Interreg
EUROPEAN UNION
North-West Europe
RAWFILL
European Regional Development Fund
Co-funded by the Walloon region

RAWFILL WP T1.1.2
Existing LFM initiatives

June 2021

Table of contents

ACRONYMS AND DEFINITIONS

COCOON: "Consortium for a Coherent European Landfill Management Strategy", an INTERREG Europe-funded project, whose objective is to develop, integrate and improve relevant policy instruments, while increasing subsidies through operational programs for landfill mining projects, https://www.interregeurope.eu/cocoon/

DST: "Decision Support Tool", a tool that will rank landfills regarding landfill mining opportunities. The ranking is based on information following ELIF structure. It will operate at 2 levels: Cedalion - "Selection" (a first level of quick screening to identify landfills with a priori interesting potential but which need further historical investigations and geophysical survey) and Orion – a roadmap to orientate the experts towards open-access tool in order to fully investigated landfills of economic interest for raw material, energy and land recovery purposes.

ELFM: "Enhanced Landfill Mining", the safe exploration, conditioning, excavation and integrated valorisation of (historic, present and/or future) landfilled waste streams as both materials (Waste-to-Material, WtM) and energy (Waste-to-Energy, WtE), using innovative transformation technologies and respecting the most stringent social and ecological criteria).

ELIF: "Enhanced Landfill Inventory Framework", a landfill inventory structure that is focused on information regarding resources that can be extracted from a landfill (materials, energy carriers and land). The ELIF is used to describe landfills not only in terms of environmental and risk issues, but focuses on the quality and the quantity of dormant materials lying on them, in order to supply relevant data for stakeholders involved in ELFM projects.

LFM: "Landfill Mining", the safe exploration, conditioning, excavation and integrated valorisation of (historic, present and/or future) landfilled waste streams as both materials (Waste-to-Material, WtM) and energy (Waste-to-Energy, WtE), without specification of technologies.

RAWFILL: "Supporting a new circular economy for RAW materials recovered from landFILLs", an INTERREG North-West Europe-funded landfill mining project, launched in March 2017, www.nweurope.eu/rawfill

RECLAIM: "Landfill mining pilot application for recovery of invaluable metals, materials, land and energy", project funded by the European Commission through Life+ 2012 vehicle, contract LIFE12 ENV/GR/000427

SMART GROUND: "SMART data collection and inteGration platform to enhance availability and accessibility of data and information in the eU territory on secondary raw materials", an H2020-funded project aiming at improving the availability and accessibility of data and information on SRM (Secondary Raw Materials) in the EU territory, while creating collaborations and synergies among the different stakeholders involved in the SRM value chain, www.smart-ground.eu

PRESENTATION OF THE RAWFILL PROJECT

RAWFILL ("Supporting a new circular economy for RAW materials recovered from landFILLs") is an INTERREG EU-funded landfill mining project, gathering partners and associated partners of North-West Europe regions and supported by EURELCO. RAWFILL was launched in March 2017 and will end in March 2020.

The ultimate goal of RAWFILL is to allow Northwest Europe public & private landfills owners & managers to implement profitable resource-recovery driven landfill mining and enhanced landfill mining projects, hereunder named LFM or ELFM according to the context.

RAWFILL develops a cost-effective standard framework for creating landfill inventories (ELIF) based on existing experiences, an innovative landfill characterization methodology by geophysical imaging and guided sampling and an associated Decision Support Tool (DST) to allow smart ELFM project prioritization. The whole concept will be demonstrated in 2 pilot sites in Flanders (Meerhout) and France (Les Champs Jouault). Additional geophysics calibration operations will take place on a few other landfills where specific information is available.

More information about RAWFILL and its progress reports can be found at the project site: www.nweurope.eu/rawfill

The ELIF will be used to describe landfills not only in terms of environmental and risk issues but will focus on the quality and the quantity of dormant materials lying on them, to supply relevant data for stakeholders involved in ELFM projects.

The ELIF is the basis for the DST ranking tool and so a prerequisite to assess feasibility, business plan & business cases for launching profitable projects.

The DST is a ranking tool that will allow ELFM projects prioritization based on a set of suitable physical, environmental, technical, and social information. It will integrate the multiple aspects involved in ELFM projects, i.e., economic, technical, environmental & social factors in order to compare and classify landfills regarding their ELFM interest.

