



LIFE Project Number  
**LIFE12 ENV/FI/000592**

**FINAL Report**  
Covering the project activities from **01/07/2013** to **31/8/2022**

Reporting Date  
**24/11/2022**

LIFE+ PROJECT NAME or Acronym  
**UPACMIC**

Project Data

<b>Project location</b>	Finland
<b>Project start date:</b>	01/07/2013
<b>Project end date:</b>	31/08/2018 <b>Extension date: 31/08/2020 Extension date: 31/08/2022</b>
<b>Total Project duration (in months)</b>	110 months (including extension of 48 months)
<b>Total budget</b>	5 010 053,00€
<b>Total eligible budget</b>	5 000 678,00 €
<b>EU contribution:</b>	2 500 339,00 €
<b>(%) of total costs</b>	49,9
<b>(%) of eligible costs</b>	50,0

Beneficiary Data

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## Abbreviations and names used in the report

RAMFI	Ramboll Finland Oy (CB)
ELY	Elinkeino-, liikenne- ja ympäristökeskus (Centre for Economic Development, Transport and the Environment (ELY Centre))
CB	Coordinating beneficiary
AB	Associated beneficiary
DL	Deadline
LCA	Life Cycle Assessment
LCC	Life Cycle Cost
MtR	Midterm report
KAP	Knowledge, Attitude, Practices study
UUMA	Finnish programme/network to foster the use of secondary materials in infrastructure construction
KAIVASU	In this project, the potential of closure facing mine sites in Northern Ostrobothnia to function as a platform for new possibilities will be assessed
FORTUM	Fortum Waste Solutions Oy (AB) Fortum bought Ekokem in April 2017 and thus the name Ekokem was updated to Fortum in the 3 <sup>rd</sup> Progress Report
SKARTA	Skarta Finland Oy (AB) Suomen Maastorakentajat changed name to Skarta Finland Oy in May 2021
WWTS	wastewater treatment sludge
The UPACMIC projects piloting sites:	
HITURA	Mine, located in Northern Ostrobothnia, Finland. nickel tailings sand.
PYHÄSALMI	Mine located ~100 kms from HITURA.
SORSASALO	Waste deposit site in Kuopio Sorsasalo, Finland.

Keywords: recycled materials, mine construction, alternative materials

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### **List of technical annexes:**

- Annex 1: The list of UPACMIC deliverables and milestones
- Annex 2: E1 Impact Monitoring report Final 2013-2022
- Annex 3: E2 Report on the networking activities carried out during the project life
- Annex 4: A3 Final technical report on materials
- Annex 5: A4 Final report on Applications / Designs
- Annex 6: B1 Final technical report on piloting
- Annex 7: B2 Final technical report on the MSCD-model (logistical model for utilisation of by-products in mine remediation)
- Annex 8: B2 Technical recommendations document
- Annex 9: B3 Final report- Quality control
- Annex 10: C1 KAP (Knowledge, Attitudes, Practices) Final report
- Annex 11: C2 Final verification report (LCC and LCA)
- Annex 12: C2 Carbon footprint Final report
- Annex 13: C2 Analysis of the socio-economic effects of the project
- Annex 14: C2 The report of Sustainability indicators
- Annex 15: Gantt chart
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### **List of dissemination annexes:**

- Annex 17: Summary of dissemination actions
- Annex 18a: After-Life Communication plan in English
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- Annex 19a: Layman´s report in English
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- Annex 21a: UPACMIC article in Ramfi webpage 06/04/2022
- Annex 21b: UPACMIC project reference in Ramfi webpage 06/04/2022
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- Annex 25: Presentation in Kaivosteollisuus ry, R&D webinar 16/02/2022
- Annex 26a: Presentation in Final webinar- Materials 16/03/2022
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Annex 33a: Project video clip in English

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Annex 34\_1-147: Pictures

## 2. Executive Summary



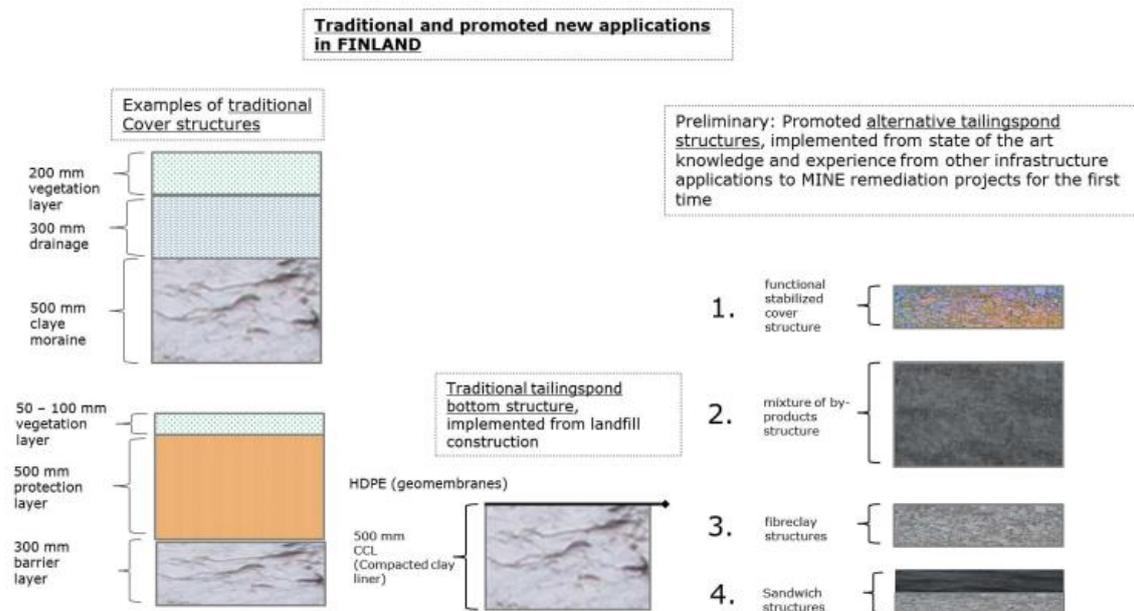
UPACMIC aimed to demonstrate the technical and environmental feasibility of structures that are suitable in the mining environment and are made of alternative materials instead of using only virgin natural aggregates, bentonite products, geomembranes or other geosynthetic materials. The innovations are based on stabilization technology and waste materials mixture development projects used in other infra projects and now the technology was tested for the first time in the mining environment. The project aim was to promote waste material utilization, reduce the need for commercial oil base products (geomembranes) and to preserve primary aggregates such as gravel from eskers. Preserving these geological formations from excessive aggregate intake, impacts also on the nearby landscapes, forests, biodiversity and recreation and other nature values. UPACMIC implement Waste Framework aspects and contributes to the European Union environmental policies with respect to resource efficiency and waste management.

UPACMIC piloted cover-, bottom- and reactive structures and implemented five different structures:

- The use of fiber clay in cover structure
- The use of surplus soil (clay) in the closure of the crushed rock area
- The use of geopolymers and limestone barrier for the purification of seepage water
- The use of reactive mat (Tektoseal) for the treatment of seepage water
- The use of water treatment sludge from Hitura, industrial by-products and surplus soils in vertical sealing barrier/ bottom structure

Applications verified how industrial by-product combinations and surplus soils can be successfully used in mine remediation structures without compromising the overall environmental protection targets. UPACMIC gives information for the European politicians and legislative authorities, mitigating the national and European legislation by addressing the use of secondary aggregates in mine remediation structures. This information is important also for stakeholders working in the field. Project promotes the addition of by-products to “mining industry materials act”, which can promote general utilization possibilities.

Figure 1 present the conventional structures used and the preliminary structures described in the proposal.



**Figure 1. Conventional structures and promoted UPACMIC applications.**

The innovative aspects of the project include the design of the proper material mixtures and structure applications for the bottom-, cover- and reactive dam structures for mine remediation site. Material mixtures are designed for specific applications and environmental protection targets. The positive chemical and physical neutralizing and alkaline properties can be used to demonstrate the positive aspects of these materials against the impact on freshwater.

The first round of the Hitura mine material tests was carried out in spring 2014. Based on the results, the most promising material mixtures were selected for the second round of testing which was carried out in summer/early autumn 2014. The tests were performed for two aggregate materials: nickel tailings and moraine with the use of various secondary materials, such as fly ash (fresh and stockpiled), fiber clay, foundry sand, lime and gypsum.

Uncertainties in the world mining markets started to appear quite soon after the project started and associated beneficiary Belvedere had to shut down their operations as the nickel price crashed. This slowed down also the intended UPACMIC actions and finally Belvedere went to bankrupt in 12/2015. As Belvedere offered the project a piloting site (Hitura Mine) for the construction activities and when the piloting site was lost, the project partners had to actively search for new piloting sites, and this was very laborious and took time.

Due to the bankrupt of Belvedere Mining company, the government had responsibilities to close the mine. Associated beneficiary Fortum started to construct at Hitura Mine as Fortum won the construct which was set up by the authority North Ostrobothnia Centre for Economic Development, Transport and the Environment. At first the cover structure was designed to construct conventionally with the natural aggregates, but the authority accepted the use of fiber clay in the cover structures. ~ about 100000 tons of natural moraine have been saved in cover structure application. Lysimeters have been installed for fiber clay cover structures at Hitura during summer 2020 and follow up continued until end of 2021. The monitoring of the site continues according to environmental permit.

Skarta Finland Oy (former Maastorakentajat Oy) won the bid for Hitura phase II mine closure in spring 2019. The bottom structure piloting for UPACMIC was meant to be carried out in Hitura during the construction of WWTS deposit site. In December 2019, ELY-Center informed that the deposit site and bottom structures for wastewater treatment sludge (WWTS) won't be constructed in Hitura mine as first planned and the sludge will be transported and deposited on deposit site in Kuopio as it is cheaper disposal option compared to construction of deposit site in Hitura. However, the deposit site where the WWTS was transported in Kuopio is owned by Fortum and the project managed to negotiate that the piloting would be carried out there. The pilot carried out by constructing a vertical sealing barrier, which is a bottom-like structure. The piloting (action B1) of bottom structures started in Kuopio in Autumn 2020.

Cover structure using surplus soil was piloted in summer 2021 during Hitura II contract by Skarta. Surplus soil structure was superior by its lower carbon emission due to significantly shorter transportation distance compared to other materials. Comparison is presented by LCA calculations in *B3 Final report – Quality control (Annex 9)*.

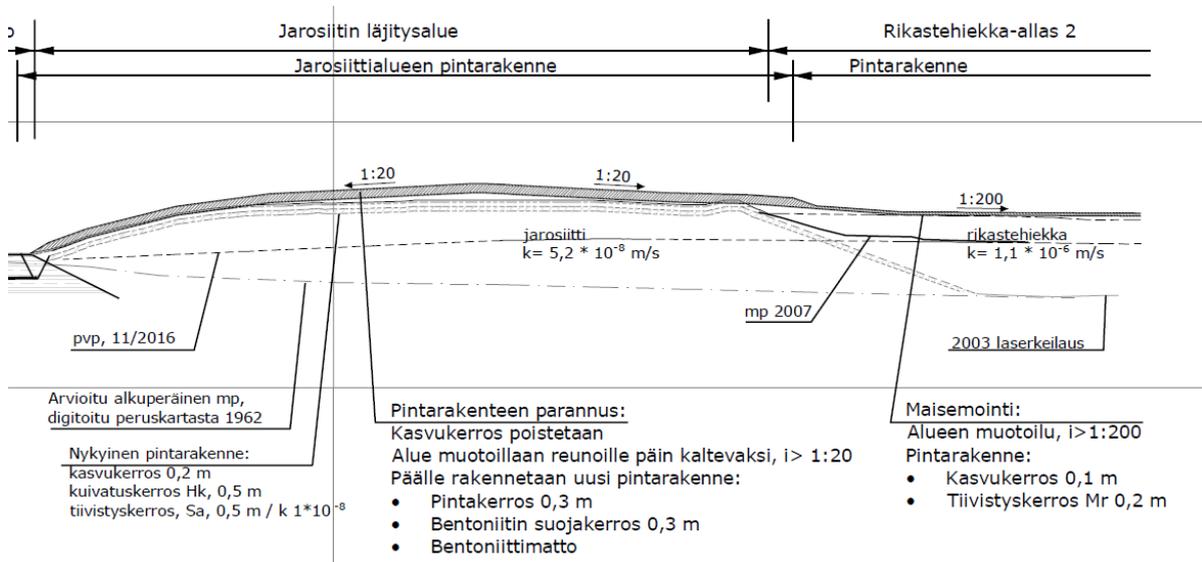
The piloting of reactive structures was carried out in Hitura mine during 2021-2022. The planning of the structures started after summer of 2020 and designing was carried out during winter and spring of 2021. At that time limestone's material test was carried out. Construction was carried out by Skarta in summer 2021 and finished 1.9.2021 when the limestone barrier was installed. Two different reactive structures were piloted. The pilot using geopolymers and limestone barrier for the purification of seepage water was carried out in cooperation with KAIVASU project and SMA Mineral Oy. The other structure tested reactive mats for the purification of seepage water, and it was carried out in cooperation with HUESKER Synthetic GmbH. The results of these two structures are presented in the *B1 Final technical report on piloting (Annex 6)*.

### Cover structure

In 2016 field tests was constructed in the Pyhäsalmi Mine where lysimeters were built (see chapter 5.1.4) with different materials. The purpose of these studies was to examine how the used materials work in real circumstances in the field and to get information of the materials and their mixtures, water permeability and leaching properties, and to complement the data that was earlier studied in laboratory circumstances. Also, attention was paid to the material treatment/handling, mixing and compacting properties. The long-term performance was monitored until November 2019 when lysimeters were demolished and samples was taken layer by layer from each lysimeter. The results of these field tests were supposed to use in larger pilot construction activities, which were at this stage thought to take place in the Pyhäsalmi Mine. Although the field tests in the Pyhäsalmi Mine gave a lot of new information, Pyhäsalmi withdrew from the project.

Results from Pyhäsalmi field tests has been utilised in nearby Hitura Mine, where the cover structure has been piloted. The pilot construction started in 2017 and originally it was planned to use 0,20 m layer of moraine in the compaction layer and above that 0,1 m layer of soil for landscaping purposes. The design was changed so that the 0,2 m moraine sealing layer was substituted with 0,25 m fiber clay sealing layer (see Figure 2).

Fiber clay structure is technically better structure than moraine structure, as fiber clay has lower water permeability which is important for this kind of structure. If fiber clay would not be used for construction purposes, the material would be combusted as it is expensive to storage large amounts of material. Fiber clay though does not have actual proper heat value due to high water content and burning yield ash which also had to dispose, so the utilization is important from the resource efficiency point of view.



**Figure 2.** The initial plan was to use 0,20 m layer of moraine on top of tailings sand (on right the side of picture), which was substituted with 0,25 m fiber clay layer.

According to the calculations, the fiber clay sealing structure has saved ~ about 64 000 tons of natural moraine aggregates. In addition, above the sealing structure in the soil layer, industrial secondary materials such as branch waste and decomposition were used, and that rises total amount of saved natural soil materials ~ about 100000 tons. The construction of surplus soil utilizing cover structure saved natural moraine aggregates ~ about 36500 tons.

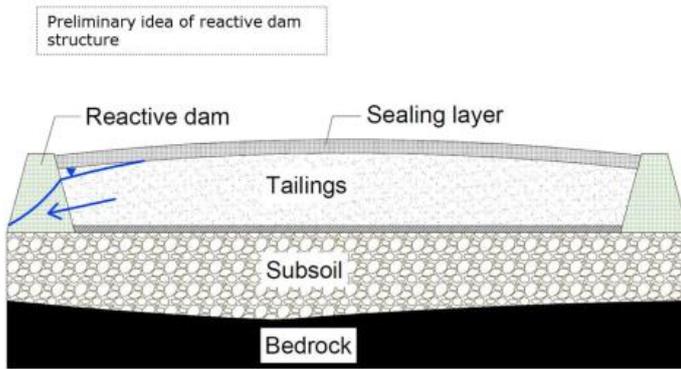
### Bottom structure/ Vertical sealing barrier

Bottom structure was not piloted but the similar sealing structure was piloted in Kuopio Sorsasalo landfill area. Sealing structure is function wise comparable with bottom structure by its negligible small water permeability value  $< 1 \times 10^{-9}$  m/s. Only difference is that structure is vertical. Same structure could be built horizontally.

The vertical sealing barrier was constructed mainly using non-virgin materials, so it has saved a lot of natural resources. The barrier is not completely ready at the end of the project, but when it is done it will save about 40 000 tonnes natural aggregates. The construction of the barrier structure will continue after UPACMIC project life.

### Reactive barrier

Reactive barrier was piloted in Hitura mine and construction was carried out by Skarta in Summer 2021. Water for reactive structures was taken from waste rock pile's seeping water ditch. Preliminary idea of reactive dam structure is presented in Figure 3. The structure had to be tailored to fit on the pilot site characteristics.



**Figure 3. Preliminary plan for reactive dam structure.**

Key deliverables in the UPACMIC project are Material matrix for mining operations, *Final technical report on materials* (Annex 4) and *Final report on applications/desings* (Annex 5). It has also been important to monitor the effects of the project, for example LCA calculations in *Final verification report* (Annex 11) and *Carbon footprint Final report* (Annex 12). More information on monitoring actions in chapter 5.3.

In this Final report the UPACMIC project is generally presented in the Introduction chapter 3. Administrative part and descriptions of the management activities are presented in chapter 4. Project technical progress is written in chapter 5, as well as dissemination activities. Financial part is presented in chapter 6.

Locations of the UPACMIC beneficiaries and piloting sites are listed in Figure 4.



- 1 Ramboll office, Luopioinen
- 2 Fortum office, Riihimäki
- 3 Skarta office, Pyhäjoki
- 4 Pyhäsalmi Mine, Pyhäsalmi (Skarta piloting site)
- 5 Hitura Mine, Nivala (Skarta and Fortum piloting site)
- 6 Waste deposit site Sorsasalo, Kuopio (Fortum piloting site)

**Figure 4. Map of key locations of UPACMIC.**

### 3. Introduction

#### 3.1 Description of background, problem and objectives

When writing the application in 2012, the mining boom had resulted in opening plenty of new mines and resulted into concerns of environmental impacts of the mining technologies. Mining and quarrying waste is a significant source of pollution and general environmental degradation, in particular of freshwater systems. At the same time approximately 60-70 million tonnes of recycled material that are suitable for construction generates per year in Finland. Also, 20-30 million tonnes of surplus soils generates per year in Finland.

