



earthresQue

Annual report

2021

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**sfi** = Senter for  
forskningsdrevet  
innovasjon

APRIL 1

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earthresQue

Edited by: H.K. French

Annual report

earthresQue report no. 2

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RCN project 310042

earthresQue, Rescue of earth materials and wastes in the circular economy, is a Centre for Research-based Innovation

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## Summary

Rescue of earth materials and wastes in the circular economy, earthresQue, hosted by the Norwegian University of Life Sciences (NMBU), is a Centre for Research-based Innovation (SFI) financed by the Research Council of Norway (RCN) and the consortium partners. The background for the centre is that contaminated soils, construction and demolition waste, slag and ashes make up more than 70% of landfilled material. In addition, large amounts of clean surplus masses from construction activities ends up in landfills. This is a waste of valuable resources and space. Improved technologies and systems for sustainable handling and treatment of waste and surplus masses requires a cross-disciplinary approach and are the focus of the earthresQue centre.

earthresQue facilitates and encourages innovation through research initiated by the needs of the user partners from the construction and waste management industry to the public sector. The centre has 24 user partners representing different parts of the material flow and value chain, all work in close collaboration with 8 research institutions.

Examples of innovations include techniques to sort valuable from hazardous wastes, new treatment processes for contaminated soils, and new technologies for making new raw materials and products from surplus masses. Furthermore, new methods to control and purify landfill leachate, and monitor gas leaks from landfills are needed. System innovations to be expected from the centre include new economic criteria and tax regulations to ensure sustainable business models and a circular waste sector. Other important outputs are new Environmental Product Declarations for technical solutions and for recycled earth materials and wastes. The centre will give a significant boost to research, knowledge development and innovation towards sustainable use of earth resources.

The focus in the first year of the centre was to establish a good dialogue with the user partners to identify relevant challenges and test sites. Mapping of obstacles that prevent reuse and recycling were identified through interviews with user partners. These revealed a combination of legal, regulatory, organizational, financial, technical and behavioural challenges. Different mass fractions have been tested in the laboratory

and on site, existing and new monitoring data from old landfills have been evaluated in a novel risk assessment framework. We have also started the work on area-reuse as part of the life cycle assessment methodology.

## Vision and objectives

*“The ambition of the Centre is to become the nationally leading and internationally renowned research and innovation centre for sustainable use of waste earth materials.”*

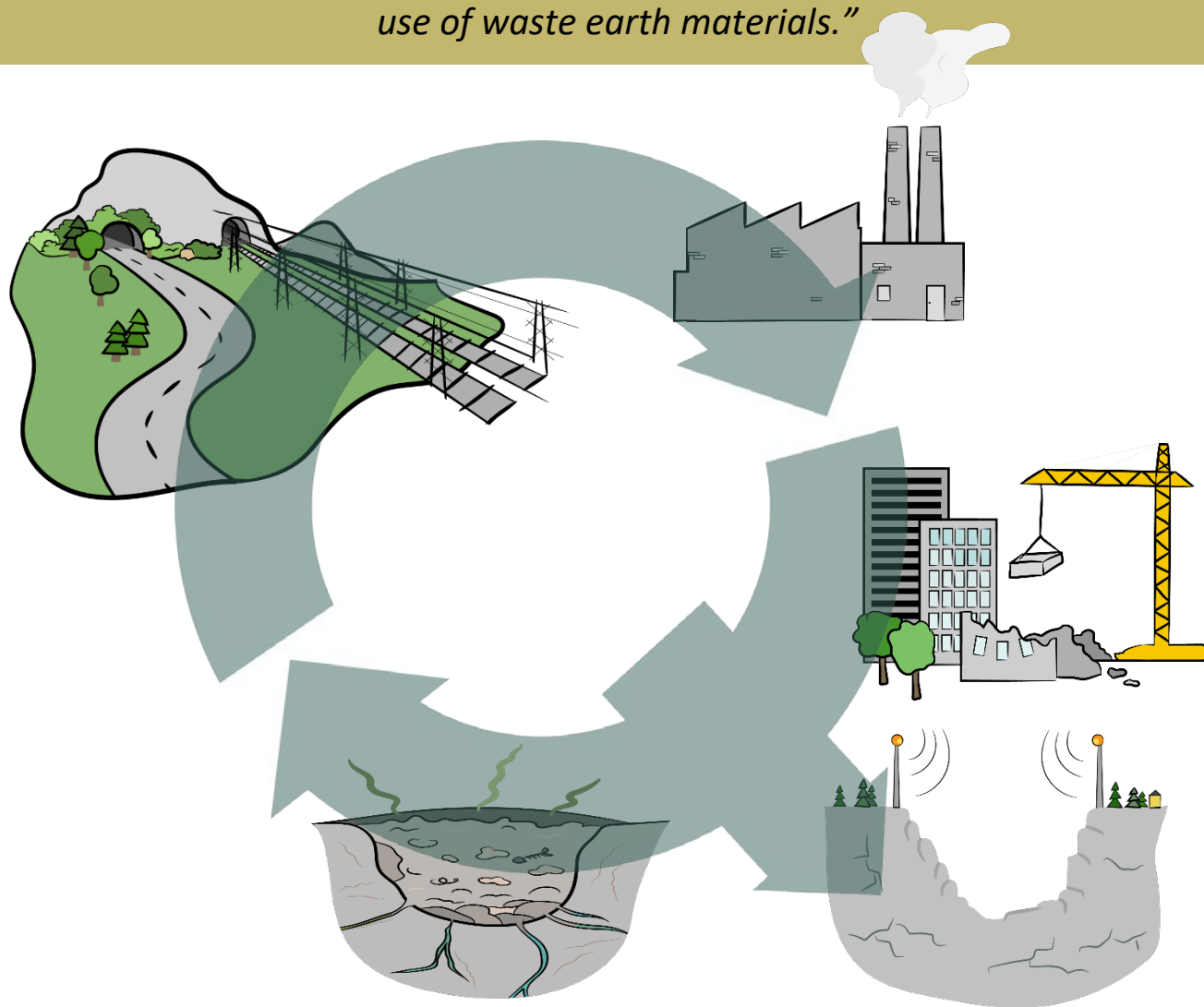


Illustration: Ida Guterud, Lindum

*Figure 1. Earth materials and wastes in the circular economy, topics of the earthresQue SFI.*

The primary objective is to develop technologies, systems innovation, and a governance framework for the most sustainable management and treatment of wastes and earth materials, building on science-based education and information.