PRESENTATION OF WP T1 "ENHANCED INVENTORY FRAMEWORK"

One main challenge for stakeholders involved in ELFM operations is to evaluate the project profitability risk based on quantity and quality of dormant resources that can be excavated and recovered from a particular landfill site. Related reliable decision elements are missing in most of the landfill inventories we have reviewed, covering NWE region. The most advanced inventories describe landfills in terms of environmental and risk issues, but give no way to evaluate, even roughly, their dormant resources potential. In most cases, even the volume of waste remain unknown and only a very general information is given about waste type (which is very often a mixture of domestic, industrial and construction wastes).

A T.1.1 analyses current situation in NWE countries by collecting structures of public & private available LFs databases/inventories.

A short review of landfill mining experiences presented hereunder (see section WP T1 – Activity A T.1.2) and focused on the methodology applied to evaluate the landfill resources potential, shows that, in the studied cases, no specific particular attention was given to the precise evaluation of resources. Other important factors lead to the decision of mining the landfill, as solving an environmental issue, recovering valuable land or performing feasibility tests. This situation is expected to change as far as the ELFM market will grow and, within North-West Europe, because some mineral resources will request more attention. For sure, in a high density populated area, the economic value of the land that can be reclaimed trough an ELFM project will remain a key decision factor.

A T.1.2 performs a benchmark analysis of the existing LFM initiatives (±20 in Europe), including legal, technical & economic issues, focusing on how the raw material content of the LFs was estimated, the accuracy of the evaluation and its economic impact in the (positive or negative) results.

Regarding existing information, the level of accuracy of some data is sometimes difficult to estimate, for example the indicated surface of the landfill which is mixed with the total surface of the site, the volume of waste which can be just a draft estimation based on a mean height, the type of waste which remain generic in uncontrolled landfills, etc. As this precision is very important for launching a ELFM feasibility study, the ELIF should specify for each DST-relevant field an accuracy estimation that will be taken into account for the ranking. The simplest one will be a classification as "poor/average/good/unknown".

Analysis of A T.1.1 and A T.1.2 leads to establish a list of suitable fields for the ELIF, which is part of the third activity of this Work Package:

A T.1.4 supplies the enhanced ELIF, i.e. a database structure taking into account LFs resources, under the form of 1) a list of fields ("indicators") and 2) a spreadsheet ("tool").

Benchmark analysis of existing LFM initiatives

Partners involved

Lead Partner

- Atrasol srl

Partners involved

- BAV
- British Geological Survey
- SAS Les Champs Jouault
- SPAQuE
- OVAM
- ULiège

Landfill mining experiences

- Depollution by mechanical sorting of the Beaucens Landfill, Conseil Départemental 64, France
- Landfill Mining in Denmark, DGE Group, Denmark
- Skarup Landfill Mining in Skanderborg, Denmark
- LFM project in France, Opale Environnement, France
- LFM pilot projects, North-Brabant, The Netherlands (3 LFM experiences)
- Landfill Mining Projects in Denmark, René M. Rosendal, Danish Waste Solutions ApS, Denmark (5 projects)
- Landfill Mining & Reclamation at Sandford Farm, Reading, UK
- Landfill Mining & Reclamation at Emerson's Green, UK
- LFM project in Onoz, Belgium (former studies prior RAWFILL's intervention)
- LAMIS: Landfill Mining Austria, Pilot Region Styria, Austria (2 LFM experiences)
- New-Mine, Austria
- Removal of Lingreville landfill, France (former studies prior RAWFILL's intervention)
- Characterization of waste for LFM purpose in Tenneville, Belgium

Other documents of interest

- COCOON, questionnaire on landfills, landfills management and (enhanced) landfill mining in the EU, March 2017
- Characterization of fine fractions from LFM: a review of previous LFM investigations, Hernandez, Höllen & Pompberger, Proceedings Sardinia 2017 / Sixteenth International Waste Management and Landfill Symposium
- Landfill reclamation, effect on waste age, Gary A. Foster, Lancaster County, MSW assessment of landfills
- Caractérisation de l'évolution de l'état de biodégradation des massifs de déchets non dangereux en post-exploitation : application de méthodes géophysiques, Thèse ANRT, IRSTEA, site des Champs Jouault