UPACMIC aimed to demonstrate the technical and environmental feasibility of structures that are suitable in the mining environment and are made of alternative materials instead of using only virgin natural aggregates, bentonite products, geomembranes or other geosynthetic materials. The innovations are based on stabilization technology and waste materials mixture development projects used in other infra projects and now the technology is tested for the first time in the mining environment. The technology was tested with three different structures – cover structures, bottom structure/sealing barrier and reactive barrier. The piloting included two different cover structures, two different reactive structures and a sealing barrier structure.

The project's aim was to promote waste material utilization, reduce the need for commercial oil-based products and to preserve primary aggregates such as gravel and esker formations. Preserving these geological formations from excessive aggregate intake, has also impacts on the formations nearby landscapes, forests, biodiversity and recreation and other nature values.

#### 3.2 Expected longer term results

In the longer term (until 2030) the secondary aggregates and industrial by-products in the mine construction, will be accepted and become an established practice in the EU, followed by significant reductions in wastes to be landfilled, primary aggregates such as natural eskers and moraine deposits, and commercial sealing products used and other reductions in releases of greenhouse gases as CO<sub>2</sub>- eq.

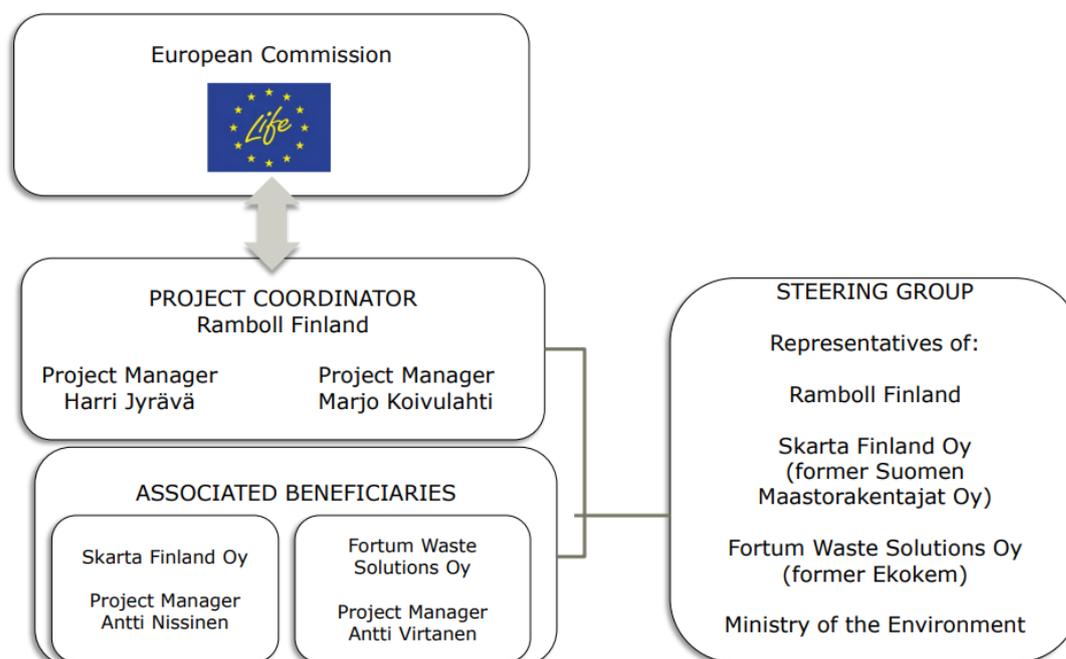
UPACMIC implements Waste Framework aspects and contributes to the European Union environmental policies with respect to resource efficiency and waste management. UPACMIC produced four practical civil engineering applications (two cover structures, bottom and reactive barrier structures), showing how industrial by-product combinations can be successfully used in mine remediation structures without compromising the overall environmental protection targets. UPACMIC gives information for the European politicians and legislative authorities, mitigating the national and European legislation by addressing the use of secondary aggregates in mine remediation structures. Project promotes the addition of by-products to “mining industry materials act”, which can promote general utilization possibilities.

## 4. Administrative part

### 4.1 Description of the management system

Ramfi as a coordinating beneficiary was the main responsible for coordinating the project, organizing the meetings and negotiations with the different stakeholders. Ramfi also actively was in contact with the associated beneficiaries and shared relevant information of project possibilities and in addition, e.g. of suitable seminars and events. Ramfi was the contact link between the project monitors and the Commission when needed. The associated beneficiaries also promoted the project needs whenever it was possible.

UPACMIC project organisation is presented in the organigramme in Figure 5.



**Figure 5. UPACMIC organigramme.**

All the partners (Ramfi, Skarta and Fortum) have been cooperating to carry out the piloting activities. The partners have also cooperated in monitoring environmental impact and dissemination of the project. Several CB-AB meetings were organised as needed. The responsibilities of each beneficiary is presented in table 1.

**Table 1. UPACMIC responsibilities of the beneficiaries.**

<b>Beneficiary</b>	<b>Responsibility</b>
Ramfi	Coordinator, management, material tests, design
Skarta	Construction works: - preliminary field tests at the Pyhäsalmi Mine in 2016 - Cover structure (surplus soil) at the Hitura mine in 2021 - Reactive structure at the Hitura Mine in 2021

Fortum	Construction works: - Cover structure (fiber clay) at the Hitura mine in 2017-2018 - Bottom structure (sealing structure) at the Kuopio waste deposit site in 2021
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As a coordinating beneficiary Ramfi organised steering group meetings which was organised in Ramfi office in Espoo or in Tampere in the beginning of the project. During the Covid epidemic the steering group met online via Teams. The steering group consists of the contact persons from Ramfi, Skarta and Fortum and, also representatives from Ministry of the Environment and the Centre for Economic Development, Transport and the Environment of Northern Ostrobothnia.

Working method in the UPACMIC project was a typical engineer and consulting company method which is based on five project phases; conception, planning, execution, control and project closing. See further for Table 2.

**Table 2. UPACMIC project phases**

<b>Project phase</b>	<b>Activities and tasks</b>	<b>When</b>
Conception	Defining the project tasks and objectives, setting the targets, creating networks	12/2014
Planning	Designing the pilot structures, and the needed tests, work instructions, quality control instruction	12/2014-06/2021
Execution	Constructing of pilot structures	09/2021
Control	Quality control of the constructions, reporting	08/2022
Project close	Final reporting	08/2022

UPACMIC project has confronted significant changes three times, which needed amendment requests to the Commission. In the project beginning there were three AB´s Lassila-Tikanoja, Hartikainen and Belvedere in the project and Ramfi acted as a projects CB.

The changes during the UPACMIC project were following:

- 1. Amendment in 2014:
  - two original partners withdrew from the project; Lassila-Tikanoja in February 2014 and Hartikainen in September 2013. These partners did not report any costs to the project and did not receive any EU funding.
  - new partners Ekokem Palvelu Oy and Suomen Maastorakentajat Oy joined the project on 09/06/2014 as associated beneficiaries. The Consortium Agreement embracing the new partners was signed in June 2014 and delivered to the Commission as an Annex to the Amendment Request. The new Project Grant Agreement including the new partners was signed in October 2014. Suomen Maastorakentajat carried out the tasks originally planned for Hartikainen and Ekokem the tasks planned for Lassila-Tikanoja.
  - The Amendment was submitted 27/06/2014

- 2. Amendment in 2016:
  - o 28/12/2015 Belvedere Mining went to bankrupt and withdrew from the project on the same date (28/12/2015). Belvedere Mining Oy’s duties under this project have been retroactively transferred to Ramfi from the start of the project on 01/07/2013. The costs by Belvedere were not reported and these costs are loss for CB Ramfi. Belvedere’s budget was transferred to the coordinating beneficiary’s budget. Belvedere was a mining company that acted in Hitura Mine and all the piloting was initially planned to carry out at Hitura mine site provided by Belvedere. Belvedere’s withdrawal caused problems and delays in finding suitable piloting sites.
  - o The Amendment with the budget changes and project extension till 31/08/2020 was submitted on 31/05/2016 and approved by the EC on 20/10/ 2016.
- In 2016 Ekokem and Fortum Environmental Construction Oy teamed up and the company continued with the name Fortum 04/04/2017 onwards. The company registration number did not change.
- 3. Amendment in 2020:
  - o Project asked for another project extension until 31/8/2022 due to delays of piloting actions described in section 5.2.1.
  - o On 01/01/2019 Fortum Environmental Construction Oy merged with Fortum Waste Solutions Oy. As a result of the merger all the rights and obligations under the Agreement have been entirely transferred to Fortum Waste Solutions Oy. Company’s registration number changed.
  - o As of 16 April 2019, Ramboll Finland Oy's official street address is Itsehallintokuja 3, 02600 Espoo.
  - o Amendment request was submitted on 30/05/2020 and it was approved in 23/06/2020. Project asked for another project extension until 31/8/2022 due to delays of piloting actions described in section 5.2.1. Also, budget and content review were made.
- On 06/05/2021 Suomen Maastorakentajat Oy changed the company name to Skarta Finland Oy (Skarta Group Oy). Company’s registration number did not change.

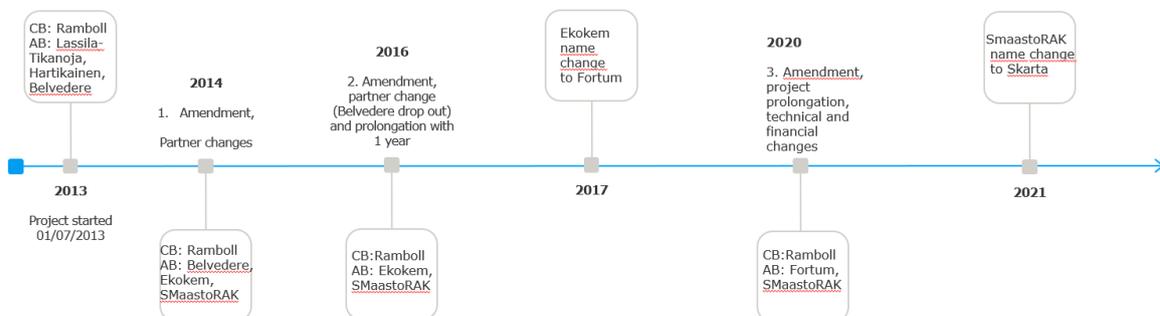


Figure 6. Timeline of changes during UPACMIC project.

## 4.2 Evaluation of the management system

As Belvedere was the beneficiary offering the project a piloting place at Hitura Mine, this caused significant delays in the project implementation as the other beneficiaries had been forced to find new solutions where the planned applications could be constructed.

Project managed to gain piloting site for cover structure at Hitura Mine, but problems finding suitable piloting sites for bottom structure and reactive barrier continued. This caused more delays for the project implementation. However, all the necessary piloting sites was found in 2019-2020.

The cooperation among all the project partners has worked well and the project coordinator has been in a frequent contact with all the parties involved. All the partners bring different added value for the project. Ramfi has a long experience on the EU projects and on the use of alternative materials in infrastructure applications. Fortum is experienced in material processing and construction issues and Skarta is experienced construction company, and this experience is highly needed when designing and implementing the applications.

Associated beneficiaries reported their costs in 3 months periods (4 times a year) to the coordinating beneficiary, which was the grounds for the EU contribution. Ramfi checked the TES tables and gave the beneficiary permission to invoice the EU contribution based on the three months period costs. Beneficiaries have their own reference number for the invoicing purposes. With Fortum it had been agreed that the reports of the detailed personnel cost reported directly to the monitor or to the Commission.

Ramfi has been actively in contact with the monitor when necessary. Ramfi has received feedback from the Commission from the Progress Reports and monitor visits and has actively responded to the feedback as asked.

The reports delivered to Commission are presented in Table 5.

**Table 3. UPACMIC progress reporting dates.**

<b>Type of report</b>	<b>Reporting date</b>
Inception report	31/03/2014
Progress report (1)	27/01/2015
Progress report (2)	21/12/2015
Progress report (3)	30/06/2017
Midterm report	31/12/2018
Progress report (4)	19/03/2020
Progress report (5)	30/06/2021
Final report	24/11/2022

## 4.3 Project management actions

The progress of the management actions is described in chapters 4.3.1...4.3.4. List of UPACMIC deliverables and milestones is presented as annex 1.

### 4.3.1 E1. Management and Monitoring

Name of activity	Planned deadline	Actual progress
Management and Monitoring	III/2022	III/2022

Name of Deliverable	Deadline	Status
Inception Report (plus: Annex 1, State-of-the Art report: Annex 2, Consortium Agreement)	01/2014	Delivered 31/03/2014
Consortium Agreement (from Action A1) is delivered	08/2013	Delivered with the Inception report
Project contact database	09/2020	Delivered with 4 <sup>th</sup> Progress Report
Green Procurement Policy	05/2014	Delivered with the 1 <sup>st</sup> Progress Report
Monitoring Final report (reported with the Final report)	08/2022	Delivered with the Final Report (Annex 2)
Monitoring report 1 (reported with the 1 <sup>st</sup> Progress report)	10/2014	Delivered with the 1 <sup>st</sup> Progress Report
Monitoring report 2 (reported with the 2 <sup>nd</sup> Progress report)	12/2015	Delivered with the 2 <sup>nd</sup> Progress Report
Monitoring report 3 (reported with the 3 <sup>rd</sup> Progress report)	02/2017	Delivered with the 3 <sup>rd</sup> Progress Report
Monitoring report 4 (reported with the 4 <sup>th</sup> Progress report)	03/2019	Delivered with 4 <sup>th</sup> Progress Report

Milestones name	Deadline	Status
-	-	-

#### Description of work

The Management Action involved the overall management and co-ordination of the project according to the details of the project plan and the financial budget and with respect to the contract with the Commission. The activities comprise of the project progress monitoring, supplying the Commission with the activity reports (inception, progress, midterm and final reports). The activity reports were collated by the project manager with the help of Ramfi's staff and other beneficiaries' administration. The projects impacts have been monitored throughout the project time and the final report, *Impact Monitoring report Final 2013-2022*, is presented as annex 2.

#### Modification of action compared to project proposal

The due dates for several milestones and deliverables were revised and accepted by Amendment to the GA no 2 (accepted in 2016) and GA no 3 (accepted in 2020). Postponing for these actions was essential to deliver sufficient details of the project progress.

### Problems encountered

This action has taken more work than initially was expected, due to the bankrupt of Belvedere in 12/2015 as we have searched new piloting sites and collaboration partners for the project. This also caused the need to make the Amendments according to the Common Provisions article 15.2.

Indicators of progress:

<b>Foreseen in the proposal</b>	<b>Achieved</b>
Frequency of the project management team meetings - 4 times a year	Project meetings were organized when needed, also via remote channels
Frequency of the SG meetings - 2 times a year	Meetings were organized when needed, 1-3 times per year
Number of project director in each organisation – 1	1
Number of project managers in each organisation – 1	1
Number of Monitoring reports – 5	5
Numerous project workers in all of the organizations of Ramfi, Skarta, Fortum	There have been numerous project workers involved in the project

### 4.3.2 E2. Networking with other projects

<b>Name of activity</b>	<b>Planned deadline</b>	<b>Actual progress</b>
Networking with other projects	III/2022	III/2022

<b>Name of Deliverable</b>	<b>Deadline</b>	<b>Status</b>
Report: Mapping activities and detailed networking plan (delivered with the inception report)	01/2014	Delivered with the Inception Report.
Report on the networking activities carried out during the project life (delivered with the final report)	08/2022	Delivered with the Final Report (Annex 3)

<b>Milestones name</b>	<b>Deadline</b>	<b>Status</b>
-	-	-

### Description of work

This action includes networking with similar project if they are open for sharing information. The aim of this Action was to establish a proper level of networking with various LIFE and other EU projects to ensure an efficient knowledge and experience

transfer in order to foster its replication in similar contexts. This Action also included establishing a UPACMIC network of European stakeholders and target audience.

Networking was mainly done nationally with different stakeholders in order to gather knowledge and to promote the project methods (see chapter 5.4.4). A list of different networks and events are presented in table 4.

**Table 4. UPACMIC Networking**

<b>Network</b>	<b>Amount</b>
Partners	8
Legislators	5
Mining Industry	22
Material producers	15
Constructors	22
Other companies or institutions	13
Projects	35
Networking events	42

The project team was in close touch with the OSAMAT LIFE (LIFE+ 09/ENV/000227) project team and LIFE Circwaste (LIFE15 IPE FI 004) project team. LIFE ABSOILS (LIFE09 ENV/FI/000575) acted as a comparison project in evaluating the UPACMIC projects impact on the environment by carbon footprint calculations. LIFE Capacity Building Project Hungary (LIFE14 CAP/HU/000010) visited the UPACMIC project in October 2016 in Espoo. The UPACMIC project was presented and, also the problems encountered were exchanged. The project results were disseminated to Hungary also. UPACMIC project visited Budapest, Hungary on 10th May 2017 at the invitation of the LIFE Capacity Building Project Hungary for the LIFE “Environment & Resource Efficiency” Training Day. UPACMIC project was invited to share experiences regarding the planning, implementation and participation of LIFE projects and to tell about the practical issues – difficulties, innovations, financial planning process, etc. Also, many other LIFE projects were contacted.

At WASCON2018 conference a Swedish company Ecoloop presented their knowledge on the use of green liquor dreg in mining environment and offered their expertise for the project. Ecoloop was a partner in EU's research and innovation funding programme HORIZON2020 PAPERCHAIN.

Co-operation has also been carried out with KAIVASU project (<https://beta oulu.fi/en/projects/mine-closure-impacts-and-possibilities>) concerning reactive barriers in 2020-2021. HybArkt -project (<https://www oulu.fi/water/node/51211>) has piloted also reactive barrier structure in Pyhäsalmi mine and pilot experiences was discussed with them.

The final seminar of the UPACMIC project was organised in cooperation with two other mining projects; ERDF and LIFE-funded mining environment projects KAIVASU and LeKaT ( <https://www.oulu.fi/fi/projektit/lennokit-kaivosvalvonnan-tukena>). The seminar was called "Uudet mahdollisuudet kaivosympäristöjen kiertotaloudessa ja kestävässä kehityksessä" and organised online via MS Teams on 16/03/2022. The event was organised online, because of the Covid situation. This was found to be a good solution and the event reached wide audience, approximately 140 participants.