### Secondary objectives:

- Recycling and reuse through new treatment processes for contaminated soils, surplus masses, C&D wastes, making them suitable as raw materials in new products. Including management of old landfill sites and sustainable solutions for future landfills.
- Sustainable management, reuse, and recycling of waste materials by developing methodologies and models to assess and document sustainability, including all aspects of environmental, social and economic aspects of recycled materials and treatment methods, based on internationally accepted standards.
- Regulatory framework and governance methodology to remove current obstacles, both in economic, regulatory, and governance terms. This includes optimised material flow and business concepts to encompass society's need for more reuse/recycling and less use of virgin earth materials.

## Research plan and strategy

Our strategy is to focus on the most relevant needs for research and innovation through close communication with the user partners. The user partners have since the proposal work been strongly involved in defining current obstacles for sustainable handling of surplus masses and knowledge gaps. Similar involvement is important for annual detailing of research plans for the short and long term. Research and ongoing projects/activities among the user and research partners are intertwined. Collaborative work is carried out at many levels from applied to state-of-the art research. The research will also be incorporated into the educational programs at NMBU and BI to ensure a competent workforce in the businesses.

### **Innovations in earthresQue will come in three main forms, all contributing to more sustainable innovations and a more circular society:**

- Substitution innovations: replacing existing methods and technologies with new technologies.
- Efficiency innovations: improving technologies and methodologies to improve their results and outcome.
- Market-creating innovations: The latter form embraces new configurations

The user partners of earthresQue identified the following key waste fractions, generated by their activities. In dialogue with researchers among the consortium partners associated research aims were outlined.

- ***Contaminated soils:*** i) reduce transport (cost and distance) ii) reduce costs for soil disposal and purchase of natural aggregates, iii) preserve landfill space, vi) conserve mined natural aggregate resources and reduce environmental and ecological impacts.
- ***Tunnel boring machine material, TBM:*** reduce volumes of full-face tunnel boring machines from larger tunnelling projects to waste sites.
- ***Soft clays, lime-cement stabilized clays and dredged sediments:*** reduce surplus masses from both building and construction (B&C) and harbour dredging disposal to landfills.
- ***Construction & Demolition wastes:*** develop treatment methods for e.g. concrete, in order to re-use wastes in construction materials.
- ***Acid drainage producing bedrock,*** these are a challenge in geologic regions with sulphide containing gneiss (Lillesand region) and black shale (Oslo region): develop novel methods for testing and treatment to mitigate oxidation both on-site (road construction) in in-situ stabilization at landfills.
- ***Ashes from bioenergy plants and bottom ashes from municipal solid waste incineration:*** develop novel methods for utilising ashes as a secondary resource.
- ***Old landfill sites and emissions:*** improve technologies towards obtaining 100% collection and utilization of methane from landfills and reduce pollutants and current risks associated with land fill leachate.
- ***Landfill mining (LM):*** develop methods to, and analyse cost-benefits of, reclaiming old landfills e.g.: remove contaminants, spatial development, recycle materials, extract energy carriers, or reduce costs for aftercare.
- ***New landfills:*** develop safe storage, and control for potential re-use, of toxic compounds and critical waste fractions. Develop methods to keep them out of the recycling loop until safe technology may become available in future.



## Organisation

### Organisational structure



The Centre administration is located at the Norwegian University of Life Science, Faculty of Environmental Science and Natural Resource Management. The centre is led by Centre Director Professor Helen K. French together with Vice-Director Gudny Okkenhaug and administrative manager Ivan Dragicevic. The overall outline of the centre organisation is shown in Figure 2.

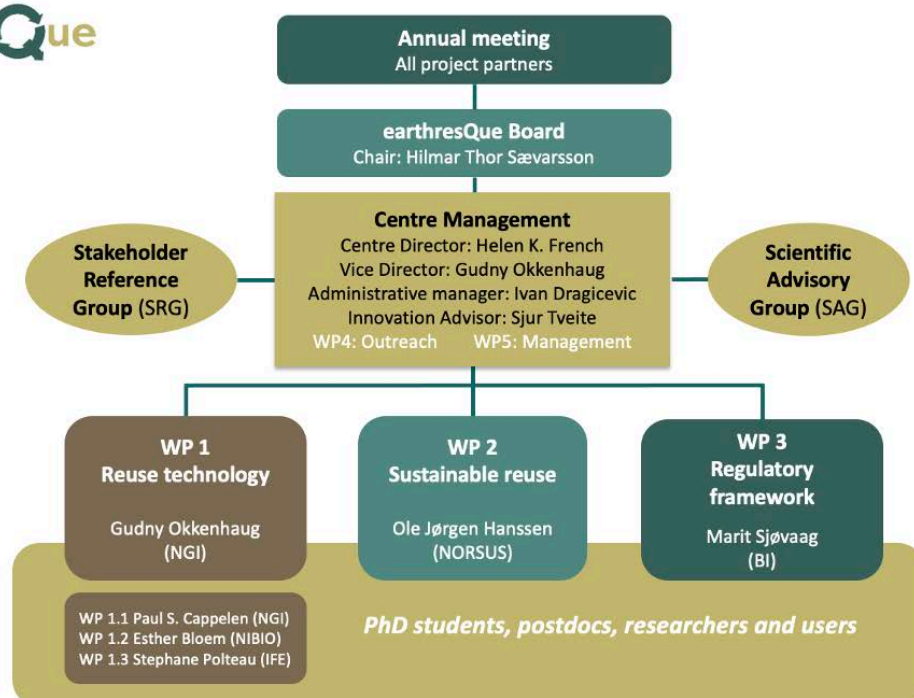


Figure 2. earthresQue organisation.

The Centre Board is the ultimate decision-making body of earthresQue SFI. The majority of its members, including the chairman, are representatives from the private and public

**earthresQue Board members:**

Hilmar Thor Sævarsson, chairman (Lindum AS), Hans Fredrik Hoen (NMBU), Guro Grøneng (NGI), Thomas Hoholm (BI), Hanne Lerche Raadal (NORSUS), Thomas Henriksen (AF Decom), Andreas Olaus Harstad (Skanska), Magnus Sparrevik (Forsvarsbygg), Lise Reinertsen (Bergen kommune), *Observing member* Tore Sjøiland, seniorrådgiver, The Research Council of Norway.

user partners. The Board consists of 9 members representing major users, the host institution, and the research institutions with WP leadership. The board meets four times a year while the centre management meets with the Board leader every month for informal updates.