- Landfill Mining: An Option to Trigger Resources? Prof. Dr.-Ing. Peter Quicker, RWTH Aachen University –Unit of Technology of Fuels, 8th CEWEP W2E congress, 2016, Rotterdam
- BAT (Best Available Techniques) Reference Document, Waste Treatment Industries, August 2006, European Commission
- BAT (Best Available Techniques) Reference Document, Waste Incineration, August 2006, European Commission
- Improved Landfill Mining, Biotechnology Advances. Volume15, Issue 2, 1997
- BENVITEC-IBH, Rehabilitation by LFM of 2 landfills in Alicante, Spain, prefeasibility assessment, March 2006
- ÖNORM S 288-1 & S 288 -2: risk assessment for polluted soil and polluted groundwater concerning impact on surface environments, September 2004

Analysis of existing experiences

This short review of landfill mining experiences focuses on the methodology applied to evaluate the landfill resources potential. It shows that, in most of the studied cases, no specific attention was given to the precise evaluation of resources. Other important factors lead to the decision of mining the landfill, as solving an environmental issue, recovering valuable land or performing feasibility tests.

Confidentiality is quite high in that domain, and many of the results have not been published. So, we will not give a detailed review of experiences that, in many cases, do not supply a lot of relevant information for our purpose.

The following questions were asked (see questionnaire in Appendix):

- Type of ELFM project:
  - R&D
  - pilot size project
  - real size project
- Dates
- Main difficulties encountered:
  - Legal issues
  - Technical issues
  - Economic issues
- How was the content of raw materials evaluated?
- What was the feedback of this evaluation?
- Recommendations for future projects?

The table hereunder summarizes the results for the 20 cases studies:

Purpose of the project/elements	**Amount**
R&D/business model development	5
Pilot size	6
Real size	7
Historical study performed	14
Sampling on site performed	16
Geophysics performed	3
Evaluation of detailed waste composition	13

Example of answers

Here is one very complete example of the received answers, which is a particularly good summary of issues that may be encountered during a successful LFM project. This example is not very representative of the main problems found elsewhere, which are described after, but is inspiring for future operations.

Short description of the project:

The commercial/industrial waste landfill was located within an area with planning permission for development by housebuilders. Remediation of the landfill was therefore required to make the land suitable for the proposed use. The physical work involved excavation of the waste, sorting of the waste to separate soils, concrete and brick from the remaining materials (including wood, textiles, plastic, paper, card, metal, rubber). The soils, concrete and brick were processed to form a material suitable for re-use to construct the development platform. The remaining materials were exported off-site for either recycling or energy recovery.

Difficulties encountered:

Legal issues: the main legal issue encountered related to the Regulatory regime under which the recovered soils, concrete and brick could be re-used to ensure that the re-use to construct the development platform could not be deemed an illegal deposition of waste in the context of the Waste Framework Directive as transposed into legislation in England and Wales. The remediation works were eventually regulated via a site based (bespoke) waste recovery permit whereby the mechanism of the recovery was the permanent deposition of waste to land.

Technical issues: the recovery of soil from landfill waste is operationally challenging in the UK climate as the efficiency of the process is hindered by precipitation. Once recovered, the material required significant chemical and geotechnical testing to confirm its long-term suitability for proposed use. Often the material has a high gas generation potential by virtue of its elevated organic content relative to inert natural soil. Therefore, our greatest technical challenge is collation of sufficient evidence to demonstrate to others that the material is suitable for proposed use.

Economic issues: the sorting/separation of waste and the backfilling of the separated soil to an appropriate specification are the two most difficult elements of the landfill remediation process. The rate at which these elements can occur has a large impact on the economic feasibility of the delivery of the project. However, the most important factor determining the economic viability is the value of the land (or the value of the properties built upon the land) after completion of the landfill remediation works.

How did you measure/evaluate the content of raw materials to recover in the landfill?

The content of the raw materials to recover (soil, concrete and brick) was evaluated from borehole logs and trial pits undertaken by others. The boreholes proved the top and base of the landfill waste to enable an estimation of its overall volume. The trial pits helped to determine the composition of the waste.

Which feedback can you give us about that?

The estimates made of volumes of waste and recoverable fractions were reasonably accurate when compared with the actual volumes at the end of the project.

What would you recommend for a future project?

The efficiency of the waste separation process dictates the speed of the landfill remediation project (where re-use of material forms a key part of the strategy).

We have tested numerous separation technologies and have found their effectiveness to be influenced in large part by the soil type that was used as the daily cover during the landfilling and its moisture content. Further work to monitor and improve separation efficiency of the technologies would be of interest.