Networking was done also through the national UUMA2/UUMA3/UUMA4 project, that promotes the use of alternative materials in infra construction ([www.uusiomaarakentaminen.fi](http://www.uusiomaarakentaminen.fi)). UUMA contacts and website had also been part of the UPACMIC dissemination. For example, the project was presented in UUMA seminars and the mining webinar on 16/03/2022 was promoted via UUMA webpage: <https://www.uusiomaarakentaminen.fi/uudet-mahdollisuudet-kaivosymp%C3%A4rist%C3%B6jen-kiertotaloudessa-ja-kest%C3%A4v%C3%A4ss%C3%A4-kehityksess%C3%A4-1632022>

Report on the networking activities carried out during the project life is presented as annex 3.

### **Modification of action compared to project proposal**

The due dates for several milestones and deliverables were revised and accepted by Amendment to the GA no 2 (accepted in 2016) and GA no 3 (accepted in 2020).

### **Problems encountered**

No problems encountered, only the delays in piloting had slowed to promote of the project results.

Indicators of progress:

<b>Foreseen in the proposal</b>	<b>Achieved</b>
The Action will be carried out according to the timetable and in the framework of the planned budget.	Delays in the piloting prolonged also this action until 2022.
The Action will map and update mapping of the projects once a year.	Has been done on a yearly basis.
Number of EU LIFE projects networking during the project lifetime (2013-2022) – 10	Several projects contacted
Number of Skype conferences – 5	2 skype meetings held with the Swedish company Ecoloop on networking issues and use of green liquor dreg in the mining construction. 1 Teams meeting with HybArkt. Several Teams meetings with KAIVASU -project concerning reactive barrier. Several Teams meeting concerning joint webinar with KAIVASU and LeKaT
Number of reports – 2	2

### 4.3.3 E3. After-Life communication plan

Name of activity	Planned deadline	Actual progress
After-Life communication plan	III/2022	III/2022

Name of Deliverable	Deadline	Status
After-Life Communication plan (delivered with the final report)	08/2022	Delivered with the Final Report (Annex 18)

Milestones name	Deadline	Status
-	-	-

#### Description of work

Ramfi in cooperation with the other partners produced an “After-LIFE Communication Plan” as a separate chapter of the final report. It is presented in Finnish and in English, and available in electronic format at projects website. The document will be printed to various occasions when needed. The aim of the plan was to design the best ways of sustaining UPACMIC impact on the stakeholders and the target audience after the end of the LIFE project. Also, the future workshops, conferences and other events both on national and international level was mapped, as they can act as forums for further dissemination of the project results. The project stakeholders and the members of the network was contacted and asked for feedback and proposals for the future. Also, an analysis of the potential future projects that could be developed with the help of the project network, was done. Projects reports and dissemination material are available at projects website at least five years After Life. After life communication plan is presented as annex 18a and 18b.

In the discussions concerning projects results it was seen important to continue studying reactive structures after project life. Longer follow up would give valuable information of the structures. UPACMIC project managed to negotiate that Feasib Analytics would continue studies and take responsibility of the structures. Feasib Analytics had been analysing the samples during the project time and the site was familiar to them. All the other piloted structures are permanent, and they can be left as such. Monitoring continues according to the instructions of the environmental permit authorities for fiber clay cover structure and vertical sealing barrier. For surplus soil cover structure After Life monitoring is not needed.

Project partners gained valuable experience in using alternative materials in mining construction and will use this information in the future projects.

#### Modification of action compared to project proposal

The due dates for several milestones and deliverables were revised and accepted by Amendment to the GA no 2 (accepted in 2016) and GA no 3 (accepted in 2020).

### Problems encountered

No problems encountered.

Indicators of progress:

Foreseen in the proposal	Achieved
Number of Communication plans which will be followed – 1	1
Beneficiaries Ramfi, Fortum, and Skarta are in active communication to create an After-Life communication plan	Active communication concerning After-Life taken place.

### 4.3.4 E4. External audit

Name of activity	Planned deadline	Actual progress
External audit	III/2022	IV/2022

Name of Deliverable	Deadline	Status
The independent audit of the final financial report (delivered with the final report)	08/2022	Delivered with the Final Report (Annex 33)

Milestones name	Deadline	Status
-	-	-

### Description of work

This Action will enable the Commission the verification of the financial statements included in the project's final report. This audit ensures that with respect to national legislation and accounting rules all costs incurred follow the stipulations of the LIFE+ Common Provisions. This independent auditing of the projects final financial report was done in the end part of EU Life+ financing.

A midterm audit was conducted from 01/07/2013 till 31/12/2016 costs. This helped the final audit as the first years of the project had been audited. There were no major problems encountered and the auditor Ms Sari Pohja from PricewaterhouseCoopers Oy discussed separately with each beneficiary on the notes she made. The final audit was made also by PricewaterhouseCoopers Oy and the auditor was Mr Sami Laalahti. The report of the final audit is presented as annex 33.

The final audition was implemented in September-November 2022 by PricewaterhouseCoopers Oy. The details of the contact person:

Ms Tiina Puukkoniemi

Authorised Public Accountant (KHT)

Assurance Services

ESG Reporting & Assurance Services Leader

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PricewaterhouseCoopers Oy

P.O. Box 1015 (Itämerentori 2), FI-00101 Helsinki, Finland

Qualification of the auditor can be checked via website provided by PRH (<https://epalvelut.prh.fi/tilintarkastajahaku/>) by searching with the auditor's name.

### Modification of action compared to project proposal

The due dates for several milestones and deliverables were revised and accepted by Amendment to the GA no 2 (accepted in 2016) and GA no 3 (accepted in 2020).

### Problems encountered

No problems encountered.

Indicators of progress:

Foreseen in the proposal	Achieved
Number of financial auditing reports created – 1	1

## 5. Technical part

### 5.1 Preparatory actions

#### 5.1.1 A1. Signing Consortium Agreement and Steering Group Launch

Action A1 was implemented in July 2014 and updated in May 2020. Action completed.

Name of activity	Planned deadline	Actual progress
Signing Consortium Agreement and Steering Group launch	III 2013	III/2014, updated II/2020.

Name of Deliverable	Deadline	Status
-	-	-

Milestones name	Deadline	Status
The consortium agreement signed, and the steering-, expanded steering and piloting group launched	08/2013	Action completed. The Consortium Agreement embracing the new partners was signed in July 2014 and delivered to the Commission as an Annex to the Amendment Request.  The Consortium Agreement was updated in 2020 and delivered to the Commission as an Annex to the Amendment Request.

### Description of work done

The Consortium Agreement embracing the new partners was signed in July 2014 and delivered to the Commission as an Annex to the Amendment Request. The Consortium Agreement was updated and signed again in 2020 and delivered to the Commission as an Annex to the Amendment Request. Details of all partner changes are described in section 4.1.

### Modification of action compared to project proposal

No modifications.

### Problems encountered

Change of the initial partners when Hartikainen and Lassila-Tikanoja withdrew from the project. Skarta (former Suomen Maastorakentajat) and Fortum (former Ekokem) took their place as new associated beneficiaries.

Indicators of progress:

<b>Foreseen in the proposal</b>	<b>Achieved</b>
Number of groups organized -/3 groups	0 (this has not seen necessary after the project started, as partners are actively in communication with together)
Number of Consortium agreements written -1	2 agreements; first signed by all the project beneficiaries and delivered to the Commission at project start. After project partner changes, new Consortium agreement was delivered to the Commission as an Annex of to the Amendment request.
Active participation like phoning and e-mailing will be calculated, as an indicator of positive spirit	Impossible to count as there has been numerous phone calls and e-mail concerning the project implementation and possibilities.

### 5.1.2 A2. Plans for Preliminary Materials and Methods and Equipment Development

Action A2 started in August 2013 and ended in March 2017. Action completed.

<b>Name of activity</b>	<b>Planned deadline</b>	<b>Actual progress</b>
Plans for Preliminary Materials and Methods and Equipment Development	IV/2016	I/2017

Name of Deliverable	Deadline	Status
State-of-art report for (preliminary materials, methods)	03/2014	Delivered with the Inception Report.
State-of-the-art report - equipment development	10/2017	Was not implemented. Discussed in Midterm Report and Progress Report 4, removal accepted in Amendment 2020
Written instructions for the equipment development and mixing procedures	10/2017	Was not implemented. Discussed in Midterm Report and Progress Report 4, removal accepted in amendment 2020

Milestones name	Deadline	Status
Preliminary development planning done and finished (so that operative work only remains)	09/2013	Completed for flow column device -> did not seem necessary. (Instead purchase of tap milling device, see chapter 5.1.4)

### **Description of work done**

The overall objective with action A2 was to prepare a fluent start for the project implementation. In this action the target applications have been determined, the availability of the relevant materials and their locations has been studied and preliminary plans has been done. This action also has included the definition of technical, environmental and economic criteria for materials and applications. The bottom structure and reactive dam structures piloting locations changed which influenced on the materials to be used. Material test were made more than was expected in preliminary planning.

### **Modification of action compared to project proposal**

Deliverables concerning the equipment development was not implemented as equipment development did not happen in the project. The equipment budget was categorised for action A4 and needed amendment for the budget. The budget changes were approved in Amendment 2020. We see that this did not harm the project objectives, instead we think it is better that we have been able to start piloting without special equipment as this will also ease the replication and transferability of the project methods. See also chapter 5.1.4.

### **Problems encountered**

As described above, equipment development was not implemented in the project. The lack of equipment development is highly due to the bankrupt of Belvedere as this caused significant delay and uncertainty for the coming applications and piloting sites. This has been agreed with the EC in Grant Agreement 2020.

The lack of equipment development is further discussed in chapter 5.2.4 Applications.

Indicators of progress:

<b>Foreseen in the proposal</b>	<b>Achieved</b>
Successful preliminary plan for laboratory prototype (flow column device to depict realistic natural conditions in laboratory) – 1	0 no plans for flow column devices as this was finally seen unnecessary
Equipment development entities depicted (pictures, technical details, purchase planning done), so that efficient designing can be started in implementation action – 1	0 this did not happen in the project due to the delay of piloting activities
Preliminary illustrations of piloting applications for barrier and dam structures – 1	1

### 5.1.3 A3. Materials

Action A3 started in July 2013 and ended in August 2022. Action completed.

<b>Name of activity</b>	<b>Planned deadline</b>	<b>Actual progress</b>
Materials	IV/2021	III/2022

<b>Name of Deliverable</b>	<b>Deadline</b>	<b>Status</b>
Final technical report (compiling all the activities and results of the materials action during the project years 2013 - 2022)	12/2021	Delivered with the Final Report (Annex 4)
Material matrix for mining operations	11/2019	Delivered with the 4 <sup>th</sup> Progress Report.

<b>Milestones name</b>	<b>Deadline</b>	<b>Status</b>
Material studies made for the bottom structure	08/2021	Finished
Material studies made for the cover and reactive dam structure	08/2021	Finished

#### **Description of work done**

To determine what secondary materials would be the most suitable for the purpose of the project pilot applications, geotechnical and environmental tests for the tailings and combinations of various materials has been tested.

The first round of the Hitura mine material tests was carried out in spring 2014. Based on the results, the most promising material mixtures were selected for the second round of testing which was carried out in summer/early autumn 2014. The tests were performed for

two aggregate materials: nickel tailings and moraine with the use of various secondary materials, such as fly ash (fresh and stockpiled), fiber clay, foundry sand, lime, gypsum.

Ramfi studied Pyhäsalmi materials, and the results were updated in July 2015.

This action was finished at the end of 2021 as the rest of vertical sealing barrier and reactive dam material testing results were added to *A3 Final technical report on materials* (Annex 4).

**Modification of action compared to project proposal**

We had to postpone the deadlines of deliverables and milestones as the piloting had delayed. The delays did not impact on the project objectives.

**Problems encountered**

No actual problems within the materials actions other than general delay of the whole project.

Indicators of progress:

<b>Foreseen in the proposal</b>	<b>Achieved</b>
Saving of the 500 000 tonnes of virgin materials that would be otherwise used for the construction of the cover and bottom structure of the tailings facilities	The piloting for cover structure applications in Hitura has saved 136 500 tons of natural moraine. Vertical sealing barrier in Sorsasalo has saved 40 000 tons natural aggregates. Total amount of saved natural moraine and aggregates is 176500 tons. Reactive structures don't save directly natural materials, but it reduces limestone waste 30 tons. The amount does not match to indicator because cover structures material thickness was much lower (total 350 mm) than 2013 demanded structure thickness $\geq 1$ m. If the thickness would have been $\geq 1$ m, the foreseen amount (500 000 tonnes) would have achieved. The material thickness was implemented according to environmental permit for this piloting site. The selected material made it possible to use thinner layer and thus reduced the use of material.
The avoidance of the use of about 180 ha of bentonite matt cover	Original plan was to avoid the use of bentonite mat on Hitura tailings pond cover structures which area were 117 ha and on new tailings pond bottom structure which area was 65 ha, so the total area would have been 182 ha. Only the cover structure realized and almost all of the cover structure area (116 ha) was able to construct without bentonite mat. It has only used in bottom structures of the ditches. The

	<p>bottom structure pilot was implemented as vertical sealing barrier structure in Sorsasalo, where the total volume of waste area has been able to increase so that a need of new landfill area was avoided. That avoids about 4 ha bentonite mat usage since the bottom and cover of a new waste area would have needed bentonite mats. Total save of bentonite mat is about 120 ha. In Hitura mine area the bentonite mat usage is under 1 %, and it would have been 100 % without the UPACMIC project.</p>
<p>The amount of total material mixtures tested and acceptable found, will be calculated. The test methods used for quantifying the applicability was based on strength testing of materials. - Finally 3 - 4 suitable recipes will be found</p>	<p>Exceeded expectations: 4&lt;, many suitable recipes have been found. It depends on the site and it's requirements, which recipes can be used.</p>
<p>Number of total material reciping entities – 3</p>	<p>Exceeded expectations: 6&lt;, material studies were made in the beginning of the project that could not be used in actual piloting. Also, material studies were made for geopolymer cover structure (planned with Betolar for summer 2020) that never realized.</p>
<p>Number of material matrix documents – 1</p>	<p>1 Finished and delivered with the 4<sup>th</sup> Progress report.</p>
<p>The progress will be advancing as long as new recipes are tested in the laboratory. When piloting starts and if quality control procedures reveal that material needs improvement, then more materials studied will be needed. The progress will be indicated by recipes studied in relation to recipes being studied in total (this is impossible to know). The final results will be disseminated in the final technical report which comprises the information found in this action.</p>	<p>All the necessary material tests were carried out and the achieved results are presented in <i>Final technical report on materials</i>.</p>
<p>Number of technical reports – 1</p>	<p>1</p>

### 5.1.4 A4. Applications

Action A4 started in August 2013 and ended in August 2022. Action completed.

Name of activity	Planned deadline	Actual progress
Applications	I/2022	I/2022

Name of Deliverable	Deadline	Status
Final report on Applications / Designs; bottom-, cover and dam structures and reactive dam	02/2022	Delivered with the Final Report. (Annex 5)
Plans for the reactive wall / Written instructions of work methods, preliminary quality control and pilot follow-up activities	05/2021	Delivered with the 5 <sup>th</sup> Progress report.
Final technical report on the equipment development - A) single unit/multifeeder system, b) auxillary spreading device, c) flow-column settings prototype (delivered with 2nd Progress Report)	03/2015	Was not implemented. Discussed in Midterm and 4th Progress Report and removal accepted in Amendment 2020.
Plans for the bottom structures of the tailings pond / Written instructions of work methods, preliminary quality control and pilot follow-up activities	05/2021	Delivered with the 5 <sup>th</sup> Progress report.
Plans for the cover of the tailings pond / Written instructions of work methods, preliminary quality control and pilot follow-up activities	5/2021	Preliminary plans delivered with Midterm report. Updated plans delivered with 5 <sup>th</sup> Progress Report.

Milestones name	Deadline	Status
-	-	-

#### Description of work done

The aim of the Applications Action is to produce plans and instructions necessary to enable the implementation of the Piloting Action. As set in the project application, the structures to be tested and demonstrated in the framework of the UPACMIC include the following:

- a cover structure of a tailings storage facility
- a reactive dam for a tailings storage facility
- bottom structure/vertical sealing barrier

The design for the trial fields of Hitura was completed in June 2014 and it was updated for Hitura materials in May 2015 and for Pyhäsalmi materials in November 2015 to

accommodate also testing of the aggregate material from the Pyhäsalmi Mine. Applications were tested in Pyhäsalmi field tests in 2016 (Figure 7).



**Figure 7. Field tests in Pyhäsalmi mine in 2016.**

Fortum made plans for the cover structure to Hitura mine and the report was delivered to EC with Mid-term report. The report was updated and send to EC with the 5<sup>th</sup> Progress report. In 2019 started the planning and testing application for stabilized cover structure for tailings sand basin. Stabilized cover structure piloting (proposed with the 2020 Amendment Request and accepted with the Amendment No 3 of 23/06/2020) did not realize in Hitura as the third-party company (external assistance), Betolar, responsible for stabilization/geopolymerization technology withdraw from the piloting.

The plans for bottom structure were delivered with the 5<sup>th</sup> Progress report. The deliverable included plans made for Kuopio and, also the previous plans made in 2014 for bottom structure piloting made for Hitura mine, which were never realized due to bankruptcy of Belvedere mining company.

Also plans for reactive structures was delivered with the 5<sup>th</sup> Progress report. The reactive barrier application design was made in cooperation with University of Oulu.

*Final report on Applications/Designs* is delivered to EC with this report as Annex 5.

Instead of column device a laboratory scale grinding mill (Figure 8) was purchased for the utilization to increase material reactivity and further for their utilization properties. The materials are grinded with the help of grinders moving in the opposite directions. These tests aim to have impact on the quality of ashes to be utilized and thus find better processing solutions for the structure alternatives.



**Figure 8. Grinding mill**

### **Modification of action compared to project proposal**

Equipment development was decided not to carry out during the project as the project time was limited and it was estimated that it is easier to replicate tested structures if they can be carried out with typical earth construction machinery. This change did not affect the overall targets of the project, it rather helps the replicability of the tested applications in other locations in the future. In addition, the flow column device prototype development was seemed unnecessary for project purpose. Removal of Final technical report on the equipment development was accepted in Amendment 2020.

