach the declared goals. Final results, well exposed in the content of the deliverables, represent a significant improvement of the knowledge and of the research in the field of groundwater quality investigation and monitoring. Thus, the project overachieved the initial expectations. Some short comments are listed below:

- All the investigated topics, including background level evaluation, groundwater age tracers, unsaturated media travel times, surface water/groundwater interactions, vulnerability assessment and approach to emerging contaminants, have been successfully analysed, comparing data and case-studies from several European countries; a very relevant engagement and coordination was required to harmonize methods and results, offering a future common platform to be easily used at EU level;
- Obtained results on groundwater quality issues will be useful also for policy development ad national and EU scale, offering several inputs able to improve the monitoring and the quality evaluation procedures; to transform simple recommendations in useful recommendations, I suggest the

preparation of specific guidelines and/or policy briefs, e.g. according with the new ZERO POLLUTION ACTION PLAN just launched by EC

- I agree with the suggestion by the other stakeholder to use the HOVER results as a starting point for reviewing the selection of relevant groundwater points of the national monitoring network; this would be done considering both the need to correctly represent the groundwater flow of each groundwater body (quantity issues), and at the same time to have a significant point in terms of groundwater quality, able to show the geogenic/environmental conditions and where necessary the human pressures too; this is not an easy task, but the results of this project and of the GeoERA program in general, clearly highlighted the need to upgrade the significance of monitoring networks at national and international scale;

An additional recommendation is to use the obtained significant technical and scientific results to promote a shift of knowledge towards a citizen/social science, firstly using FAIR principles in data sharing (a very relevant reached goal by the project), and as soon as possible opening the door to stakeholders coming from the society, representing both the main users and the civil associations, not forgetting young generations/scholars; official data, methods and guidelines published and promoted by the National Geological Surveys can strongly improve the perception of the relevance of groundwater in daily life; in this direction, I suggest to promote this debate in 2022, namely the “international year of groundwater” (see World Water Day “Making the invisible visible”)

Annex 1: Review meeting list of participants

Name	Role	Organisation
Joop Hasselman	GeoERA coordinator	Netherlands Organisation for Applied Scientific Research
Marco Petitta	GeoERA Stakeholder	University of Rome
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
Luka Serianz	Scientific Reviewer	Geological Survey of Slovenia
Klaus Hinsby	Theme coordinator	Geological Survey of Denmark and Greenland
Laurence Gourcy	HOVER Project manager	The French Geological Survey
Daniel Elster	Project member and WP3 lead	Geological Survey of Austria
Jens Aamand	Project member and WP4 lead	Geological Survey of Denmark and Greenland
Mathew Ascot	Project member and WP5 lead	British Geological Survey
Stefan Broda	Project member and WP7 lead	Federal Institute for Geosciences and Natural Resources, Germany
Benjamin Lopez	Project member and WP8 lead	The French Geological Survey