The centre management is supported by the Stakeholder Reference Group (SRG) representing the stakeholder community and the Scientific Advisory group (SAG), described under International cooperation. SRG helps the Centre reach a larger group of relevant stakeholders and implement results into relevant organizations and governance units.

**Stakeholder Reference Group (SRG) members:**

Gunnar Grini, from the Federation of Norwegian Industries. Jonas Vevatne, nye Asker kommune. He was previously the Norwegian government's key advisor in construction and property affairs (Statsbygg), building commissioner, property manager and property developer. BANENOR, the Norwegian government agency owning and responsible for maintaining and operating the Norwegian railway network. Lene S. Heier, the Norwegian public road administration. Cecilie Lind Norwegian Waste Management and Recycling Association. Eli Mathisen, the Environment Directorate responsible for regulations and control mechanisms for contaminated masses and land fill sites and Olaf Brastad, Bellona, a NGO implementing sustainable environmental solutions.

Research carried out in earthresQue is organized in five work packages which are connected through tiers of activities illustrated in Figure 3. Workpackage (WP) 1 Reuse technology consists of 3 sub-work packages that are strongly linked and require close collaboration dealing with recycling and reuse of earth materials and waste better designs and monitoring of old and new landfills. Most of the private user partners operate at tier 1 but are strongly dependent on the sustainability and regulatory framework, while our public user partners operate at the regulatory level but manage tier 1 challenges and solutions. The success of new technology developed in WP1 is strongly dependent on the assessment of sustainability of reuse and recycling technologies and practise (WP2) and the regulatory framework (WP3), hence the work tasks require an iterative approach. To ensure a cross-disciplinary approach, it was decided in 2021 to construct the organisation closer to case study sites such as Brånåsen, Slettebakken, Rekefjord, Borg-havn with associated sites with similar challenges. Some cases are focused on mass fraction or contaminant challenges such as e.g. PFAS. Work in the WPs is driven by the research and innovation needs highlighted by the user partners and supporting the dissemination activities (WP4). The management activities (WP5) will encompass all WP activities and partners involved.

#### WP5: Management

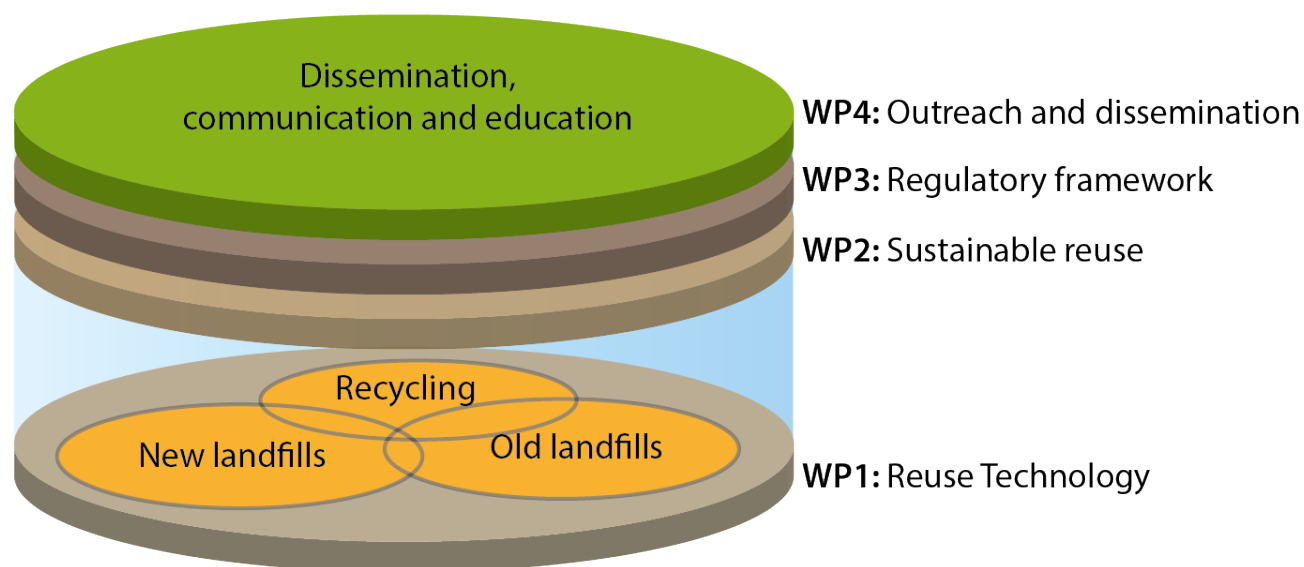


Figure 3. Tiers of workpackages and their interactions.

An overview of lead research scientist of each WP or Sub-WP is given in Table 1. Their background is described further in the Appendices.

Table 1. Main contact person for the work packages.

Work package	Responsible contact	Institution
WP1 Reuse technology	Gudny Okkenhaug	NGI
WP1.1. Recycling and reuse	Paul Cappelen	NGI
WP1.2. Old landfills	Esther Bloem	NIBIO
WP1.3. New landfills	Stephane Polteau	IFE
WP2 Sustainable reuse	Ole Jørgen Hanssen	NORSUS
WP3 Regulatory framework	Marit Sjøvaag	BI
WP4 Dissemination and outreach	Helen French	NMBU
WP5 Management	Ivan Dragicevic	NMBU

An informal *Research Forum* has been established for exchange of results and discussion among PhD students, post-docs, researchers and users that are directly linked to research activities through their facilities, e.g. old landfills, instalment of new steps in reuse/cycling treatment plants. A strong link will be established with existing and new Master programs, and other educational components of the centre's activities.

The centre has established an innovation group with representatives from both private (2) and public (2) user partners. In addition, the group consists of a resource person from the technology transfer office on Campus Ås (ARD Innovation). The centre's innovation adviser is the secretary of the group and is also part of the centre's management. The innovation group will in regular meetings with the WP leaders contribute to the assessment of ideas, results, and further innovation work, and will advise the centre management and the board on utilization and commercialization. ARD Innovation is engaged in the supply of competence and capacity in the ongoing innovation work, and Eik Lab (Center for Student Innovation at NMBU) is involved in connecting students with the project and its user partners. Every quarter, the centre will arrange a seminar or workshop where project participants develop insight and skills in innovation.