Grinding mill was purchased instead of the flow column device as described in Midterm report. The necessary laboratory testing for reactive barrier could be done with standard leaching tests (such as column test or batch leaching test). The grinding mill was used in laboratory for material treatment studies to support piloting actions which was seen more useful for the project objectives. The grinding mill can be used for dry materials, such as various type of fly ashes or dry lime waste, to decrease the grain size and increase the surface area of the material. The increased grain size improves the material reactivity if it is used as a stabilization agent in stabilized structures. The grinding mill was shown and discussed with monitor Luule Sinnisov during mission in 6.-7.5.2019.

The budget reserved for the equipment development was allocated in other cost categories and this budget change was accepted in Amendment 2020.

Original deadline for plans for the bottom structures of the tailings pond was 10/2014, and plans for the cover of the tailings pond was 12/2014. Both of the reports were updated in 2015 and again in 2021. Plans for the reactive wall was originally to be finished 1/2015 but was postponed due to the delays in the project. These reports were accepted to be finished 5/2021 in amendment 2020.

**Problems encountered**

As previously discussed, the bankrupt of the associated beneficiary Belvedere Mining who offered the project the piloting site impacted negatively on the project progress by delaying it and as there has been severe uncertainty on the piloting sites for the piloting structures, the associated beneficiaries have not seen it appropriate to start the equipment development if there is no actual use for them.

Instead, the applications were designed in such way that they can be constructed with the current and existing equipment which will ease the replication and introduction of the methods later within Europe as special and costly modifications are not needed.

Indicators of progress:

<b>Foreseen in the proposal</b>	<b>Achieved</b>
Plans for 3 pilot applications will be ready and allow for the start of piloting action (B1) - number of plans 3	3
Because of the applications plans 500 000 tonnes of virgin materials that would be otherwise used for the construction of the cover and bottom structure of the tailings facilities will be saved and replaced by secondary materials	Total amount of saved natural moraine and aggregates is 176500 tons. Reactive structures do not save directly natural materials, but it reduces limestone waste 30 tons. The amount does not match to indicator because cover structures material thickness was much lower (total 350 mm) than 2013 demanded structure thickness $\geq 1$ m.
The action will allow for the avoidance of the use of about 180 ha of bentonite matt cover	The piloting for cover structure in Hitura saved bentonite mat total 30 ha. The piloted area was smaller than evaluated in the beginning of the project, this explains the lower amount in savings of the bentonite mat.
The application plans will allow for the overall replacement of the virgin materials in the 3 pilot applications reaching 70%.	71%
Number of Technical Reports – 3	0, removal accepted in Amendment 2020.
Number of Information Reports (Work specifications) - 1	1, Final report on Applications
Number of laboratory prototypes developed – 1	0, removal accepted in Amendment 2020
Number of Equipment entities developed – 2	0, removal accepted in Amendment 2020

## 5.2 Implementation actions

### 5.2.1 B1. Piloting

Action B1 started in April 2014 and ended in August 2022. Action completed.

<b>Name of activity</b>	<b>Planned deadline</b>	<b>Actual progress</b>
Piloting	III/2022	III/2022

<b>Name of Deliverable</b>	<b>Deadline</b>	<b>Status</b>
Technical report, piloting bottom structure	10/2018	Was not implemented, accepted in the EC letter of 06/03/2019. The content is to be included in the Final technical report on piloting.
Technical report, piloting cover structure	11/2017	Was not implemented, accepted in the EC letter of 06/03/2019. The content is to be included in the Final technical report on piloting.
Technical report, piloting reactive dam structure (delivered with the Midterm report)	12/2018	Was not implemented, accepted in the EC letter of 06/03/2019. The content is to be included in the Final technical report on piloting.
Final technical report on piloting (delivered with the 4 <sup>th</sup> Progress Report)	08/2022	Delivered with the Final Report. (Annex 6)

<b>Milestones name</b>	<b>Deadline</b>	<b>Status</b>
Start of piloting action	04/2014	Piloting started in the Hitura Mine 10/2017.
All practical piloting completed	12/2021	Finished

#### **Description of work done**

The aim of the Piloting Action is to demonstrate the practical implementation of sustainable and eco-efficient mine construction processes based on secondary materials.

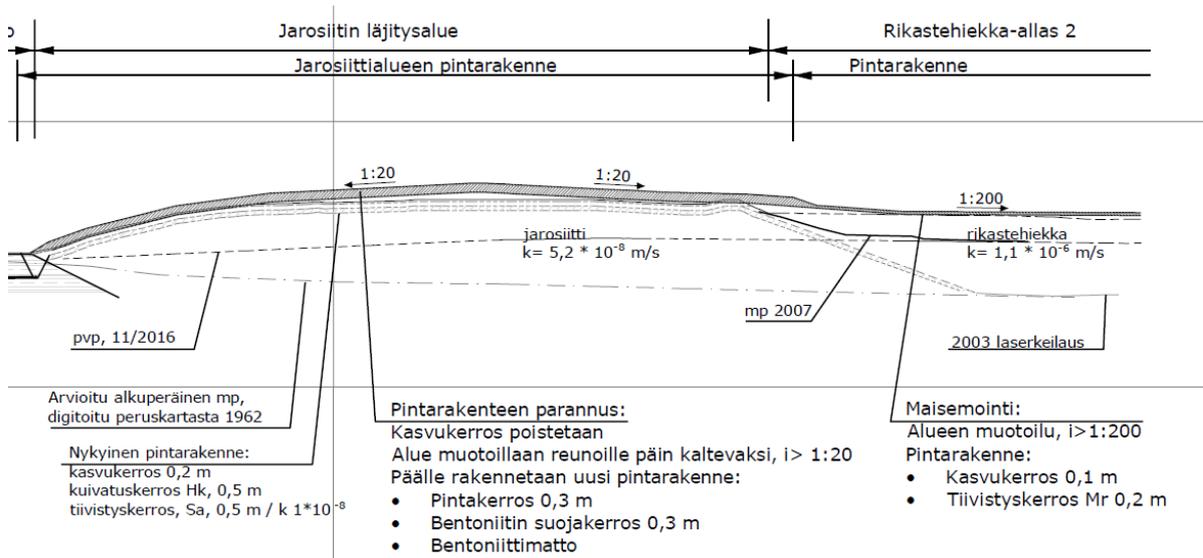
Bankruptcy of Belvedere in 2015 caused severe delays in the piloting action as UPACMIC lost the piloting site. A lot of effort was put in to finding suitable piloting sites. Negotiations was made to pilot bottom structure and reactive barrier in Särkiniemi Mine, which is also taken care of Finnish government and local ELY-centre after bankruptcy of the mining company. However, the government did not grant funding for Särkiniemi mine closure and the closure was postponed in the future. The information came in 4/2019.

## Cover structure

In 2016 field tests were constructed in the Pyhäsalmi Mine where lysimeters were built (see chapter 5.1.4) with different materials. The purpose of these studies was to examine how the used materials work in real circumstances in the field and to get information of the materials and their mixtures, water permeability and leaching properties, and to complement the data that was earlier studied in laboratory circumstances. Also, attention was paid to the material treatment/handling, mixing and compacting properties. The long-term performance was monitored in November 2019 when lysimeters were torn down and samples were taken layer by layer from each lysimeter. The results of these field tests were supposed to be used in larger pilot construction activities, which were at this stage thought to take place in the Pyhäsalmi Mine. Although the field tests in the Pyhäsalmi Mine gave a lot of new information, Pyhäsalmi withdrew from the project in 2018.

Results from Pyhäsalmi field tests have been utilised in nearby Hitura Mine, where the cover structure has been piloted. The pilot construction started in 2017 and originally it was planned to use 0,20 m layer of moraine in the compaction layer and above that 0,1 m layer of soil for landscaping purposes. The design was changed so that the 0,2 m moraine sealing layer was substituted with 0,25 m fiber clay sealing layer (see Figure 9).

Fiber clay structure is technically better structure than moraine structure, as fiber clay has lower water permeability which is important for this kind of structure. Also, its technical benefit is that fiber clay doesn't make cracks so easily when it dries as would happen to clay. If fiber clay would have not been used for construction purposes, the material would be combusted as it is expensive to store large amounts of material. Fiber clay though does not have actual proper heat value due to high water content and burning yield ash which also had to be disposed, so the utilization is important from the resource efficiency point of view.



**Figure 9.** The initial plan was to use 0,20 m layer of moraine on top of tailings sand (on right the side of picture), which was substituted with 0,25 m fiber clay layer.

According to the calculations, only changing the moraine sealing layer to the fiber clay sealing layer structure has saved ~ about 64 000 tons of natural moraine aggregates. In addition, above the sealing structure in the soil layer, industrial secondary materials such as

branch waste and decomposition are used, and that rises total amount of saved natural soil materials ~ about 100000 tons. The construction of surplus soil utilizing cover structure saved natural moraine aggregates ~ about 36500 tons.

The stabilized cover structure did not realize as Skarta (former Maastorakentajat) responsible foreman in Hitura (Matti Helaakoski) was injured during summer 2020 and after sick leave he shifted to work in other company. This caused major delay on this pilot planning and the third-party company Betolar responsible for stabilization/geopolymerization technology withdraw from the piloting. The absence of stabilized cover structure does not have effect on other actions.

Instead of stabilized structure piloting was decided to pilot smart material utilisation (= using surplus soils nearby instead of transporting virgin aggregates longer distance) in the cover of crushed stone pile in pre-crushing station in Hitura. The purpose of the cover structure is to reduce the formation of metal containing seepage water from the pile to the environment. The pilot area size is approximately 3,6 ha. Originally this pile was meant to be covered with moraine, which would have been transported from the 20 km distance to the site. Now all needed amount of the moraine is replaced with surplus clay and soils. Suitable surplus clay material was available in nearby of Hitura Mine and the utilization of surplus soils in cover layer reduced material transportation and costs compared to moraine cover layer. This piloting includes streamlined LCA study (including construction, transportation and materials) on the CO2 emission reduction potential in the case where surplus soils are used to replace virgin aggregates in mine cover structures. The material consumption as well as work method and construction time for clay and moraine structures were observed during the construction to produced information for LCA calculation. This cover structure pilot construction was carried out by Skarta in Summer 2021.



Levelled tailings sand

Fiber clay

Covered tailings sand (with fiber clay)

Fiber clay cover structures 2021

**Figure 10. Piloting activities in Hitura mine in 2018 and 2021 field visit (one of lysimeters front left on last picture).**

### Bottom structure/ Vertical sealing barrier

The bottom structure piloting for UPACMIC was meant to be carried out in Hitura during the construction of WWTS deposit site. In December 2019 ELY-Center informed that the deposit site and bottom structures for wastewater treatment sludge (WWTS) won't be constructed in Hitura mine as first planned. However, the deposit site where the WWTS is now transported in Kuopio is owned by AB Fortum. We were able to negotiate to carry out the bottom structure piloting in their site in Kuopio. Fortum carried out test structure in autumn 2020 to test the pilot structure in smaller scale. The construction continues after project life, but the calculations in *B3 Final report-Quality control (annex 9)* are taken into account for the complete structure.

In Sorsasalo's landfill area was piloted vertical sealing barrier, which separate inert waste and hazardous waste landfills and prevent leaching water flow from hazardous side to inert side. Pilot structure was constructed mainly using surplus soils and waste material which are otherwise deposited to same landfill without utilizing those land construction properties. The wall is still under a construction, but it will be finished before end of year 2022. Wall was about halfway done at winter 2021-2022. Vertical sealing layer is constructed using 1000 mm wide mould where surplus clay is packed with excavator. Beside of sealing wall is on both side drainage layer which is constructed using coarse fraction of sieved bottom ash from power plant. Drainage layer is 500 mm wide. Both side of previously mentioned layers is 5 m wide support layer which is constructed using surplus soils, ash and Hitura mine water treatment sludge. On each side is used soil which is originally planned to store that side of wall.



Figure 11. Pilot of vertical sealing layer in Sorsasalo.

### Reactive structures

Preparatory works for reactive barrier piloting (excavating of ditch for seepage water) was done during summer 2020 in Hitura waste rock pile area. The purpose of preparatory works was to channel seepage water ditch ready in the area where we have enough space to

carry out the piloting. The construction of reactive barrier pilot was carried out in Summer 2021.

Reactive structures are tested in Hitura mine's area during 2021 and 2022. Water for these structures is taken from side rock piles seeping water ditch. That water is contaminated by heavy metals (mostly nickel) and little bit acidic (pH 5-5,5). There are piloted 2 different reactive structure which are limestone dam combined geopolymer adsorbent and adsorption mats.

First structures main working mechanism is rising water pH by limestone which create conditions where metals precipitate on bottom of pond after limestone dam. Geopolymer adsorbent adsorb remaining metals. Second structure is commercial adsorption mat Tektoseal® 4000 made by Huesker GmbH company. The mat is made of two layer of geotextile where is granulated adsorbent between them. Mat is installed between gravel layers. Second pilot structure compose two identical ponds which are sequentially. Water flow through mats by gravity.



Figure 12. Reactive structure pilots 2021.

Reactive structures are monitored with water samples before structure and after it. Main focus of pilot is research structures operating time in real mine conditions. Results are shown in *B1 final technical report on piloting (annex 6)* and *B3 Final report- Quality control (Annex 9)*.

The closure of the Hitura Mine work was ordered by the North Ostrobothnia Centre of Economic Development, Transport and Environment which also has been a supervising authority for the Hitura Mine during its operation time.

### **Modification of action compared to project proposal**

Initially it was planned to produce four deliverables as following:

- Technical report, piloting bottom structure
- Technical report, piloting cover structure
- Technical report, piloting reactive dam structure
- Final technical report on piloting

We suggested combining all these reports to one final technical piloting as this would serve best for the project dissemination purposes. The intended separate reports on different pilot structures have similarities and issues to be studied together, so it was not reasonable to separate the reports. This was not foreseen when writing the proposal. Combining of the deliverables did not have impacts on the project progressing, implementation nor financial matters – instead the report combining all the mentioned structures and related issues produced deeper information and the project results are easier to disseminate. This proposal was accepted in amendment No 3, in 2020.

### Problems encountered

As previously discussed, the bankrupt of the associated beneficiary Belvedere Mining who offered the project the piloting site impacted negatively on the project progress by delaying it and as there has been severe uncertainty on the piloting sites for the piloting structures. The delay in the progress caused also increase in the management budget (action E1) which is further discussed in chapter 6.1.

Indicators of progress:

<b>Foreseen in the proposal</b>	<b>Achieved</b>
Implementation of the action according to the planned timetable, list of milestones and deliverables, and the budget framework.	The project time extension provided in amendment 2020 was essential for B1 action, as most of the pilot construction has been carried out during fall 2020 and summer 2021, which would have been out of original project deadline 31.8.2020.
Total area constructed, the amount of test fields constructed (percentage of total area piloted). The demonstration site will have a specific area/size. The finished construction will be compared to total area and a percentage point of finished structure, will be given. The exact area of construction will depend on various things, material recipes, - transportation, - overall economic,- environmental permitting. The different possible work methods and the verification (meaning testing on field) will reveal how many valid working methods exists for these materials.	At the vertical sealing barrier structure the pre-building field tests were about 2,4% of the total area of the wall. At fiber clay sealing structure the area of test fields were about 0,4% of total area of fiber clay sealing layers in pilot.
Calculation of new discovered working methods, tested working methods and new ideas for improvement. Tested working methods will be categorized for different materials as (rejected, suitable for certain materials and structures).	There are tested several working methods in the project. Compacting with a mold is a suitable method for compacting soft materials like clay when forming a wall. For other materials suitable compacting method is running over about three times by heavy working machines. There are tested material processing by a grinding mill in the project. Using the mill for course materials like bottom ash or slag, it could be possible to make the material more

	reactive. Grinding method can be scaled up using example industrial ball mill. Material mixtures mixability was tested using tractor powered concrete mixer. Gypsum mixed easily and suits for mixtures, but ash doesn't mix well so mixing it needs more research. Material mixing can be scaled up using windrows turners.
Number of piloting sites - 1 site	2 (Hitura Mine and Sorsasalo Kuopio)
Number of clear piloting entities - 4	4: Bottom/vertical sealing barrier, reactive wall, cover using fiber clay and cover using surplus soil
Number of Technical Reports – 4	1, Final technical report

### 5.2.2 B2. Logistical Model

Action B2 started in March 2014 and ended in August 2022. Action completed.

<b>Name of activity</b>	<b>Planned deadline</b>	<b>Actual progress</b>
Logistical Model	III/2022	III/2022

<b>Name of Deliverable</b>	<b>Deadline</b>	<b>Status</b>
Final technical report on the MSCD-model (logistical model for utilisation of by-products in mine remediation)	08/2022	Delivered with the Final Report. (Annex 7)
Technical recommendations document	08/2022	Delivered with the Final Report. (Annex 8)

<b>Milestones name</b>	<b>Deadline</b>	<b>Status</b>
The MSCD-model for mining industry finished, and all aspects reported	08/2022	Finished

#### **Description of work done**

The foundation for creating the Logistical Model has been laid by creating a network of wastes as secondary materials producers to be involved in the UPACMIC project as material suppliers as reported in the Inception Report. The preliminary report on the logistical issues concerning material locations, distances to the pilot site and prices was delivered in May 2014 and updated and send to EC with Final Report (annex 7). All experience gathered while carrying out the material testing, pilot design and construction was utilised for the needs of this action and the best practices reported in technical recommendations document which was delivered with Final Report (annex 8).

### Modification of action compared to project proposal

The delays in Action B1 postponed the deadlines of deliverables in Action B2. The delays did not impact on the project objectives but impacted on the deadlines significantly. The deliverables were accepted to be delivered with the Final Report in amendment 2020.

### Problems encountered

No actual problems other than general delay of the whole project.

Indicators of progress:

Foreseen in the proposal	Achieved
Material supply chain development model developed – 1	1
Number of stakeholders involved in the action – 10	Exceeded expectations: 10< (project partners 3, material producers 8, several transporting companies and subcontractors)
Number of technical reports – 1	2

### 5.2.3 B3. Quality Control and Verification

Action B3 started in April 2014 and ended in August 2022. Action completed.

Name of activity	Planned deadline	Actual progress
Quality Control and Verification	III/2022	III/2022

Name of Deliverable	Deadline	Status
Final report – Quality control, summarizing report	08/2022	Delivered with the Final Report. (Annex 9)

Milestones name	Deadline	Status
Start of the quality control in piloting site	06/2014	Finished

### Description of work

The design concerning the quality control system for the pilot applications has been carried out and the plan was submitted with the Progress Report 1. The launch of this Action has been delayed because of delays in actual piloting. Quality control is done during construction by Troxler measurements which measures structures density after compaction works. By density measurements could water permeability be evaluated, which was the main monitored value. Visual observation and machine tracking is also used constantly during construction phase. When structures were ready lysimeters are used to monitoring real water permeability of structures. Water from lysimeter is calculated quantitatively and analysed. Reactive structures are monitored by water sampling before structures and after structures. Results from each analysis is plotted against time, so the differentiation is more

clearly shown, and trends be found. Results are shown in *B3 Final report- Quality control (Annex 9)*.

### **Modification of action compared to project proposal**

The delays in Action B1 postponed also the deadlines of deliverables in Action B3. The delays did not impact on the project objectives but impacted on the deadlines significantly. The deliverables were accepted to be delivered with the Final Report in Amendment 2020.

### **Problems encountered**

No actual problems other than general delay of the whole project.

Indicators of progress:

<b>Foreseen in the proposal</b>	<b>Achieved</b>
The quality control methods (such as the density of the compacted material will be compared to values indicated by laboratory tests). A percentage point will be given for those quality control measurements that will pass the laboratory test stage created limit values.	The vertical sealing barrier (66 measurements) and fiber clay cover structure (180 measurements) was measured by Troxler. K value was analysed for 6 samples and all reached requirements. All these measurements passed the limit values, 100%. At Pyhäsalmi mine field tests measurements was carried out by scales and volume determination. 15 measurements were made of which 33% passed the limits.
Number of sand- and water volumetric, or radiation-based measurements done - This varies on the amount of materials selected for constructing - Approximately 50 - 200 measurements	275 Troxler measurements.
Accepted framework for quality control management system for by-product mixtures in mine remediation sites – 1	1

## 5.3 Monitoring of the impact of project actions

### 5.3.1 C1. Monitoring of the Impact on the Target Audience

Action C1 started in March 2014 and ended in August 2022. Action completed.

<b>Name of activity</b>	<b>Planned deadline</b>	<b>Actual progress</b>
Monitoring of the impact on the target audience	III/2022	III/2022

<b>Name of Deliverable</b>	<b>Deadline</b>	<b>Status</b>
Baseline report – KAP Survey method, placed on the project website	01/2014	Submitted with the Inception report.
Result report – KAP Survey results, “Project Ending” / “Final results” (annex with the Final report)	08/2022	Delivered with the Final Report. (Annex 10)
Final results report – KAP Survey results, “Project Ending” / “Final results” (annex with the Final report)	01/2020	Was not implemented. Accepted in the EC letter of 06/03/2019. The content is the same as in the deliverable “Result report – Kap survey results, Project ending/Final results”.
Result report – KAP Survey results, “Project Start” / “Beginning Situation”	12/2014	Submitted with the Progress Report 1 and update delivered with 2 <sup>nd</sup> Progress Report.

<b>Milestones name</b>	<b>Deadline</b>	<b>Status</b>
-	-	-

### **Description of work**

The baseline study started in 2014 with a review of the situation in the waste and secondary materials in Finland as compared to some other countries, as well as with a review of the current situation in the secondary materials’ sector. The KAP (knowledge, attitude, practices) questionnaire was placed at the project website and distributed via project newsletter and at WASCON 2015 conference project presentation. The preliminary results of the Action were presented in the Inception Report.

At the final stage of the project another KAP questionnaire was implemented and distributed via website, newsletter and events during Spring 2022. Project beneficiary’s pilot projects managers from Fortum and Skarta was interviewed in 4/2022 and their encountered challenges and good practices were collected for KAP final report. The results of this Action including the analysis of the replies to the KAP questionnaires, and the interpretation of the focus group discussions and overall conclusions is reported in *KAP (Knowledge, Attitudes, Practices) Final report* (annex 10).

### **Modification of action compared to project proposal**

There had occurred an error when listing the deliverables and the “Final results report – KAP Survey results, “Project Ending” / “Final results” (annex with the Final report) “ is duplicate of the report “Result report – KAP Survey results, “Project Ending” / “Final results” (annex with the Final report)” and thus the first report mentioned shall be deleted in order to rationalize the deliverables. Deleting the other report was accepted in the EC letter of 06/03/2019.

The due date for Result report - KAP Survey results was revised and accepted by Amendment to the GA no 2 (accepted in 2016) and GA no 3 (accepted in 2020).

### Problems encountered

Despite the hard work on collecting answers to KAP questionnaire, the number of responses was relatively low. It was estimated that this is due to the fact that people are very busy in their work lives. However, many productive discussions took place during project life for example in seminars and we could use this information to evaluate the situation.

Indicators of progress:

<b>Foreseen in the proposal</b>	<b>Achieved</b>
Action carried out according to the timetable and within the frames of the planned budget.	Action was carried out according to the timetable in Amendment 2020.
Number of KAP questionnaires carried out and analysed – 2	2
Number of KAP questionnaires recipients each time – 750	The exact number of recipients could not be calculated, but it has been estimated that it would be approximately 750.
Number of Baseline reports – 1	1
Number of Action reports – 1	1 (only final report)
Number of Focus Group meetings (arranged together with workshops or other seminars) – 3	The discussion about the project subjects has been active in various events during the project. The topics has also been discussed in partner meetings and steering group meetings.
Number of event satisfaction questionnaires – 3	1, after the project final seminar.

### 5.3.2 C2. Monitoring of the Project Actions Impact on the Environmental Problem Targeted and Assessment of the Socio-economic Impact

Action C2 started in April 2014 and ended in August 2022. Action completed.

<b>Name of activity</b>	<b>Planned deadline</b>	<b>Actual progress</b>
Monitoring of the Project Actions Impact on the Environmental Problem Targeted and Assessment of the Socio-economic Impact	III/2022	III/2022

<b>Name of Deliverable</b>	<b>Deadline</b>	<b>Status</b>
Final Verification report (includes LCC/LCA + external review, delivered with the final report)	08/2022	Delivered with the Final Report. (Annex 11)

Carbon Footprint report 1 (Annex with 1 <sup>st</sup> Progress report)	10/2014	Delivered with the 1 <sup>st</sup> Progress Report
Carbon Footprint report 2 (Annex with 2 <sup>nd</sup> Progress report)	12/2015	Delivered with the 2 <sup>nd</sup> Progress Report
Carbon Footprint report 3 (Annex with 3 <sup>rd</sup> Progress report)	02/2017	Delivered with the 3 <sup>rd</sup> Progress Report
Carbon Footprint report 4 (Annex with 4 <sup>th</sup> Progress report)	03/2019	Delivered with the 4 <sup>th</sup> Progress Report
Carbon Footprint report 5 (Annex with the final report)	8/2022	Delivered with the Final Report. (Annex 12)
Eco-efficiency report (published in webpage and reported as an Annex with the 4 <sup>th</sup> Progress report)	03/2019	Was not implemented. Accepted in the EC letter of 06/03/2019. Content is included in “Final verification report”.
Analysis of the socio-economic effects of the project (delivered with the final report)	08/2022	Delivered with the Final Report. (Annex 13)

Milestones name	Deadline	Status
Carbon footprint counting instructions delivered to the partners	08/2013	Finished

### Description of work

This Action includes the streamlined LCA (Life Cycle Assessment) and LCC (Life Cycle Cost) studies. LCA/LCC studies provide a proof that use of the project methods and procedures results in a more favourable impact on the environment. The verification results included also statements of the external experts working in Aalto university.

LCA is calculated based on the ISO standard (EN ISO 14040:2006). In the UPACMIC project LCA has been carried out as a simplified version (streamlined LCA), where the analysis was limited to the lifecycle phases A1-A3 *product stage* (raw material supply, transport and manufacturing) and A4-5 *construction process* (transport, installation) according to CEN/TC 350 standard EN 15643-5. The analysed structures are permanent and therefore nothing will be done about them after construction.

LCA is calculated for 3 pilot and in each also is done one or two alternative scenarios which are then compared to really constructed pilots. The three pilots are:

- Fiber clay and moraine sealing layer in Hitura
- Surplus soil sealing layer in Hitura
- Vertical sealing barrier in Sorsasalo

Fiber clay structure is compared against figurative case where fiber clay producers are 50 km a way from construction site and moraine is transported from 37 km a way. Surplus cover structure is compared against case if it is constructed using same moraine than in tailings sand basin cover and case if fiber clay from Oulu is used. Vertical sealing layer which is constructed mostly using non-virgin materials is compared against case where all materials are crushed virgin stone. The results were reviewed by external auditors from

Aalto University, Ms. Leena Korkiala-Tantt (Professor, Civil Engineering) and Mr. Henry Gustavsson (University teacher, Civil Engineering). Results and the review are shown in *C2 Final Verification report* (Annex 11)

The carbon footprint of the project has been calculated during project life and the situation has been reported with the Progress Reports 1,2,3 and 4. The final calculations have been made and reported in *Carbon footprint Final report* (annex 12).

Assessment of the socio-economic impact was made at the end of the project. The impact on the local community, population and economy was evaluated. The information was gathered in many discussions with project partners, seminars and, also in cooperation with other projects working at Hitura Mine (KAIVASU and LeKaT projects). Local newspaper and social media were also monitored to assess the situation. *C2 Analysis of the socio-economic effects of the project* is delivered to EC with this Final Report (annex 13).

This Action also included the development of sustainability indicators. The indicators can be used for measuring and controlling the sustainability of the methods and practices proposed by the UPACMIC project in the future projects. *The report of Sustainability indicators* is delivered to EC with this Final Report (annex 14).

### **Modification of action compared to project proposal**

As described in the table of deliverables, the report “Eco-efficiency report (published in webpage and reported as an Annex with the 4<sup>th</sup> Progress report)” is foreseen unnecessary. The removal of this report was accepted in EC letter of 06/03/2019. Eco-efficiency issues were discussed in the Final Verification Report more thoroughly which also serves the needs of decision-makers and authorities. Eco-efficiency was dealt also on a general level in Layman’s Report.

The due dates for several milestones and deliverables were revised and accepted by Amendment to the GA no 2 (accepted in 2016) and GA no 3 (accepted in 2020). The delays did not affect to the action implementation.

### **Problems encountered**

No problems encountered other than the general project delay.

Indicators of progress:

<b>Foreseen in the proposal</b>	<b>Achieved</b>
The Action will be carried out according to the timetable and in the budget framework	Action was carried out according to the timetable in Amendment 2020
Number of the preliminary study version – 1	1
Minimal number of events where preliminary results presented – 4	4 (Kaivosteollisuus ry R&D seminar, projects final webinar, MASU seminar and UUMA seminar)
Number of experts commented the study – 2	2
Number of Eco-efficiency reports – 1	0 (Was not implemented. Content is included in “Final verification report”.)

Number of recipients of the Report link – 1500	Reports has been added to project webpage when ready. The first Carbon footprint report was published in 2014. The exact amount of webpage visitors could not be calculated as the webpage analytics was turned of by Google and started again in 2020 (see chapter 5.4.3 Project Website).
Number of Carbon Footprint reports – 5	5

## 5.4 Dissemination actions

### 5.4.1 D1. Presentation Materials, Layman’s report, Media work

Action D1 started in November 2013 and ended in August 2022. Action completed.

<b>Name of activity</b>	<b>Planned deadline</b>	<b>Actual progress</b>
Presentation Materials, Layman’s report, Media work	III/2022	III/2022

<b>Name of Deliverable</b>	<b>Deadline</b>	<b>Status</b>
Laymans’ report (in English, as an Annex with the final report)	08/2022	Delivered with the Final Report. (Annex 19a in English and Annex 19b in Finnish)
Press release about the UPACMIC project	02/2015	Delivered with the Progress Report 1.
Project brochure in English and in Finnish	12/2013	Delivered with the Midterm Report
Intermediate slide presentation	09/2017	Delivered with the Midterm Report
Project video clip	08/2022	Delivered with the Final Report (annex 33a and 33b)
Annual project newsletters	08/2022	5 letters sent to the target audience during the project (newsletter 5 as annex 23)
Final slide presentation	08/2022	Delivered with the Final Report. (Annex 20)

<b>Milestones name</b>	<b>Deadline</b>	<b>Status</b>
Press release 1 sent to media	12/2013	Submitted with the Inception Report.
Press release 2 sent to media	12/2016	Submitted with the Progress Report 2.
Press release 3 sent to media	01/2018	Delivered with the Midterm report

Press release 4 sent to media	11/2019	Submitted with the 4 <sup>th</sup> Progress Report
Presentation Materials, Layman´s reports and video clip created/finished	08/2022	Final slide presentation, Layman´s report and video clip delivered with the Final Report
Active screening of dissemination opportunities started	08/2013	Started during project time and on-going in After-Life action.

### Description of work

The objective of action D1 is to produce various types of communication and dissemination materials which are presented in different events, occasions and in the UPACMIC website. The materials comprise of the project presentations, layman's report, brochures, project video clip, newspaper articles and press releases.

The results achieved in action D1 is presented in table 5.

**Table 5. The achieved results of Action D1 compared to the project proposal.**

	<b>Foreseen</b>	<b>Achieved</b>
1.	The project presentations	17 presentations made, including Intermediate slide presentation and Final slide presentation.
2.	Layman's report (in English and in Finnish)	Produced in English and in Finnish and both are available at project website.
3.	Brochures in Finnish and in English	Produced in English and in Finnish and both are available in project website. 400 copies printed per language and disseminated in events.
4.	DVD-presentation	Project video clip was made in English and in Finnish. Both videos are presented in YouTube and project webpage and disseminated in various events.
5.	Newspaper articles (goal 10) and press releases (goal 4).	10 articles achieved in newspapers and various webpages. 4 press releases sent.
6.	TV and radio	No TV or radio broadcasts achieved. It was found to be very hard to get the subject of this project to reach media attention.
7.	Visual materials produced for the media campaign needs will be also available on-line not only at the project website.	Dissemination materials are easily reached at project

		webpage (project deliverables page). The project partners have links to the project website. Also, project information is available in various webpages of participated events, online newspapers etc.
8.	Annual newsletters (goal 4)	5 newsletters sent (year 2014,2018,2020,2021,2022). In addition, up-to-date news was published at projects Twitter account from June 2016.
9.	Slide presentations will be created in different languages (Finnish, English and Swedish).	Slide presentations are available in English and in Finnish. Swedish presentation was not relevant during the project.

Materials produced in this action contributed to capacity building of the stakeholders involved and targeted and they will also serve the strengthening the LIFE+ programme brand among all the target audiences.

In the early stages of the project a brochure was produced in English and in Finnish and it was delivered with relevant occasions during project time. Also, a logo for the project had been created (see Figure 9). Logo was created by RAMFI personnel (graphic designer). Later, during project video clip process, a gif animation was made of the UPACMIC logo. Same logo as gif animation was added to the projects website and used in e-mail correspondence.



**Figure 13. UPACMIC logo.**

This action included continuous observance of relevant medias which would be suitable for UPACMIC project. As the time has changed during the project years, and the circulation of newspapers are decreased, it was more relevant to publish the articles in web-based media rather than only in the newspapers. (E.g. media Taloussanommat was written in the proposal but that media does not publish printed material anymore). Web-based media are more widely available which increase dissemination probability to outside of national borders.

First press release was sent to the Finnish media by Belvedere and Ramfi in the early stages of the project in 2013. Article concerning UPACMIC project was published at Belvedere website in 15/8/2013 and in Nivala lehti magazine in 22/08/2013. Nivala lehti is a local newspaper in the area of Hitura mine. An article was published in Sydän-Hämeen lehti magazine in 29/12/2016. In addition, a dissemination plan was created by a freelancer journalist in 2016. Short article about UPACMIC objectives was released in Uusiouutiset (Finnish Circular Economy News), number 08/2017. In May 2018, press release was sent to the media. UPACMIC workshop at WASCON 2018 conference was introduced in Europa Nu article in 2018. The next press release was sent to media in 2020, when Hitura phase I was finished, and we could inform that the first piloting report had been published. Article of UPACMIC was published in International Mining webpage in 14/04/2020. Article of UPACMIC project in Ramfi intra was published in 23/04/2020. The projects final webinar received media attention and an article was published about it at Uusiouutiset in 10/05/2022. A professional article was published in July 2022 at Materia-lehti magazine number 3/2022 (annex 30b).

As the project prolonged another media work plan was made for the years 2021 and 2022. Dissemination work was active at the end of the project as we wanted to share information of the results from the piloting activities.

A freelancer journalist interviewed the project team and wrote an article and a project reference which was published in Ramfi webpage 06/04/2022 (Annexes 21a and 21b). An article was also published in Kiertotalouden uutiskirje (Circular economy newsletter) in 13/04/2022 (Annex 22). There are over 4000 recipients of the newsletter.

Project progress and latest news was disseminated by projects newsletters to the target audience. Five newsletters were sent during project time to approximately 450 recipients. The last letter was sent 25/02/2022 (Annex 23). Twitter account was used to inform instantly about events and on-going actions. The twitter feed was shown also on project websites home page.

During the project years, multiple presentation was made for different occasions. At the end of the project the participation to events and disseminating was very active as the projects results were available:

- Presentation in Uusiomaarakentamisen vuosiseminaari 10/11/2021, recovered materials in groundworks seminar. (Annex 24)
- Presentation in Kaivosteollisuus ry, R&D webinar 16/02/2022. Kaivosteollisuus ry is a mining association in Finland. (Annex 25)
- Three UPACMIC presentations in projects final webinar "Uudet mahdollisuudet kaivosympäristöjen kiertotaloudessa ja kestävässä kehityksessä" 16/03/2022
  - o Materials (Annex 26a)
  - o Pilots and results (Annex 26b)
  - o Lessons learned, experiences of the constructor (Annex 26c)
- Presentation in MASU (Maaperän Suojelu = soil protection and remediation of contaminated soil) seminar 08/04/2022 (Annex 28)
- Presentation at Ramboll Circular community meeting 15/6/2022 (Annex 29)

Final slide presentation was produced to serve the needs of After Life dissemination (Annex 20). All of the presentations produced during the project are listed in UPACMIC Dissemination actions 2013-2022 excel (annex 17).