The Centre has several interlinked field and laboratory activities, and WP leaders are responsible for the coordination of these. The WP leaders evaluate yearly work-plans and progress based on submitted tasks and progress reports as defined by the proposal.

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As the centre leader, NMBU takes the responsibility of the management and dissemination activities of the project, while the research WPs are coordinated by members of the research partners. Periodic reports contain information about work progress, use of resources, any discrepancies in the work schedule and results. Annual partner meetings are organised by NMBU in collaboration with the partners.

## **Partners**

Our user partners range from municipalities and entrepreneurs to small start-up companies and business clusters, geographically distributed over all of Norway (Fig. 4). They represent an enthusiastic group which combined with our scientific partners creates an inspiring working environment. Close collaboration between the different groups is a prerequisite for understanding the challenges of the industry and society which in turn nurtures creative research and innovation.

### *Research partners*

BI - Norwegian Business School, IFE - Institute for Energy Technology, NGI - the Norwegian Geotechnical Institute, NORSUS - Norwegian Institute for Sustainability Research, NIBIO - Norwegian Institute of Bioeconomy Research, NILU - Norwegian Institute for Air Research, NIVA - Norwegian Institute for Water Research and NMBU - Norwegian University of Life Sciences as centre coordinator.

### *Industrial partners*

AF Decom, Borg havn, Borregaard, Eyde-klyngen, Frevar, Kronos Titan, Lindum, Mivanor/Iris, Innherred renovasjon, NCCE, NOAH, Perpetuum, Scandi Energy, Skanska, Stena Recycling

### *Partners from the public sector*

Bergen municipality, Forsvarsbygg / The Norwegian Defence Estates Agency, Fredrikstad municipality, Lillestrøm municipality, Oslo municipality, Rogaland County, Skien municipality, Viken County and Ås municipality.



Figure 4. Geographical distribution of earthresQue user partners.





### Cooperation between the centre's partners

Despite covid-19, there has been mobility of researchers, personnel, and students between the partners. User partners have been in dialogue with the researchers for outlining objectives of PhD projects. This ensures close collaboration between PhD students and user partners. This has included providing samples, using their facilities to conduct experiments and pilot tests as well as interviewing user partners. Two master's students were employed during the summer period by user partners, Lillestrøm municipality (Brånåsen) and NOAH (Langøya). This work will form the basis for their Master theses. Another master student was employed by NORSUS. Three students finished their master thesis in close collaboration with our user partners; Lindum and Skanska.

Several field excursions were organised in 2021. Employees at NOAH and Lindum visited laboratory facilities at NMBU to provide a better basis for discussing experiments. Researchers from NMBU, NGI and IFE had a two-day field trip to NOAH's possible future landfill in the old rock quarry at Rekefjord, where the researchers gained useful

knowledge about site operations. Several of the partners are also involved in mapping research questions and practical solutions for the dredging of Borg-havn at the outlet of Norway's largest river Glomma in Fredrikstad.



ill. photo: H.K. French, Field visit to Øra -Ramsar wetland site outside Borg-havn, at the outlet of river Glomma

As part of the introductory course in Environmental Science (MINA 302), students visited NOAH Langøya landfill site and a composting facility at Lindum in Drammen. In addition PhD and Master students presented their work within earthresQue to the students.





ill. photo: Sigrid T. Kjær, Students from NMBU visiting the facilities of Lindum

At the annual meeting, all participants were invited to a tour of the soil washing facility of AF Decom at Nes Environmental Park.



ill. photo: NMBU, earthresQue partners visiting NES miljøpark, AF Decom during the annual meeting in 2021

## Scientific activities and results

**Contaminated soils:** We are looking into barriers for reuse of contaminated surplus masses in construction and building projects. Research is focused on the risk of spreading contaminants from reused materials, either masses can be sieved on site or treated at an external facility (Fig. 5). The leachate of pollutants from the reused masses are compared to leachate from pristine masses from quarries for reference. To do this we will construct 1m<sup>3</sup> lysimeter containers and observe pollutants in the leachate over time from different masses. Other focus areas are on PFAS contaminated soil and water, and contaminants from shooting ranges. We have also started the work on ways of including area-reuse in life cycle assessment.