To the WASCON 2018 conference a poster “Utilisation of by-products and alternative construction materials in new mine construction” was also disseminated.

The project video clip was ordered from external assistant Vinovinkkeli (invoicing by the name SLP Group Oy) which had the necessary skills to film, photograph, edit and animate the video in high-quality. The graphic design was made by a company named Kaukokatse, which acted as a subcontractor of Vinovinkkeli. The video was designed together with Ramfi staff and Vinovinkkeli experts. By using both video materials from piloting, graphical design and animation, the result was versatile and the project actions was easy to understand. Vinovinkkeli also produced the gif animation mentioned earlier. The project video clip was disseminated through webpage, Ramboll Finland’s YouTube channel and seminars at the final stages of the project. Project video is presented as annex 33a (English version) and annex 33b (Finnish version).

During the project life the implementation was documented by photographs taken by CB Ramfi and by AB Skarta and Fortum. The photographs have been used as dissemination materials in presentations, newsletters, website etc. High-quality photographs had also been taken during project video filming at Hitura mine in Summer 2021 by Eetu Keränen photography (subcontractor of Vinovinkkeli). Best of the photographs are presented as annex 34.

### **Modification of action compared to project proposal**

In the proposal DVD presentation was mentioned but as the media world has changed fast during the project years, DVDs are not anymore suitable deliverable for stakeholders. Instead, project video clip was made, and it was published in the project website and in Ramfi YouTube channel and used as a presentation material in different occasions.

### **Problems encountered**

No problems encountered other than the general project delay.

Indicators of progress:

<b>Foreseen in the proposal</b>	<b>Achieved</b>
Number of Presentation materials: brochures (1 A4 page) in Finnish and English - 5000 pieces (3000 in English, 2000 in Finnish)	English and Finnish brochure printed, both 400 pieces. As it is a trend nowadays, less printing material is produced, and the brochure is also distributed by e-mail. In addition, a poster has been created.
Number of Layman’s reports - 3000 (2000 in English and 1000 in Finnish)	Layman’s report is not printed as it is a trend nowadays, less printing material is produced. The main distributed route is by e-mail and via project website.
Number of project presentations like slide presentations (Finnish, English, Swedish, different emphasis) – 6	17 presentations in Finnish and in English

Number of annual newsletters (published yearly, April) – 4	5 newsletters published
Number of DVDs - 1 type (500 copies)	DVD is outdated dissemination material type so this is replaced by video clip that is loaded in the website and in in Youtube
Number of press releases – 4	4
Number of newspaper articles - 10 (from which a smaller amount is expected to be published)	3 paper magazines and 7 articles at internet.
Active media work carried out resulting in at least 2 interviews	3 interviews done in accordance with newspaper articles (Sydän-Hämeen Lehti, Uusiouutiset, Ramfi webpage article)
Materials kept updated throughout the whole duration of the project	Materials updated throughout the project time

#### 5.4.2 D2. Life+ Information Boards

Action D2 started in October 2013 and ended in June 2020. Action completed.

Name of activity	Planned deadline	Actual progress
Life+ Information Boards	II/2020	II/2020

Name of Deliverable	Deadline	Status
-	-	-

Milestones name	Deadline	Status
LIFE information boards placed near the site	06/2014	Erected for Pyhäsalmi, Hitura and Sorsasalo, Kuopio.

#### Description of work

The objective of this action was to erect two LIFE+ notice boards. Eventually, three notice boards was erected to Pyhäsalmi mine, Hitura mine and waste deposite site at Kuopio.



Figure 14. LIFE+ Information Board in Hitura site.

### Modification of action compared to project proposal

Total 3 separate LIFE notice boards were needed as the piloting structures piloted in different locations instead of one, as written in the proposal.

### Problems encountered

No problems encountered other than the general project delay.

Indicators of progress:

Foreseen in the proposal	Achieved
Number of erected Life Notice boards – 2	3

### 5.4.3 D3. Project Website

Action D3 started in December 2013 and ended in August 2022. Action completed.

Name of activity	Planned deadline	Actual progress
Project website	III/2022	III/2022

Name of Deliverable	Deadline	Status
-	-	-

Milestones name	Deadline	Status
Web page operating	10/2013	Was operating and updated on a regular basis

## Description of work

The objective of this action is to communicate the project's objectives and results to improve the awareness of a sustainable and eco-efficient mine construction method. The website was launched already in the beginning of the project as described in the proposal and the webpages have been updated at least 1-2 times a year. The webpage is available in English and in Finnish. Figure 15 presents the front page of the project website.

All the essential project deliverables and information has been updated to the webpage for dissemination and After Life use.

The address is: [https://projektit.ramboll.fi/life/upacmic/index\\_eng.html](https://projektit.ramboll.fi/life/upacmic/index_eng.html)

The project webpage will be maintained at least 5 years after project end by Ramboll Finland.

**UPACMIC - LIFE12 ENV/FI/000592**  
Utilisation of by-products and alternative construction materials in new Mine Construction

**What?**  
UPACMIC (Utilisation of by-products and alternative construction materials in new mine Construction, LIFE12 ENV/FI/000592) aims to utilize alternative construction materials in new mining facilities and remediating the existing ones.

**How?**  
The approach proposed by the project derives from waste material mixture methods applied in various infrastructure development projects. Owing to the UPACMIC project this technology will be implemented in the mining industry for the first time.

**Why?**  
Alternative construction materials will replace non-renewable natural materials such as eskers and moraines, as well as commercial sealing products like bentonite mattes and geosynthetic geomembranes.

**Who?**  
The UPACMIC project is coordinated by [Ramboll Finland Oy](#) and associated beneficiaries are [Skarta Finland Oy](#) and [Fortum Waste Solutions Oy](#).

The project is financed by the EU LIFE+ Environmental Policy & Governance programme and Ministry of the Environment.

**When?**  
1.7.2013-31.08.2022

**Other information**  
The project serves the needs of developing the European and national environmental legislation and policy on better resource and waste management practices. It is aimed that the UPACMIC project will contribute to the process of recognising new, innovative solutions such as intelligent material mixtures with positive buffering qualities as possible alternative materials in the construction and remediation of mining waste storage facilities.

The main by-products being investigated are fly-ash from power generation and furnaces, fibre clays from the paper industries, gypsum and foundry sands. These products have active neutralising and/or sealing properties and have been successfully used to date on smaller scale containment processes in other sectors. Tailings dam construction and rehabilitation are a major part of the mining industries capital costs and later closure costs. To find ways to increase the safety and environmental effectiveness of these processes, while reducing costs is the laudable goal of this project.

Home  
Background and objectives  
Project Partners  
Pilot applications  
Networking  
Contact

News  
Project deliverables  
Gallery

Tweets by UPACMIC

Figure 15. Front page of the UPACMIC webpage.

In addition, UPACMIC project has a Twitter account (@UPACMIC) which was not foreseen during writing the proposal. The Twitter feed was placed also to the project website and its purpose was to operate as a platform for interactive discussion and for

networking with other projects. Twitter was used to inform events and latest news in real time. The projects Twitter account has now 56 followers and 31 posts.

### Modification of action compared to project proposal

Twitter account was added which was not foreseen in the proposal. As described below, the indicators of the progress of this action, the levels of succeeding are set very high and we are not sure if these numbers are relevant nowadays as the use of different medias has changed significantly during the project years.

### Problems encountered

Visitor count of the project website was monitored during the project time. However, the total count can't be calculated as the data from the beginning of the project was lost due to changes in services by Google. There was no notice of this change in advance by Google. The tracking of the visitor count restarted at 26/03/2020.

### Indicators of progress:

Foreseen in the proposal	Achieved
40 000 hits at the project website annually (average). LEVEL 1: 20 000 - 40 000; LEVEL 2: 10 000 - 20 000; LEVEL 3: 1 000 - 10 000; LEVEL 4; 0 – 1000	In 2021 UPACMIC website had 125 users and 121 of them were new users. 843 pages was viewed. Total amount of users for the period 26/03/2020-31/05/2022 was 277. These amounts are relatively low despite the fact that the website was referred in many occasions (newsletters, presentations, articles). The project has found these indicators very ambitious. The results were compared with UUMA programme, that has wider topic, audience and community compared to UPACMIC. UUMA programme had 5 646 users at their website in 2021. Even this, much bigger project, remains at level 4.
20 000 downloads of the project information materials. LEVEL 1: 10 000 - 20 000; LEVEL 2: 5 000 - 10 000; LEVEL 3: 1 000 - 5 000; LEVEL 4; 0 – 1000	The level is assumed to be at 4. The level of downloads was not possible to track.
20 000 downloads of the guidelines (after the completion of Action D5). LEVEL 1: 10 000 - 20 000; LEVEL 2: 5000 - 10 000; LEVEL 3: 1 000 - 5 000; LEVEL 4	The level is assumed to be at 4. The level of downloads was not possible to track.
All project partners use the website effectively, qualitative parameter	AB Fortum and Skarta has information of the UPACMIC project and link to projects website in their company websites: - Fortum: <a href="https://www.Fortum.fi/yriyksille-ja-yhteisoille/kierratys-ja-jatepalvelut/ymparistorakentaminen/rakennettu-">https://www.Fortum.fi/yriyksille-ja-yhteisoille/kierratys-ja-jatepalvelut/ymparistorakentaminen/rakennettu-</a>

	ymparisto-vaatii-yllapitoa-ja-kestavaa-kehitysta - Skarta: <a href="https://Skartagroup.fi/en/Skarta-group-2/Skarta-specialised-construction/">https://Skartagroup.fi/en/Skarta-group-2/Skarta-specialised-construction/</a>
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The progress indicator used counts annual hits and downloads made in the website. A certain judgement is given for each count, in the following way:

LEVEL 4: no progress

LEVEL 3: low progress

LEVEL 2: good progress

LEVEL 1: excellent progress

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#### 5.4.4 D4. Participation in and Organisation of National and International events, workshops, seminars

Action D4 started in September 2013 and ended in June 2022. Action completed.

Name of activity	Planned deadline	Actual progress
Participation in and Organisation of National and International events, workshops, seminars	III/2022	II/2022

Name of Deliverable	Deadline	Status
International workshop proceedings	03/2018	International workshop arranged during the WASCON2018 conference in Tampere, Helsinki.

Milestones name	Deadline	Status
Organisation of National workshop Nro 1 / latest	12/2017	As WASCON2018 conference was organised in Tampere Finland, the organized workshop also served the needs of national issues. The total participants in WASCON2018 were approximately 200.
Organisation of National workshop Nro 2 / latest	12/2021	Uudet mahdollisuudet kaivosympäristöjen kiertotaloudessa ja kestävässä kehityksessä webinar was organised in cooperation with two other mining projects; ERDF and LIFE-funded mining environment projects KAIVASU and LeKaT. The joint seminar was carried out online on March 16, 2022 (approx. 140 participants. Programme as annex 29)

Organisation of International workshop in Finland / lates	12/2017	International workshop arranged during the WASCON2018 conference in Tampere, Helsinki ( <a href="https://www.ril.fi/en/events/wascon-2018/program/workshops/alternative-materials-in-mining-environment.html">https://www.ril.fi/en/events/wascon-2018/program/workshops/alternative-materials-in-mining-environment.html</a> )
Participation in 2/4 conferences done, dissemination work there accomplished	12/2017	Completed: <ul style="list-style-type: none"> <li>- WASCON2015</li> <li>- AshTradeConference 2017</li> </ul>
Participation in 4/4 conferences done, dissemination work there accomplished	08/2022	<ul style="list-style-type: none"> <li>- WASCON2018</li> <li>- Due to Covid pandemic it was hard to find a suitable conference to attend. The project submitted a paper to International Mining Congress and Exhibition of Turkey, 22-25.3.2022. The conference was planned to be held as a hybrid event. However, the conference had decided not to allow online participation at last minute. For this reason, UPACMIC project was not able to attend the conference because of corona situation and its travel restrictions. Paper was submitted and published. (Conference programme as annex 30)</li> </ul>

### **Description of work**

This action contains the participation in and organization of professional events. Participation in the events throughout the project has been very important to deliver the information about the UPACMIC project and methods and to learn related topics especially in the field of water processing issues in the mining areas. Especially at the final stages of the project it was important to attend as many events as possible to disseminate the project results. Projects final seminar was organised in cooperation with two other mining projects; ERDF and LIFE-funded mining environment projects KAIVASU and LeKaT. The joint seminar was carried out online in MS Teams on March 16, 2022 and had approximately 140 participants (programme as annex 27). The list of all events UPACMIC project has participated is presented in the Summary of dissemination actions (annex 17).

### **Modification of action compared to project proposal**

It has been written in the proposal that the workshops would be organised in Hitora and Helsinki. The first national and international workshop was arranged during WASCON2018 in Tampere. The second seminar was arranged online with two other projects. The project teams decided to carry out the workshop online due to uncertainties caused by Covid epidemic. By combining three projects which had the same topics from

different angle, and all acted in Hitura mine, served the needs of target audience to receive information. In the proposal it was presented that the international conference will take place in Oulu in 2017. The joint workshop acted as a final seminar. There were specialists speaking and productive conversations during the event.

The project team was not able to attend the fourth conference. A paper was submitted to International Mining Congress and Exhibition of Turkey, 22-25.3.2022 and accepted. The conference was initially planned to be held as a hybrid event. The conference organizers had decided not to allow online participation at last minute. UPACMIC project was not able to attend the conference because of corona situation and its travel restrictions. However, the paper was published at the conference. (Conference programme as annex 30)

### Problems encountered

Due to Covid pandemic it was hard to find a suitable conference to attend at the final stages of the project.

Indicators of progress:

Foreseen in the proposal	Achieved
Number of National workshops organized – 2	2 (WASCON 2018, the international workshop served also the needs of national workshop and projects final workshop arranged 16/3/2022 online)
Number of International workshops/conferences (not an expensive scientific conference) organized in Finland – 1	1
Number participations in conferences (presenting technical publications or scientific paper about the project) – 4	participation in 3 different conferences (WASCON2015, AshTradeConference 2017, WASCON2018). Paper submitted and published in IMCET2022 conference.

### 5.4.5 D5. Guidelines and Technical publications on the project

Action D5 started in January 2015 and ended in August 2022. Action completed.

Name of activity	Planned deadline	Actual progress
Guidelines and Technical publications on the project	III/2022	III/2022

Name of Deliverable	Deadline	Status
Guidelines and Technical Publications (for stakeholders, mining sector etc.) + disseminated through the webpage	08/2022	Delivered with the Final Report (annex 32a and 32b).

<b>Milestones name</b>	<b>Deadline</b>	<b>Status</b>
Paper submitted to 1 conference	03/2015	Submitted to WASCON2015 conference
Paper submitted to 2 conferences	12/2017	Submitted to WASCON2018 conference.
Paper submitted to 3 conferences	12/2018	Submitted to Sardinia symposium conference, September 2019
Paper submitted to 4 conferences + professional magazine (material-lehti)	12/2021	Submitted to IMCET 2022 conference and to Materia-lehti magazine (Annexes 31a and 31b)

### **Description of work**

In this action guidelines and technical publications for project stakeholders was created. The best practises and lessons learned was put together in user friendly guide of the topic “utilization of alternative construction materials in mine construction”. The guide is available in English (annex 32a) and in Finnish (annex 32b) and it is disseminated through projects website and in future conferences and events.

The last technical paper was submitted to International Mining Congress and Exhibition of Turkey, 22-25.3.2022 (programme in annex 30 and article in annex 31a). Technical article was published in Materia-lehti magazine edition 7/2022 (annex 31b).

### **Modification of action compared to project proposal**

No modifications.

### **Problems encountered**

No problems encountered other than the general project delay.

Indicators of progress:

<b>Foreseen in the proposal</b>	<b>Achieved</b>
Number of written technical and practical guidelines in Finnish (will be published on the webpage) – 1	1
Number of written technical and practical guidelines in English (will be published on the webpage, large target audience) – 1	1
Number of written and submitted articles to conferences and magazines – 4	4 submissions, to WASCON2015, WASCON2018, Sardinia 2019 and IMCET2022 + Materia-lehti magazine.

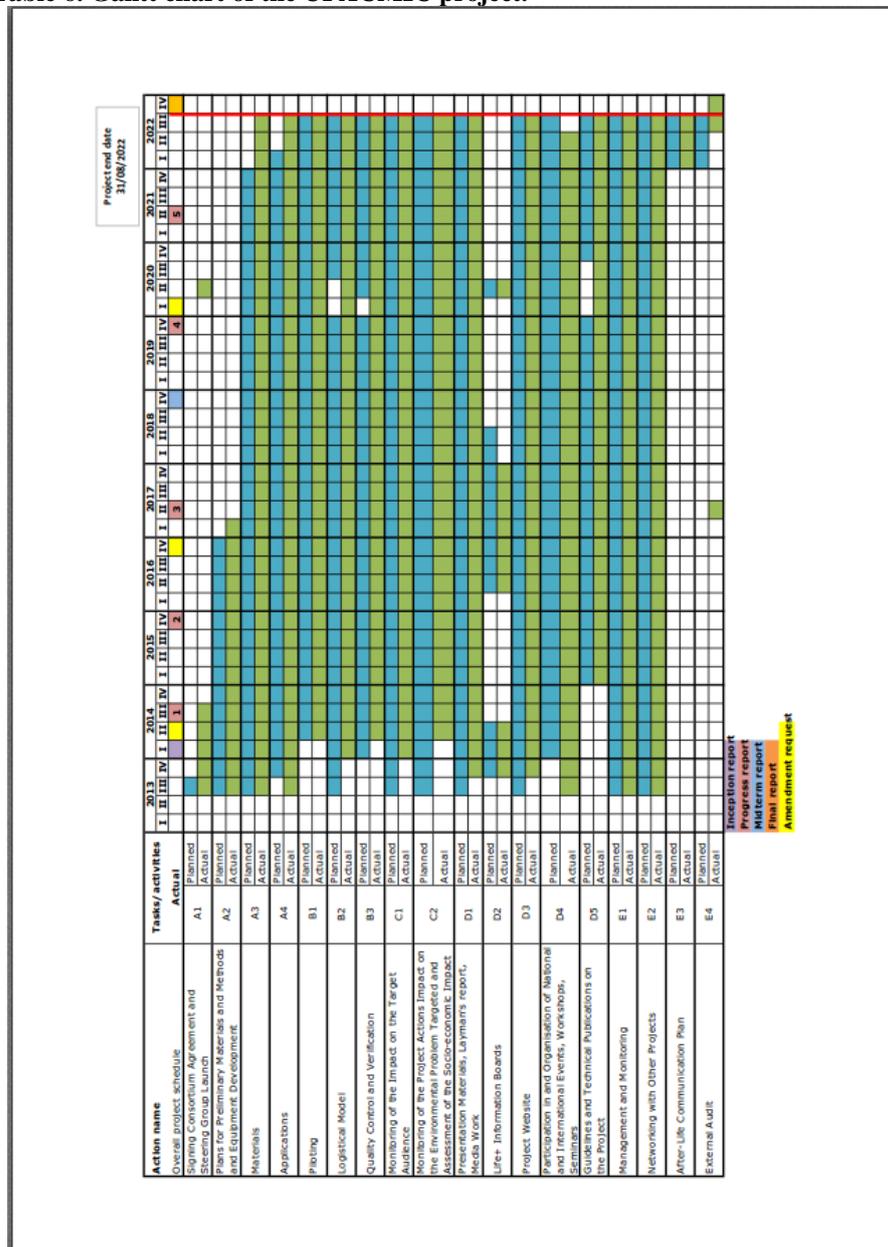
## 5.5 Evaluation of Project Implementation

The project has phased difficulties for reasons that the project team could not influence, such as partner bankrupt. Despite the problems encountered the participants had been persistent in contact with new possible mining companies and discussed with them on the possibilities of UPACMIC applications.