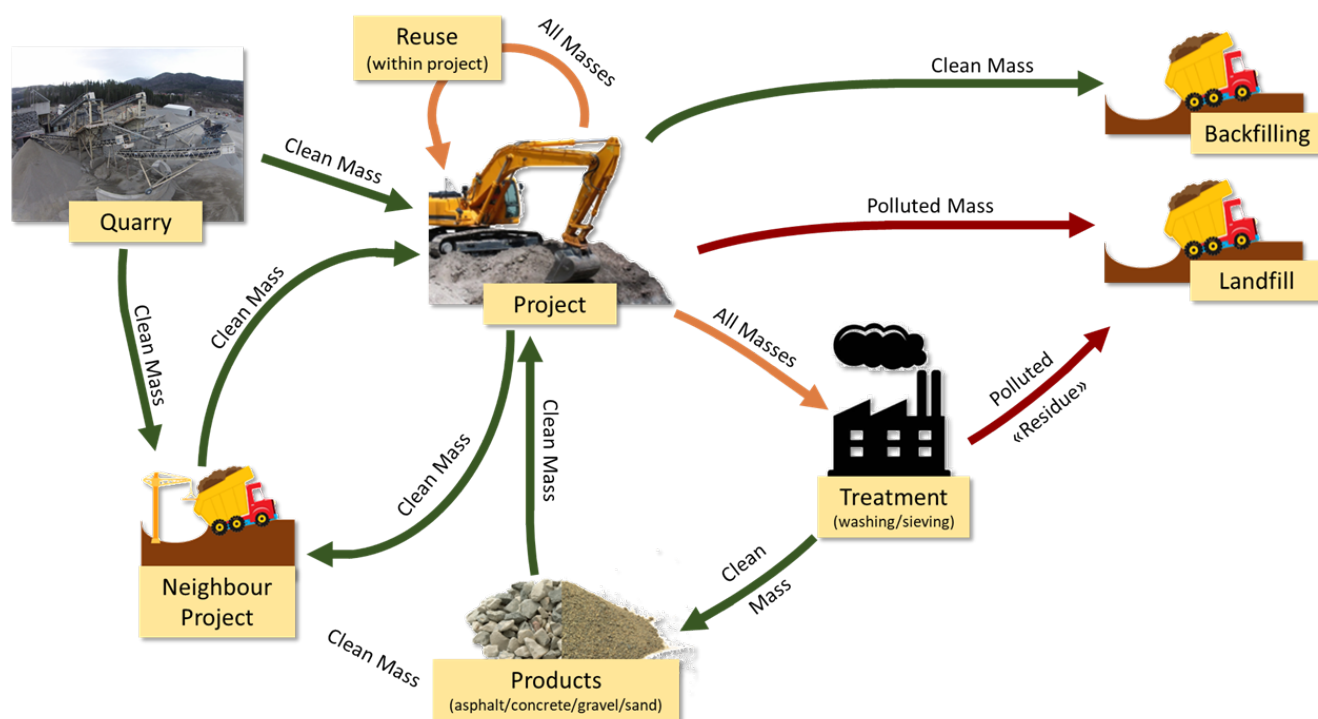


Illustration: Andreas B. Smebye, NGI

Figure 5 Re-use of earth materials requires improved knowledge on the risk of spreading contaminants from reused materials, treatment can include sieving on site or treatment at an external facility

**Tunnel boring machine material, TBM:** The TBM pulp contains fines, which means that the pulp can be sensitive to frost heave. In addition, it has less favourable grain shape



compared to blasted rock mass from the same rock. The flat grains are crushed at the edges. In earthresQue we will continue the work started in GEOreCIRC. This concluded that re-use, although the material was uncontaminated, requires good sampling and testing procedures for selecting suitable applications. This will be done in collaboration with Skanska and Oslo kommune's work on a tunnel for new water supply for Oslo, this project will provide several million m<sup>3</sup> of TBM.

***Soft clays, lime-cement stabilized clays and dredged sediments:*** Lime and cement bind water and increases the strength of quick and soft clay and is used in most constructions projects where this is a problem. After the infrastructure is in place most of the lime stabilised clay is driven to a landfill. We are testing different properties of this material. Reuse of fine-grained geological material such as lime cement stabilized clay from building and construction projects or press filter residue (PFR) from the soil washing



ill. photo: Stefan Ritter, Testing alternative materials for top cover at NOAH Langøya

plant of AF Decom at Nes Miljøpark has initially been investigated in the laboratory for its suitability as impermeable layers in constructed geological barriers. This can, for example, be used as top cover of closed landfills. Compression properties have been tested at NOAH Langøya.



Ill. photo: Stefan Ritter, Testing alternative materials for top cover at NOAH Langøya

Work on sustainable reuse of dredged sediments has started through a feasibility study near the outlet of Glomma in Fredrikstad. Several of our partners are involved here. Our user partner Borg-havn will dredge the outlet to ensure sufficient depth for harbour activities. Sustainable reuse of the dredged sediments requires technology for sorting, to remove contaminants, and sensible re-use of these sediments. The site will be one of our case studies



**Construction & Demolition wastes:** In earthresQue we are continuing the work started by NGI in collaboration with the Norwegian Environment Agency and the industry, to examine the release of Cr (VI) from concrete. As a result of this work, a threshold for Cr (VI) was established for the use of concrete in construction work. Tests on concrete from demolition projects have been performed, for example for the treatment of acid-forming rocks, this took place at the study sites NOAH Langøya and Lindum Oredalen. This also includes long-term studies of black shale with monitoring of acid formation and effect of treatment. Research fellow Cathrine Eckbo (NGI/NMBU) received a Norwegian Environmental Award (Miljøringenprisen) 2021 for her work with sustainable recycling of concrete. This award acknowledges research projects with results and innovations that are highly relevant to the industry. <https://miljoringen.no/miljoringenprisen-for-2021-gikk-til-ngi-prosjektet-baerekraftig-jendvinning-av-betong/>



ill. photo: NGI, How can materials from demolition be reused?

**Acid drainage producing bedrock,** these are a challenge in geologic regions with sulphide containing gneiss (Lillesand region) and black shale (Oslo region). earthresQue

will develop novel methods for testing and treatment to mitigate oxidation both on-site (road construction) in in-situ stabilization at landfills. Leaching of heavy metals from black shale taken from a road construction project at Jevnaker was examined in columns studies in the laboratory. The leaching from fine and coarse alum shale is higher than the threshold value of 30 µg U/ L, while Bjørkåsholm black shale is lower and near the threshold value, most likely because of a lower content of sulphide minerals and a higher content of carbonate minerals. Hence these properties of the bedrock are important to map prior to road construction.

***Ashes from bioenergy plants and bottom ashes from municipal solid waste incineration:*** The work to develop novel methods for utilising ashes as a secondary resource is in its initial phase, though some collaborative activities for included ashes in other products has started.

***Old landfill sites and emissions:*** At the closed landfill at Brånåsen in Lillestrøm, the subsurface was examined with electrical resistivity tomography, (a geophysical method) Figure 6. Gas emissions (methane) due to the decomposition in the old landfill masses was also measured at the same site. The goal is to understand how water flow and distribution of landfill masses affects gas releases, and how the environmental conditions around such sites can be improved. This will provide knowledge to better assess local mitigation options.

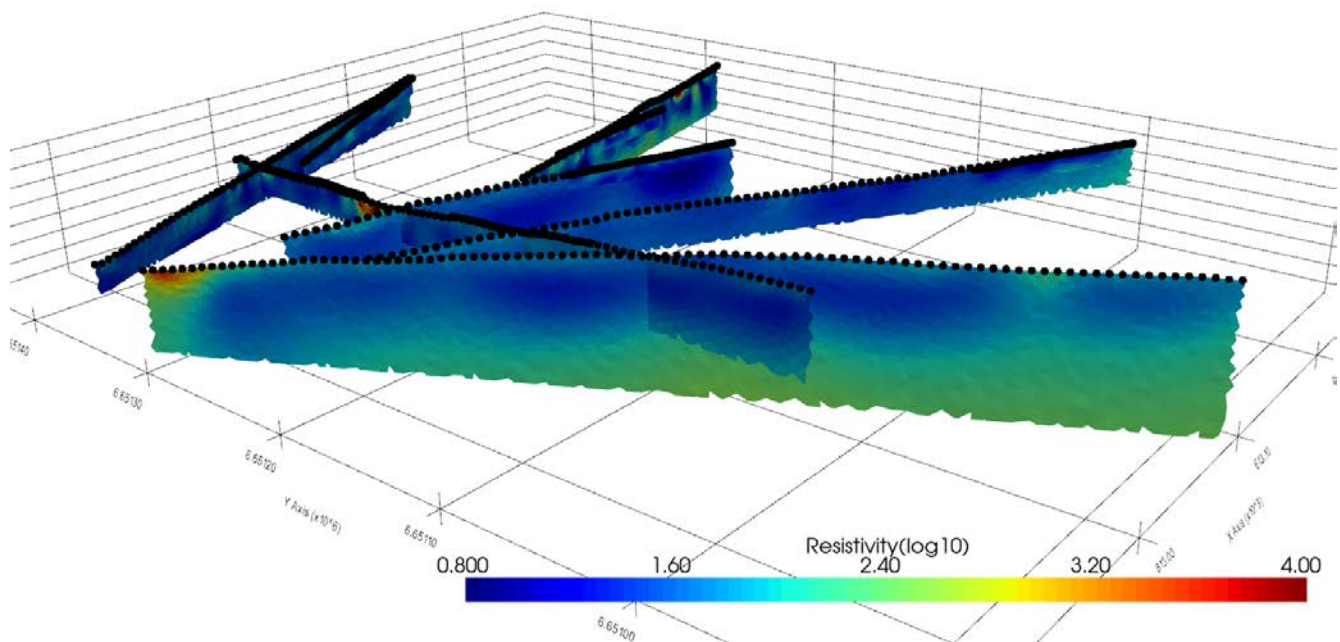


Figure 6 Preliminary inversions and visualisation of electrical resistivity distribution at Brånåsen, Malin Hassum and Fredrik N. Kleven, ResIPy. The green colour in the 2D profile in front is interpreted as the underlying bedrock.

**Landfill mining (LM):** Work in the landfill mining group defined the following knowledge gaps and challenges for landfill mining in Norway:

- Better defined methodology for classifying existing landfills (old landfills) and their contents.
- Address inconsistencies between different regulations/guidelines, and possibly revise some of these, e.g. TA 2553 (Health-based contaminant levels for contaminated soil, the Norwegian Environment Agency).
- Better methodology for sorting and cleaning with the aim of increased recycling
- Preparation of regulations related to disposal of removed landfill site masses, as well as ensuring that legal solutions for re-disposal are available.
- Create certification schemes and regulations that make it easier to sell clean products at the end of the cleaning process

**New landfills:** We are in the process of developing methods to ensure good assessment methodologies for the documentation of potential sites for new landfills, e.g. in disused rock quarries. Water and contaminant transport at such sites, take place in fractured systems - these are highly complicated to map and model the effects of, hence research is needed. A MSc and a PhD student are working together at this case study site to map



the fracture network based on advanced laser scanning methods on the rock face combined with borehole hole methods.



ill. photo: H.K. French, Installing automatic sensors to monitor groundwater fluctuations and temperature at NOAH's site at Rekefjord.

## International cooperation

International collaboration is important to ensure state of the art knowledge is brought into the centre, but also to make the centre known internationally. In 2021 PhD students from Germany and Pakistan were included in the centre. One of our PhD students is funded by Marie Skłodowska-Curie Actions & Support to Experts, and will include a research stay in Canada through Grant Agreement number: 778120 - Geomaterials: from Waste to Resource (GeoRes). We have also participated in proposals for student and staff exchanges, stays abroad and recruitment of international scientists, including a Marie Curie application for a joint PhD with Luleå University of Technology. University of Nancy, France is the project manager.

earthresQue researchers have international collaboration with the EU funded project



RAWFILL (INTEREG project) supporting a new circular economy for RAW materials recovered from landfills

<https://www.nweurope.eu/projects/project-search/supporting-a-new-circular-economy-for-raw-materials-recovered-from-landfills/>

earthresQue researchers have also had collaboration with Paperchain, an EU funded circular economy project (<https://www.paperchain.eu/the-project/>)




The earthresQue Scientific Advisory Group (SAG) gives expert advice to the centre management and can take part in all partners meetings, conferences and other activities where research and innovation plans and main results are being discussed. The SAG can help the centre align to state-of-the-art knowledge and provides an excellent platform for establishing spin off projects.



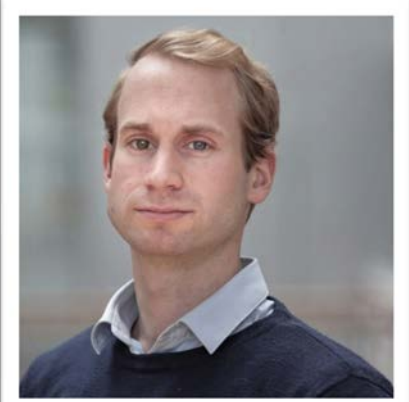
**Scientific Advisory Group (SAG) members:**

- Dr. Thomas Pabst, Polytechnique Montreal, Canada (Hydrogeology and mine-tailings)
- Dr. Christian Maurice, Luleå University of Technology, Sweden (Reuse of surplus masses and mineral waste)
- Prof. Anders Damgaard, Danish Technical University, Denmark (Modelling of incineration, landfilling and recycling of household waste)
- Prof. Andrew Binley, Lancaster University, UK (Hydrogeophysics)
- Dr. Kristina Lundberg, Ecoloop and Luleå Technical University, Sweden (Sustainable rock management)

## Recruitment

### Active earthresQue associated PhD students in 2021

	<p>Title: PFAS stabilisation with waste Main supervisor: Jan Mulder, NMBU earthresQue Work package: 1.1</p>
	<p>Title: Leaching properties and acid neutralisation effect of crushed concrete waste for sustainable concrete recycling Main supervisor: Gudny Okkenhaug, NGI og NMBU earthresQue Work package: 1.1</p>
	<p>Title: Tracing carbon in landfills Main supervisor: Peter Dörsch, NMBU earthresQue Work package: 1.2</p>

	<p>Title: Characterization of fractured rock and flow modelling to determine the natural geological barrier for new landfill sites Main supervisor: Helen K. French, NMBU earthresQue Work package: 1.3</p>
<p>Jan Schneider</p>	<p>Title: Radionuclides and the geological environment Main supervisor: Ole Christian Lind, NMBU earthresQue Work package: 1.3</p>
	<p>Title: Ecosystem resource management in the Norwegian Defence system Main supervisor: Ole Jørgen Hanssen, NORSUS og NMBU earthresQue Work package: 2</p>
	<p>Title: Circular construction industry: organizational conditions for sustainable mass handling Main supervisor: Debbie Harrison, Handelshøyskolen BI earthresQue Work package: 3</p>