The delays also caused the increase in the management activities (action E1) as promoting the project has taken much personnel resources, as also amendment requests. Project extension with four years increased the management budget. Delays compared to the original plan is described in the Gantt chart in Table 6. Gantt chart is also presented in Excel format (annex 15).

The overall evaluation in implementation of the project is described in Table 7 and 8.

**Table 6. Gantt chart of the UPACMIC project.**



**Table 7. Evaluation of the objectives by action in UPACMIC project.**

Action	Objectives and results foreseen in the revised proposal	Achieved	Evaluation
A1	<p><b>Expected results:</b> To form a steering group and practices for co-operation, to sign and deliver the consortium agreement, to interact with the authorities.</p>	<p>Consortium agreement has been signed and delivered to the Commission, the practicalities of the co-operation has been established.</p>	<p>There have not been difficulties implementing action A1, although changes in partners took place immediately when project started and two beneficiaries Lassila-Tikanoja and Hartikainen were changed to Skarta (previously Suomen Maastorakentajat and Fortum (previously Ekokem)).</p>
A2	<p><b>Expected results:</b> To define the application details and to confirm the material types used in the pilot. Availability of the materials and their locations. Technical, environmental and economical criteria for materials, applications and test procedures set for Actions A3, A4, B1 and B2. Studyplan for the material tests for action A3.</p>	<p>Application details and the availability of the materials and their locations are mapped and studied. Technical, environmental and economical criterias are set.</p>	<p>Due to the changes of the piloting sites, more material test was carried out compared to the preliminary study plan. The mapping and studying the available materials were useful in the actions A3, A4, B1 and B2.</p>
A3	<p><b>Expected results:</b> Savings of 500 000 tonnes of virgin materials and about 180 ha of bentonite matt cover. 70 % of the materials used in the pilot structures are waste materials. Minimum three alternative material recipes for each layer of the pilots' structures will be produced. Information and reference data produced for actions A4, B2 and B3.  Material matrix that can be replicated in other mining applications will be developed.  Sampling, geotechnical and environmental characterisation tests of the potential materials done.</p>	<p>For the cover structure, at least 80 000 tonnes of natural moraine material are saved. The construction still ongoing.  Different material recipes have been developed for different purposes in the laboratory, for the field tests in Pyhäsalmi mine and for the construction of cover structure in Hitura. The amount of recipes is at least 10. Material matrix is yet unfinished as the piloting activities are not completed. Extensive material tests completed.</p>	<p>The expected savings of 500 000 tonnes of natural aggregates was not reached, because the size of piloting areas was smaller than expected. As the project lost the initial piloting site where all the structures were supposed to be constructed, the structures to be piloted was smaller than initially thought. This yet does not impact on the proposed solutions and their applicability to replicate the method. The target of saving 70% of natural aggregates was achieved as the amount was 71%.</p>
A4	<p><b>Expected results:</b> 70 % of the materials used during the construction of the 3 pilots' structures are waste materials.  Plans for three different pilot applications will ready and allow for</p>	<p>- 5 structures implemented, and 71% virgin natural material replaced - all the UPACMIC solutions are applicable to future mine projects</p>	<p>All the objectives achieved.</p>

	<p>the timely start of the piloting action B1.</p> <p>1) New structure solutions which are applicable to new mine remediation sites.</p> <p>2) New preliminary ideas will be achieved which relate to challenges and possibilities in structure thickness, structure properties quantification, mixing and feeding of wet/wet; dry/dry and wet/dry materials.</p> <p>3) The applications innovated, and results achieved will be reported in technical reports as deliverables</p>	<p>- material features were tested and many technically and environmentally suitable material mixes were found</p> <p>- The applications and results are reported</p>	
B1	<p><b>Expected results:</b></p> <p>3 engineering applications determined and planned to be constructed -&gt; savings of 75 % in the use of virgin materials</p> <p>Valuable information gathered to disseminate around the mining industry, contractors, scientific community and legislators. However, the following key results are expected.</p> <p>1) The superb qualities of intelligent by-product mixtures, and their applicability to mining remediation targets.</p> <p>2) A direct result of how to use deep mixing technology to insert reactive waste materials to reactive dam structure.</p> <p>3) A direct result of how to use layer stabilization technology to construct functional sealing layers.</p> <p>4) Huge masses of materials are transported into mining area. Best practices of handling capacity and open space issues for materials and machines, transportation inside the site and open air handling of materials, are verified.</p> <p>5) State of the art information of applicability of single-unit/multi-feeder system prototype to alternative material blending, and alternative construction material development.</p> <p>Four technical reports will be written about each of the pilots and a summarizing final report of all the experiences of the mine remediation with alternative construction products.</p>	<p>- 5 structures implemented, and 71% virgin natural material replaced</p> <p>- Different by-product mixtures have been tested in the laboratory and in the field tests in Pyhäsalmi Mine.</p> <p>- Deep mixing and layer stabilization technics was not used in the constructions as it was initially estimated. The construction could be implemented using conventional equipment.</p> <p>- The best practices for material handling and their utilization properties in the field were found and are reported in <i>Final technical report on piloting</i> and <i>Final technical report on the MSCD-model</i></p> <p>- Initially four technical reports have been proposed as deliverables, but it was decided to combine these reports to one technical report as all structure development produces information and synergy between structures and these issues should be studied together (accepted in the EC letter of 06/03/2019).</p>	<p>Some changes have been made to initial proposal, but overall project objectives are achieved.</p>

B2	<p><b>Expected results:</b> Regional co-operation network will be created and serve the needs of this project and possibly some similar applications that might follow. Logistical model created and take into consideration the effect of storage to the material and other logistical parameters such as transportation methods, amounts and distances. A feasibility model will be created to analyse the overall cost structure of mine construction (including transportation methods) and to allow succesful and realistic planning of replication operations. Development of technical recommendations document.</p>	<p>Network has been created in the early stage of the project. Logistical model was developed and Technical recommendations document published at the end of the project. These documents can be used in the planning of the future projects.</p>	<p>All the objectives achieved.</p>
B3	<p><b>Expected results:</b> 1) To give an answer if it is possible to create reliable quality control system for industrial by-products 2) A SWOT model (including strengths, weaknesses, objectives and threats) for each of the quality control method/technologies will be compared and the most suitable is evaluated. Due to comparison and demonstration of the most suitable method, best practices for quality control methods can be created. 3) The action will answer the question, was the demonstration site constructed according to rules and quality standards developed for these materials and the overall mine closure environment?</p>	<p>These results are under examination now as the cover structure piloting has started and is yet ongoing. To finalize these, information from bottom structure and reactive dam structure is also needed.</p>	<p>These results will be achieved as intended and there is no reason why reliable quality control system, best practices or quality construction would not be accomplished.</p>
C1	<p><b>Expected results:</b> It was expected that the results of the first KAP questionnaire will provide a good overview of the current awareness and attitude concerning the eco-efficient use of secondary materials and sustainable infrastructure planning and construction. It should also provide the project team with a better and updated understanding of the information needs that will be addressed by the project. The KAP survey will be conducted twice and it will reach 750 recipients every time. It is expected that the project team will receive 550 answers to each KAP questionnaire. In addition,</p>	<p>KAP questionnaire was carried out in the early stages of the project and again in the final stages of the project. The questionnaires were widely distributed, and useful information was obtained from several discussions with the target audience. The results were analysed at the beginning of the project and compared and reported in final report.</p>	<p>The project team got a good overview from the KAP questionnaires and conversations with the target audience. Despite the hard work, the number of the KAP questionnaire answers was relatively low. However, there were several group meetings that also produced valuable information for analysing the situation.</p>

	focus group discussions will take place in various events. The results will be analysed and reported.		
C2	<p><b>Expected results:</b></p> <ul style="list-style-type: none"> <li>- The LCA/LCC studies will be performed and include the data provided by project Implementation Actions.</li> <li>- LCA/LCC studies will provide a proof that the use of the project proposed methods and procedures in the tailings dams closure process results in a more favourable impact on the natural and built environment and human health and wellbeing by a diminished use of use of natural resources, energy and transportation as well as minimizing the waste streams disposed at landfills.</li> <li>- The Preliminary results will be presented at various dissemination events prior to the final report (eg. project seminars, the international conference, networking activities). The expected audience is 500 persons.</li> <li>- The carbon footprint of the project will be calculated during the project life</li> <li>- Sustainability indicators will be created. The indicators can be used for measuring and controlling the sustainability of the methods and practices proposed by the project</li> <li>- The verification results including the statements of the external experts will be published in the form of a report at the end of the project period and placed at the project website in 2022. The link to the report will be actively disseminated to 1500 recipients.</li> <li>- An assessment of the projects socio-economic impact on the local community, population and economy is made</li> <li>- The results of Action C2 will in the long run give background for a legislative change as the authorities have lacked enough sound information and well-documented cases in order to proceed with the decisions.</li> </ul>	<p>-LCA/LCC studies were made and reported. The report was reviewed by two external experts and by results verified that the use of the project proposed methods and procedures diminished use of use of natural resources, energy and transportation as well as minimizing the waste streams disposed at landfills. The results were disseminated in various events during the project.</p> <ul style="list-style-type: none"> <li>- The carbon footprint of the project has been monitored through out the project and results reported to EC and published in website five times during the project.</li> <li>- Sustainability indicators were created in the end of the project. The indicators can be used as a tool evaluating and designing new projects</li> <li>- An assessment of the projects socio-economic impact on the local community, population and economy was made and reported to EC and disseminated.</li> </ul>	<p>Project achieved good results with the verification report, although long distances in Finland created challenges for the transportation point of view. The results give important information for the method to be replicated and they have been disseminated in various events achieving approx. audience of 500.</p> <p>The UPACMIC project had a positive impact on the local community and it's economy.</p>
D1	<p><b>Expected results:</b></p> <p>The work done and outputs created in this action are concrete</p>	<p>A lot of dissemination activities has been done within the project and</p>	<p>The project and its methods have got positive interest from the field. It seems that the</p>

	<p>dissemination materials. They are materials that are sent, given and shared with all interested parties related directly or indirectly to the project. The produced materials and their sharing will contribute to capacity building of the stakeholders involved and target audiences. In addition, the communication and dissemination materials created, will result into effective strengthening of the LIFE+ programme brand among all who receive dissemination materials. After this action, plenty of good quality and multifarious material will be available to support the communication and dissemination actions of the UPACMIC project. The dissemination and sharing of the material produced will be done according the communication plan created in action D1. Accomplished media work, is crucial for achieving enough capacity building to target the development of recycling society. More quantitative information is written on the indicator of progress part of this action.</p>	<p>active screening of dissemination opportunities was carried out throughout the project. The project methods, objectives, material possibilities, preliminary results, project phases and difficulties has been disseminated in various occasions. Project brochure (A4) has been distributed whenever possible and relevant. Brochure is available in English and in Finnish. Project has own logo and later in the project also a gif animation was created. 16 different presentations of the project were made for various events, and also a poster. Project video published in English and in Finnish. Press releases were sent and 7 articles was written during the project years. Layman's report is available in English and in Finnish. Project has a twitter account @UPACMIC.</p>	<p>difficulties which raised in the mining field/world markets immediately after the project started impact still on the general progress of the mining industry. As the use of recycled/recovered/alternative materials generally in infra field is getting more and more attention nowadays in Finland, this will also impact positively on the UPACMIC possibilities. National UUMA4 programme is promoting the use of above mentioned materials and through this the knowledge, awareness and possibilities also gradually will reach the mining industry.</p>
D2	<p><b>Expected results:</b> The erection of LIFE Information boards, is a concrete step towards better dissemination and improvement of the LIFE+ brand.</p>	<p>LIFE Information Board had been set up at Pyhäsalmi Mine (for the field test), at Hitura Mine where two cover structures and reactive structures was constructed. Third LIFE information board erected to Kuopio waste deposite site, where the bottom structure/sealing barrier was constructed.</p>	<p>LIFE Information Boards erected successfully to the piloting sites.</p>
D3	<p><b>Expected results:</b> This Action will result in a well-designed and user-friendly project website. The stakeholders and the target audience will be informed about the project progress and news with the frequent updates. The page will create a forum for communication for the stakeholders, target audience and</p>	<p>Website was launched in early stages of the project and the pages was updated at least twice a year to keep the data updated and to be sure the contact information is correct.</p>	<p>We are satisfied with our current webpages. By the end of the project all the deliverables and necessary information has been placed to the sites. This website helps also the After Life actions and the project team can refer to it in the future events and discussions.</p>

	<p>other bodies interested in the project. It is expected that the interactive functions of the site will engage the users in discussions and provide comments. The site will also bring improved awareness of similar projects by offering links to them. It is also expected that the project website will improve the general awareness of the LIFE brand.</p>		
D4	<p><b>Expected results:</b></p> <ul style="list-style-type: none"> <li>- Two national events organised. The expected number of participants for each national event is 100.</li> <li>- One international conference organised in Finland. The target for the participants is 200.</li> <li>- Effective dissemination of knowledge allowed by participation in the national and international events (3-4).</li> <li>- The awareness of the methods of utilization of alternative construction materials in mine remediation site, positively affected.</li> <li>- The events have served as forums for discussion and exchanges of experience.</li> <li>- The network established by the UPACMIC project strengthened.</li> </ul>	<p>Dissemination has been done at several occasions, to be mentioned WASCON2015 in Santander, Spain, WASCON2018 in Tampere, Finland and Ash Trade Conference in Tallinn, Estonia as for international events. For national events the project topics were discussed and presented for example in Kaivosaltaat (Mining basis) seminar 2017, national workshop at WASCON2018, Kiertotalous ja kaivosympäristö seminar 2020 (circular economy and mining basins) and the joint mining webinar in 2022. Altogether 24 events were participated and dissemination work there done.</p>	<p>The dissemination work and participating in various events has been active. At the end of the project Covid epidemic infected the arrangements of the events and many of them was cancelled, moved to another time or changed to virtual sessions. Some of the intended participations for UPACMIC team was cancelled as the events was moved to date beyond the project time. However, virtual webinars considered to be effective eventually. This allowed participation regardless the long distances and it was easy to attend. For example, for the joint final webinar at the end of the project participated approx. 140 persons, which exceeded expectations. The project was not able to arrange an international conference due to the Covid epidemic.</p>
D5	<p><b>Expected results:</b></p> <p>Papers will be sent to conferences. One paper is sent to 4 different conferences and one mining industries professional magazine (Materia-lehti) - Vuorimiesyhdistys ry.</p> <p>The active dissemination effect of guidelines and technical publications will be remarkable for the individual legislators. Well prepared guidelines concerning the by-product utilization will give the legislator in depth change to familiarize in the positive effects of UPACMIC project and the technosphere of alternative construction materials. Legislators have a change to absorb</p>	<p>Papers have been sent to conferences, WASCON2015, WASCON2018, Sardinia symposium conference 2019 and IMCET 2022 conference. In addition, paper has been sent to Materia-lehti magazine and published in 08/07/2022.</p> <p>A user friendly technical guideline was written in English and in Finnish and published on the webpage.</p>	<p>All the papers sent to the conferences was published. Unfortunately, we were not able to attend the last conference due to the Covid epidemic. However, the papers reached the target audience. Also the technical guideline will serve the needs of the target audience.</p>

	information at their own pace from technical reports and guidelines.		
E1	<p><b>Expected results:</b> The project will be carried out with respect to the Grant Agreement between the Commission and RAMFI as the coordinating beneficiary, and with respect to the Common Provisions as annex of the Grant Agreement.</p> <p>The project director (coordinator) and the project manager will work very closely in order to successfully manage the project. They will be in continual touch with all the Action Managers in RAMFI and the partner organisations. The project team meetings will be organised regularly, at the interval of 3 months and this will assure a proper level of monitoring and cooperation. This will lead to a well-managed project that is able to perform all the project actions according to the timetable.</p> <p>The project management team will be supported by the work of the Steering Group. The regular meetings of steering group (see action A1) will result in a good level of cooperation.</p>	The coordinator RAMFI has been actively in contact with the beneficiaries by phone, e-mail and meetings that has been organised 1-2 per year. Skype/Teams meetings has also been organised when needed, due to long distances between beneficiaries.	Due to the 4 year extension of the project duration, more management activities has been needed compared to the initial 5 year project duration. Due to the changes in partnerships, bankrupt of Belvedere and the general delay, three amendments have been compulsory to make.
E2	<p><b>Expected results:</b> It is expected that the UPACMIC project will successfully map the relevant EU projects and localise the contact persons in the early stage of the project duration. The project team will be in touch with other teams and they will establish a working cooperation network. The list of the projects will be updated once a year in order to allow for the inclusion of the new relevant projects. The network members will be invited to participate in Skype conference once a year during the project duration. It is expected that the network might connect about 10 different projects in the years 2013-2018. The results of the UPACMIC project will be made available in an active way to the network members, and others will benefit from the knowledge generated and lessons learned. In the same way it is expected that the</p>	UPACMIC has done networking mainly by contacting project straight by e-mail. LIFE Hungary Capacity Building Project contacted UPACMIC, made a project visit and mutually invited UPACMIC to Hungary to share LIFE project experiences in May 2017. Project co-operated closely with KAIVASU-project and UUMA programme. Various discussions with other projects was occurred during the project life sharing experiences.	As the project suffered from severe delays, the networking activities was more less in the first half of the project than initially was thought. As the project overcame the problems and all the activities were able to proceed at full speed, also the networking activities were more active.