## Communication and dissemination activities

Results from the project have been presented internally and externally. Several presentations have been given at national seminars and meetings in forums that are relevant to user partners. The centre has established a close collaboration with Avfall Norge (Norwegian waste management and recycling association) a central network for many of our user partners but gives a wider outreach. Due to covid-19, participation in international conferences has been minimal. We are in the process of planning how the educational institutions NMBU and BI, can improve the knowledge basis and educate candidates with a suitable background for the industries represented by our user partners.



earthresQue research in the media

## Appendices

### A1 Personnel

Key Researchers		
Name	Institution	Main research area
Helen K. French	NMBU, MINA	SFI coordinator, Hydrogeology
Peter Dörsch	NMBU, MINA	Soil agronomy, nitrogen cycle
Åsgeir Almås	NMBU, MINA	Soil Chemistry
Jonathan Coleman	NMBU, MINA	Nature restauration
Ivar Maalen-Johansen	NMBU, Realtek	Geomatics
Gudny Okkenhaug	NGI	Environmental chemistry, Environmental Geology
Andreas B. Smebye	NGI	Environmental chemistry, Environmental Geology
Stefan Ritter	NGI	Environmental geotechniques
Håkon A. Langberg	NGI	Environmental chemistry, Environmental Geology
Paul Cappelen	NGI	Environmental chemistry, Environmental Geology
Cathrine Eckbo	NGI	Environmental chemistry, Environmental Geology
Frøydis Meen Wærsted	NGI	Environmental chemistry, Environmental Geology
Sarah Hale	NGI	Environmental chemistry, Environmental Geology
Ole Jørgen Hanssen	NORSUS	Sustainability, life cycle assessment, waste resources
Hanne Lerche Raadal	NORSUS	Sustainability, life cycle assessment, waste resources
Kari-Anne Lyng	NORSUS	Sustainability, life cycle assessment, waste resources
Mafalda Silva	NORSUS	Sustainability, life cycle assessment, waste resources
Marit Sjøvaag	BI	Governance
Espen Skaldehaug	BI	Economics
Eivind Furuseth	BI	Tax law
Caroline Dale Ditlev-Simonsen	BI	CSR
Debbie Harrison	BI	Strategy
Esther Bloem	NIBIO	Geophysics, Hydrogeology
Trond Mæhlum	NIBIO	Leachate Treatment
Ketil Haarstad	NIBIO	Landfill Mining
Ove Bergersen	NIBIO	Gas mitigation
Stéphane Polteau	IFE	Geology
Christian A. Schöpke	IFE	Gas mitigation
Laura Ferrando-Climent	IFE	Synthetic tracers
Marie Bourdeaux-Goget	IFE	Chemist
Sissel Brit Rannekleiv	NIVA	Leachate monitoring
Knut Erik Tollefsen	NIVA	Risk assessment
Samantha Martins	NIVA	Risk assessment
Evert Bouman	NILU	Sustainability, life cycle assessment

PhD students with financial support from the Centre budget				
Name	Nationality	Period	Sex M/F	Topic
Cathrine Eckbo	Norwegian	2021-2024	F	Concrete recycling and methods for re-use.
Olav B. Soldal	Norwegian	2021-2024	M	Regulatory framework and tax regimes for recycling of earth materials
Jan Schneider	German	2021-2024	M	Transport of radionuclides, interaction with the geological environment
	Pakistan	2021-2024		Characterisation of fractured rock and flow modelling to determine the natural geological barrier for new landfill sites.
Bilal Tariq			M	

PhD students working on projects in the centre with financial support from other sources					
Name	Funding	Nationality	Period	Sex M/F	Topic
Karen Ane Skjennum	Lindum/ NRC	Norwegian	2019- 2022	F	Stabilisation of PFAS contaminated soil
Christian Alexander Schöpke	IFE	Norwegian & German	2020- 2023	M	Methane emission from old landfills
Hugo Firmo	BI	Portuguese	2021- 2024	M	Servitization and circular economy
Simen Arne Kirkhorn	FFI	Norwegian	2021- 2024	M	Sustainable ecosystem resource management in the Norwegian Defence sector
Einar Bratteng	NRC-PhD	Norwegian	2021- 2024	M	Laws and regulation aspects of wastes and transformation to resources

Master's degrees			
Name	Sex M/F	Period	Topic
Tonje Strømø	F	2020-2021	Black shale in road construction and potential leachate
Aud Helene Rosenvinge	F	2020-2021	Contaminated landfill leachate monitoring
Reidar Dahl Rasmussen	M	2020-2021	Leaching of hexavalent chromium from concrete
Anny Qvale	F	2021	PFAS adsorption in soil
Bjørnar Nevland-Knudsen	M	2021-2022	Landfill site characterization
Malin Hassum	F	2021-2022	Vannbalanse og vanntransport i og omkring Brånåsen deponi, kartlegging av spredningsveier for forurensning.
Hanne Ugstad	F	2022-2023	Nyttiggjøring av betong

## A2 Accounts

### Annual accounts for 2021

Funding (1000 NOK)	Amount	Costs (1000 NOK)	Amount
The Research Council	6089		
The Host Institution NMBU	2077	NMBU	4073
Research Partners*	1837	Research Partners	8946
Enterprise partners**	4073	Enterprise partners	2972
Public partners***	2654	Public partners	1039
		Equipment	
<b>Total sum</b>	<b>16730</b>		<b>16730</b>

\* NMBU, NGI, BI, NORSUS, NIBIO, IFE, NIVA, NILU

\*\* AF Decom, Borg havn, Borregaard, Eyde-klyngen, Frevar, Innherred renovasjon, Kronos Titan, Lindum/Lindum Oredalen, Mivanor/Iris, NCCE, NOAH, Perpetuum, Scandi Energy, Skanska, Stena Recycling

\*\*\* Bergen kommune, Forsvarsbygg, Fredrikstad kommune, Lillestrøm kommune, Oslo kommune, Rogaland fylkeskommune, Skien kommune, Viken fylkeskommune, Ås kommune

The total budget of SFI earthresQue is 215 mill NOK and all partners have a substantial in-kind contribution to the centre. The financing of earthresQue is based on contributions from the Norwegian research council (NRC), and cash and in-kind contributions from the public, private enterprises NMBU and the research partners.



## A3 Publications

### Research Articles

Author(s):	Title:	Journal	Year	ISSN/ISBN	DOI	Vol
Hale, Sarah; Roque, Antonio Jose; Okkenhaug, Gudny; Sørmo, Erlend; Lenoir, Thomas; Carlsson, Christel; Kupryianchy, Darya; Flyhammar, Peter; Inder, Bojan	The reuse of excavated soils from construction and demolition projects: Limitations and possibilities	Sustainability	2021		10.3390/ su13116 083	13

### Book article

Author(s):	Title:	Book title	Year	ISSN/ ISBN	DOI	Pages
Okkenhaug, Gudny; Smebye, Andreas	Shooting range contamination: antimony occurrence, transport, and fate	Antimony	2021		10.1515/ 9783110668 711-008	173-190

### Other publications

Author(s):	Title:	Archive	Year	ISSN/ISBN	DOI
Rosenvinge, Aud Helene	Nye metoder for kartlegging av spredning av tungmetaller fra deponi	Mater thesis	2021	NMBU	
Strømø, Tonje	Forståelse av Miljøutfordringer knyttet til bygging av vei i områder med svartskifer med potensial for sur avrenning	Mater thesis	2021	NMBU	
Eckbo, Cathrine	Ser på løsninger for å gjenvinne betong	NMBU webpage			

### Professional/scientific oral presentations

Author(s):	Title:	Meeting	Year	Dates
Akervold, Kolbjørn	Landfill Mining i Norge. Hvordan er dagens situasjon for å gjenvinne ressurser fra norske deponier. Avfall er ressurser anbragt på feil sted.	Miljøringens temamøter, Massehåndtering/overvåking	2021	Nov 17-18
French, Helen K.; Okkenhaug Gudny, Hanssen, Ole Jørgen, Sjøvaag, Marit	earthresQue - fra avfall til ressurs	Avfall Norge, Deponiseminaret	2021	Oct 28
Raadal, Hanne Lerche	Bærekraftig innovasjon gjennom industriell symbiose og earthresQue		2021	
Barlindhaug, John	Redeponering av gamle	Avfall Norge, Deponiseminaret	2021	Oct 28



	deponier som skal saneres			
Eckbo, Cathrine	Bærekraftig gjenvinning av betong		2021	
Eckbo, Cathrine; Hale, Sarah; Okkenhaug, Gudny; Engelsen, Christian John	Bærekraftig gjenvinning av betong. Utlekking av heksavalent krom i betong		2021	
Engelsen, Christian John; Eckbo, Cathrine	EarthresQue-Bærekraftig gjenvinning av betong? et steg mot den sirkulære økonomien		2021	
French, Helen K.	earthresQue, et ambisiøst navn på et SFI som skal bidra til å gi bransjen som håndterer overskuddsmasser og avfall et kunnskapsløft og nye løsninger	NMBU - Rector's group	2021	Feb 16
French, Helen K.	earthresQue et SFI som skal utvikle teknologier og systemer for bærekraftig håndtering og behandling av avfall og overskuddsmasser i den sirkulære økonomien	Meetings with Avfall Norge, Pådriv, Konnekt, Nedre-Glomma, Fredrikstad, Bærum Ressursbank, and other collaborative organisations	2021	several
French, Helen K.; Okkenhaug, Gudny; Hansen, Ole Jørgen; Sjøvaag, Marit	earthresQue - fra avfall til ressurs	Avfall Norge, Deponiseminaret	2021	Oct 28
Mæhlum, Trond	Naturbaserte renseløsninger for sigevann fra eldre deponier	Miljøringens temamøter, Massehåndtering/overvåking	2021	Nov 17-18
Okkenhaug, Gudny	Hva er forurenset grunn?	Seksjon for miljø og arbeidsmedisin ved Ullevål sykehus, OUS, Digital fagdag, Helse og forurenset grunn	2021	June 16
Okkenhaug, Gudny; Hale, Sarah; Sørmo, Erland	Reuse of low-level contaminated soil - Lessons learnt from projects in Norway		2021	
Raadal, Hanne Lerche	Kort presentasjon av to pågående prosjekter: Bærekraftig innovasjon gjennom industriell symbiose SFI earthresQue		2021	
Rosenvinge, Aud Helene	Nye metoder for kartlegging av spredning av tungmetaller fra deponi	Miljøringens temamøter, Massehåndtering/overvåking	2021	Nov 17-18

Schöpke, Christian Alexander	Emisjonsmålinger og gassutslipp fra nedlagte deponier	Miljøringens temamøter, Massehåndtering/overvåking	2021	Nov 17-18
Smebye, Andreas	Jakten på forurensning i vann		2021	
Strømø, Tonje; French, Helen Kristine; Okkenhaug, Gudny; Harstad, Andreas Olaus	Avrenning fra svartskifer med ulik forvittringsgrad Nye E16: Kleggerudkrysset	Miljøringens temamøter, Massehåndtering/overvåking	2021	Nov 17-18
Tollefsen, Knut-Erik	Kumulativ risikovurdering av sivevann fra eldre deponier	Miljøringens temamøter, Massehåndtering/overvåking	2021	Nov 17-18

## News articles

Author(s):	Title:	Newspaper/magazine	Year	Date
Eckbo, Cathrine; Lokna, Maria	Hvor ble det av Y-blokka?	Morgenbladet	2021	
Eckbo, Cathrine; Søderholm, Jørn	Det kan bli lettere å bygge med knust betong	Anleggsmaskinen	2021	
Engelsen, Christian John; Eckbo, Cathrine	Nå kan det bli lettere gjenbruke betong. Vanlig jord har forbløffende virkning på fryktet giftstoff	Teknisk Ukeblad	2021	Dec -20
French, Helen K. Interviewed by Nancy Strand	Fra deponi til sirkulær massehåndtering. <a href="https://shows.acast.com/sirkuler/episodes/fra-deponi">https://shows.acast.com/sirkuler/episodes/fra-deponi</a> ,	Avfall Norge, Sirkuler, gjenvinningsbransjens podcast, Season 3, Ep. 9	2021	Oct 22



ill. photo: H.K. French, inside a potential new landfill site in the rock quarry at Rekefjord