	UPACMIC will benefit from the knowledge and experience of those projects concerning both the content and successful management tips. Two reports will be created in this action. One at the beginning and one at the end of the project life.		
E3	<b>Expected results:</b> The After-Life Communication plan will be designed in a cooperation of the project partners and stakeholders and it will enable a good level of dissemination of the project results for the period of five years.	The After-Life plan was made at the end of the project in Finnish and in English.	After-Life communication plan was made in co-operation with project stakeholders and the members of the network. The continuation of the reactive barrier follow-up was seen important, and the project was able to negotiate company Feasib Oy to continue with the work. All the other structures are permanent. Future potential projects and dissemination opportunities were mapped for after life actions.
E4	<b>Expected results:</b> This action evaluates the accounting details of the project and summarizes the project as accomplished. Audit report will be included in deliverables.	Midterm audit was done per 31.12.2016 by PricewaterhouseCoopers Oy. As the audit was midterm audit, no report was conducted at this stage. The Final Audit was implemented by PricewaterhouseCoopers Oy after the end of the project and the project was audited for the whole project duration from 01/07/2013 to 31/08/2022.	It was declared in the Final Audit report that they obtained reasonable assurance that the project gives a true and fair view of expenses, income and investments incurred by the beneficiaries. The project acted in accordance with the LIFE+ programme Common Provisions and the national legislation and accounting rules.

**Table 8. Evaluation of the overall objectives in UPACMIC project.**

<b>Objectives and results foreseen in the revised proposal</b>	<b>Achieved</b>	<b>Evaluation</b>
The project will produce at least three practical civil-engineering applications, demonstrative pilots, which show how industrial by-product combinations can be successfully used in mine remediation structures, without compromising the overall environmental protection targets.	Four applications piloted: two different cover structures, reactive structure and vertical sealing barrier. The application plans allowed for the overall replacement of the virgin materials in the 3 pilot applications reaching 71% (foreseen in the proposal 70%).	The project demonstrated that by-product combinations can be successfully used in mine remediation structures, without compromising the overall environmental protection targets. The piloted areas were smaller than foreseen in the proposal and this is why objectives was not achieved when measured savings in tonnes. When measured in percentages, project objectives were reached.

<p>The project will deliver know-how, information, and instructions with the help of active dissemination events and effective dissemination tools to the most important target groups: mining industry, EU, legislative authorities, municipalities, contractors, and designers in Europe.</p>	<p>The project has participated in 42 events with approximately 6000-7000 participants including representatives from important target groups. The project has produced deliverables that gives information to the target group, for example easy-to use guide and technical reports on materials, applications and piloting.</p>	<p>The project has produced a lot of important information to target audience and disseminated it at events. This information is also available at projects website and dissemination continues after life.</p>
<p>The project will give information for the European politicians and legislative authorities, and mitigate the national and European legislation addressing use of secondary aggregates in mine remediation structures.</p>	<p>The EU Commission is a critical stakeholder for the project. The European commission extractive waste directive of 2006 required member states to draw up an updated list of decommissioned and abandoned extractive waste sites that cause serious damage to the environment, or which could pose a serious threat to human health or the environment in the short to medium term. Abandoned mines are under the responsibility of the State and the authorities. In Finland, abandoned mines has been mapped by ELY Centres KAJAK project and the research of the environmental impact of these mines are ongoing.</p>	<p>The information received from the project implementation has been disseminated to national and international legislators. Events has acted an important role in dissemination actions. Numerous conversations have taken place about the legislative changes needed in the filed so that by-products can be effectively used in Mining construction in the future. In addition, project newsletter, website and project deliverables has been used as a tool in spreading the information. Ministry on the Environment was actively involved in the project and was part of the projects steering group.</p>
<p>Project strives to promote addition of by-products to "mining industry materials act", which would promote general utilization possibilities.</p>	<p>Numerous materials have been tested during the project and, also their environmental compatibility. This gives a lot of information about the possibilities in using alternative materials in environmentally safe way.</p>	<p>The information produced by the project gives tools to evaluate all the benefits reached by using alternative materials. They also give assurance to the Mining sector to choose more environmental friendly construction applications instead of the traditional way.</p>
<p>Stakeholders are given plenty of new information on how to improve overall environmental protection level and the overall sustainability of the mining industry.</p>	<p>The environmental effects have been monitored through out the project. The findings and lessons learned have been reported in numerous reports, for example Final verification report and Carbon footprint report. Project also produced the report of sustainability indicators which gives tools to evaluate the future projects.</p>	<p>The project gathered plenty of information of the environmental benefits of the solutions suggested by the project. The information was disseminated in numerous events and are available to all audience at the project website.</p>
<p>In the longer term (until 2020 - 2030) the secondary aggregates and industrial by-products in mine construction, will be</p>	<p>The secondary aggregates and industrial by-products are expected to be accepted and become an established practice in</p>	<p>Slowing down the climate change is now the goal of many companies and institutes. The project gives plenty of useful</p>

accepted and become an established practice in EU, followed by significant reductions in waste to be landfilled, primary aggregates such as natural eskers and moraine deposits, and commercial sealing products used and other reductions in releases of greenhouse gases as CO <sub>2</sub> -eqv. (See "climate change description").	the EU.	information to support this goal. The need and will to choose environmentally friendly solutions enable the alternative materials to become an established practice in EU. However, this change happens in a long time period.
Innovative material combinations and their applications will be compared with the contemporary design criteria. Overall environmental score will be calculated based on LCA/LCC methods. Experience on the total supply chain development model (SCDM) will be shared as a result of this project.	The solutions by the project have been verified to reach the requirements of contemporary design criteria. LCA/LCC calculations are included in the Final verification report. Best practices of supply chain have been shared in Final technical report on the MSCD-model, which includes information about the materials, logistics and storing.	The project achieved to reach this goal and delivered supporting documents.

## 5.6 Analysis of long-term benefits

When writing the application in 2012, the mining boom had resulted in opening plenty of new mines and resulted into concerns of environmental impacts of the mining technologies. Mining and quarrying waste is a significant source of pollution and general environmental degradation, in particular of freshwater systems. It was 26,6% of the total waste generation in EU in 2018. Specially Estonia and Finland recorded high values of total waste compared to other EU members in 2018, and most of the waste generated from mining activities. In Finland the share of mining waste was 75% in 2018. (Source: Eurostat and Tilastokeskus).

Approximately 60-70 million tonnes of recycled material that are suitable for construction generates per year in Finland. Only 10% this material is reused at this point. Also, 20-30 million tonnes of surplus soils generates per year in Finland and high quantities has been stocked already. (Source: <https://circhubs.fi/tietopankki/maa-ja-kiviainekset/>)

Mining operations also produce more than 400 million tons of waste from the extractive industries each year in the EU and the yearly amount of produced tailings materials is approximately 15-20 million tons. For example, in Finland there were 47 tailings impoundments in 2011 and about 40 mines and quarries, size ranging from 1 ha to 900 ha and volume varying from 10 000 m<sup>3</sup> to 100 000 000 m<sup>3</sup>. Remediation of Finnish tailings heaps consumes hundreds of million tons of natural aggregates and enormous amounts of commercial sealing products, together generating huge amounts of greenhouse gas emissions.

In the longer term (until 2020 - 2030) the secondary aggregates and industrial by-products in the mine construction, is expected to be accepted and become an established practice in the EU, followed by significant reductions in wastes to be landfilled, primary aggregates such as natural eskers and moraine deposits, and commercial sealing products used and other reductions in releases of greenhouse gases as CO<sub>2</sub>- eq.

UPACMIC implements Waste Framework aspects and contributes to the European Union environmental policies with respect to resource efficiency and waste management. UPACMIC produced four practical civil engineering applications (two cover structures, bottom and reactive barrier structures), showing how industrial by-product combinations can be successfully used in mine remediation structures without compromising the overall environmental protection targets. UPACMIC gives information for the European politicians and legislative authorities, mitigating the national and European legislation by addressing the use of secondary aggregates in mine remediation structures. Project promotes the addition of by-products to “mining industry materials act”, which can promote general utilization possibilities.

### 5.6.1 Environmental benefits

Approximately totally 80 000 tons of natural moraine has been saved during the cover structure construction in Hitura mine. Moraine is coarse soil type through which the rainwater and melt water filtrates, generating ground water (see Figure 16). The cover structure piloting was part of a bigger construction work in order to have comparative information on the work methods and structures. In addition, above the cover structure in the soil layer, industrial secondary materials such as branch waste and decomposition are used, and this also has saved natural soil materials ~21000 m<sup>3</sup>

Fiber clay structure is technically better structure than moraine structure, as fiber clay has better water permeability which is important for this kind of structure. If fiber clay would not be used for construction purposes, the material would be combusted as it is expensive to storage large amounts of material. Fiber clay though does not have actual proper heat value due to high water content, so the utilization is important from the resource efficiency point of view.

Smart material utilisation by local Surplus clay structure in Hitura saved natural moraine aggregates about 16 970 m<sup>3</sup> in sealing layer and 3 400 m<sup>3</sup> in growth layer, where is used surplus growth layer from nearby field.

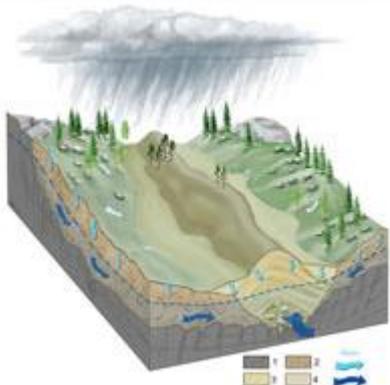
Vertical sealing layer structure in Sorsasalo has saved 19 500 m<sup>3</sup> of natural moraine and aggregates. This gives also new functional usage to soils that otherwise were just dumped to landfill area.

Totally approximately 100 000 m<sup>3</sup> of natural moraine soil is saved directly in actions of UPACMIC-project. That is at least 150 000 tons of saved moraine. Dissemination activities inspired projects impact can't be quantified and smart material utilisation may be implemented in other projects and sectors due to this project.

Mines wastewater is often contaminated by heavy metals and can be acidic. Reactive structures lower water's pollutants concentrations significantly and acidic water's pH value rises suitable level. Reactive structures proves that mines polluted waters can be treated by

passive structures which doesn't need electricity and needs only slightly maintenance. That is great in remote areas where mines often are located and after mine operation electricity and continuous maintenance may not be easily available.

Expected results of the UPACMIC project was to save in CO2 emissions. The project team concluded that the CO2 emissions can be significantly decreased, but the transportation distances must be evaluated carefully. It is essential that the by-product is produced nearby the construction site. The streamlined LCA/LCC calculations was done. LCA/LCC studies provide a proof that use of the project methods and procedures results in a more favourable impact on the environment. LCC gives clear indication that much less costly recyclable materials are more attractive than natural virgin soils.



**Figure 16. Groundwater formation 1) solid rock, 2) moraine, 3) esker formation, 4) sediments of fine sand and silt. (Reference: Geological Survey of Finland).**

These natural esker formations are important ground water formation areas and if the aggregate material from the eskers are utilized, nothing can bring back these formations. This kind of use of alternative use materials is very important especially in Finland, where use approximately 15,5 tons aggregates per capita according to the Finnish Environmental Institute. This rate is one of the highest in Europe due to abundant reserves of aggregate materials in Finland. We find this one of the key aspects and of the UPACMIC project objectives.

The use of recovered/recycled/alternative materials is 'reuse' according to the Waste Framework waste hierarchy (Directive 2008/98/EC). In case alternative materials would not be used in this kind of application, the material would be utilised in landfill structures but as the number of landfills is to be decreased, old ones are shut down and no more new landfills are based, new innovations for the material are needed.

Utilisation of alternative materials will also bring positive impact for the mining industry which has been many times on a negative spotlight because of various environmental related problems. For the European competitiveness it is important that mines have environmentally and economically safe surroundings to operate.

UPACMIC project brings together different industries, such as paper and forest industry with mining and construction industries. Co-operation is essential to create solutions together and to efficiently as possible take steps towards resource efficiency.

New Government Decree (843/2017) on the recovery of certain waste in earth construction has come to effect in Finland starting from 1<sup>st</sup> January 2018 and the results of the UPACMIC project will also improve know-how and awareness of the alternative material (waste) utilisation in earth construction applications.

### 5.6.2 Long-term benefits and sustainability

Alternative materials have been used in landfill sealing layers for a long-time, but now they were used for the first time in the mining environment. The project provided examples and results that gives a needed boost for future mining projects to utilize alternative materials. The materials were tested extensively, and the provided material matrix will help the future projects in assessment of the material possibilities. It is seen that even more practical experiences would give valuable information to the mining field. Experiences from the piloting actions has brought for Fortum and Skarta new know-how and the companies can refer to the project when negotiating new opportunities. Increasing the use of alternative materials is an important objective to projects target audience ie ELY, AVI, material producers and constructors and the knowledge of the possibilities and the interest in the field has been increased.

In the future cost savings can be achieved with the solutions proposed by UPACMIC. It is important that the distance between material producer and construction site is not too long. Long distance increase costs and, also negative impact to nature. For example, fiber clay is more cost-effective than moraine when the distance is not too high. Utilization of waste material cut costs of material producer viewpoint too, because then there is no landfilling or waste fees.

The UPACMIC method has brought good reputation for the Hitura Mine. In the surroundings of Nivala, where Hitura mine locates, many people lost their jobs when the mining company went to bankrupt. Now the construction activities to shut down the mine has brought vitality to the area as the construction workers have work and the local hotel & restaurant has customers on a daily basis. The local people are satisfied that the mine will be closed and available for other use. Earlier dust was flying with the wind to the town which caused inconvenience for the locals. Because of the construction work the dust problem was solved.

Long-term benefits and sustainability can be evaluated by the sustainability indicators suggested by the project. With the indicators it was verified that material emissions and costs can be reduced with alternative materials like waste or by-product. Also, it can be noted that unutilized materials waste incineration or disposal would cause negative effect to the nature.

### 5.6.3 Replicability, demonstration, transferability, cooperation

The construction methods have been conventional construction method where excavators have been used. Compacting of the layers has been done by driving on top of the layer exact amount as has been written in the working methods. This kind of construction does not require special equipment, but attention must be paid to the handling of materials.

Fiber clay can be processed to the desired form for example with crawler based working machines. When spreading the material, also wheel loader can be used. Fiber clay is usually compacted in the structure with two layers, but the final compaction work amount is determined based on available machinery and test structure<sup>1</sup>.

Fiber clay transferability is improved by using transport cart which are designed for woodchips and peat. This kind of cart has higher walls than ordinary earthmoving vehicle which allow larger cargo capacity of lighter fiber clay and full load transportations. With ordinary earthmoving vehicle it would be half loaded by weight wise and that would add more transportation costs and emissions.

The construction does not require special equipment, but few new methods for shaping and working has been implemented and the use of fiber clay in the mining environment is easily replicated and know-how transferred. The method will create new business opportunities e.g. with material processing, storage and other material related issues. Resource efficiency is important as the whole society needs to take actions towards circular economy practices.

Vertical sealing layer construction by mould is easy and effective method. It creates right thickness and dense wall. Utilisation of surplus soils and other secondary material such as ash is almost 100 % of pilot structure. Material transportation over support layers with a dumper and simultaneously compacting them while driving, creates more efficiency constructing method compared traditional method where compacting is separate working phase and needs additional machines such as rollers. Project beneficiary Fortum is utilised secondary materials in other projects outside of UPACMIC such as surplus clay sealing layer for landfill of Topinoja. This adaptation of know how of UPACMIC projects will continue also after UPACMIC project and expand to other sectors as well.

Reactive structures proves that mines polluted waters can be treated by passive and robust structures which doesn't need electricity and needs only slightly maintenance. That is great in remote areas where mines often are located and after mine operation electricity and continuous maintenance may not be easily available. Positive results from pilots might generate more interest toward passive solutions which are easily scaled up or down to match each operating conditions.

#### 5.6.4 Best practice lessons

It has been found a challenge due to long distances in Finland to make the pilot construction structures cost-effective as the transportation costs can rise too high and the CO2 emission rises. This might be a problem in sparsely-populated Scandinavia but in elsewhere in Europe the transportation cost or distances are not that high. The landfill areas are also more limited in other Europe which great need to recycle materials which suits for construction.

This is also related to the storage of the materials, so that there is enough material available for the needed structures. This issue will be also studied in action B2 Logistical Model.

Based on the experiences in cover structure piloting, following issues has been found in order to make the use of alternative materials possible:

- Project group/constructor has to have a genuine desire to use alternative materials and to save natural resources
- Quick decision-making processes are needed for material choices
- The designer has to have know-how, understanding and experience on different possible material choices

- The constructor has to have sufficient experience and skills to construct with different materials in variable circumstances and different type of sites
- Preliminary tests and test structures are needed to guarantee quality construct

### 5.6.5 Innovation and demonstration value

Technical Readiness Level TRL of UPACMIC methods for the fiber clay cover structure is approximately at level 7: System prototype demonstration in operational environment. The reactive dam structure is estimated to be at level 6-7: Technology demonstrated in relevant environment/System prototype demonstration in operational environment. Vertical sealing barrier is approximately at level 7 and as a bottom structure it would be at level 5: Technology validated in relevant environment. Surplus soil cover layer is at level 9: Actual system proven in operational environment

The demonstration value of the UPACMIC project by EU funding is extremely crucial, as without EU funding this kind of applications would not have been able to test and construct. This demonstration is important in Finland where the use of natural aggregates is highest in Europe (15,5 tonnes per capita) and the protection of ground water formations are important to secure the clean drinking water supplies.

### 5.6.6 Long term indicators of the project success

Future indicators for the project success are:

- number of applications in the mining environment where alternative materials are used (first in Finland, then in Scandinavia and gradually in Europe)
- number of conference writings
- citations on the project deliverables and conference writings
- requests to share experiences on the method and the project
- visits at the website
- number of viewings of the project video (finalized in the end)
- how well the structures function during the follow-up period
- how many new design sites are interested in the UPACMIC methods