Would an enhanced landfill inventory structure as we propose to supply with RAWFILL be helpful for you?
If the landfill inventory provides accurate data about the composition of the landfill waste, then it would inevitably be useful for those involved in landfill remediation to help them understand the likely costs of remediating a landfill. It would also assist in the remediation options appraisal stage to ensure that the most appropriate remediation strategy for the site is adopted.

Main issues encountered

Among the problems encountered in many LFM pilot and real size projects, we have highlighted the following ones:

- Unexpected presence of asbestos, which is very difficult to detect during survey phase, and can lead to high elimination costs,
- Bad estimation of volume due to poor historical studies, soil irregularities and unexpected buried masses of wastes,
- Bad estimation of composition based on simplified historical studies,
- Low value of recovered materials (excepted recoverable metals, but they count for less than 5 % inside domestic waste landfills),
- In all cases, the percentage of "fine" materials that cannot be valorised is high, more than 40%. "Fine" materials are not precisely determined, as they are sometimes described as "soils", but we can assume that this fraction size distribution is between 0 and 30 to 50 mm. Very often, it increases with the age of the waste due to fragmentation and degradation. Fine materials cannot be valorised at reasonable cost, have poor geotechnical properties, and often contain contaminants exceeding accepted thresholds, so that they cannot even been recycled as civil engineering backfills.

Real cases were performed to solve environmental urgent problems (ex: Lingreville, Beaucens), recover materials (ex: Onoz), recover volume for further landfilling or reclaiming land (ex: Stockley Park), which is also the purpose of some pilot and R&D cases.

Geophysics is sometimes performed, through Georadar and EM- electromagnetic prospection, with not so good precision, probably due to insufficient calibration and lack of crossovers between several methods.

Conclusions

Until now, not much focus has been put on the evaluation of the lying resources that can be found in landfills where ELFM works, pilot or real scale, have been performed. One explanation is that the decision of mining these landfills was taken regarding other parameters, as solving an important environmental issue, or reclaiming valuable land. The valorisation on the waste was more seen as a "by-product" of the whole ELFM process. However, the situation is changing as real size LFM works with materials valorisation are now launched. As the benefits of the recovery were expected to be very limited, not many efforts have been made to evaluate the content of resources prior to performing the works.

Evaluations were of limited precision, regarding waste volume or geophysics. Regarding geophysics, the use of a single method prospection does not supply much precise and relevant information, for several reasons:

- use of methods with low and limited vertical resolution (limited to a few meters deep, mainly < 5 m),
- use of methods with poor contrast between bedrock and waste,
- use of methods with poor contrast between categories of waste.

In the future, this situation will also change thanks to RAWFILL promotion of multi-methods geophysical imaging that many stakeholders are ready to experiment. Multi-methods geophysical imaging is the only way to express the maximum of added value to data collection.

More globally, this situation is expected to change as far as the ELFM market will grow and, within North-West Europe, because some mineral resources (e.g. Aluminium) will request more attention. So, the RAWFILL methodology will really become necessary in order to select profitable projects.

For sure, in a high density populated area as NWE, the economic value of the land that can be reclaimed trough an ELFM project will remain a key decision factor.

As far as geophysical imaging is concerned, the use of a combination of different methods on the same landfill as promoted by RAWFILL seems to be a pre-requisite for a precise evaluation of the landfill geometry and the waste composition. Please see deliverables related to geophysical imaging, landfill miner guide and detailed case studies (www.nweurope.eu/rawfill).

Contact

Feel free to contact us.

Coordination office:

BELGIUM	SPAQuE Boulevard M. Destenay 13 4000 Liège	c.neculau@spaque.be

Contact details of the project partners:

BELGIUM	Atrasol	renaud.derijdt@atrasol.eu
	Cleantech Flanders / VITO	alain.ducheyne@vito.be
	OVAM	ewille@ovam.be
		f.nguyen@ulg.ac.be
FRANCE	Université de Liège	champsjouault@gmail.com
GERMANY	SAS Les Champs Jouault	pbv@bavmail.de
THE UK	BAV	jecha@bgs.ac.uk
	NERC	

Appendix: Questionnaire 2 « LFM Initiatives »

WORKPACKAGE WP T1
ENHANCED LANDFILL INVENTORY FRAMEWORK (ELIF)
REQUEST FOR INFORMATION – LANDFILL MINING EXPERIENCES

1. Introduction

RAWFILL ("Supporting a new circular economy for RAW materials recovered from landFILLs") is a new EU-funded landfill mining project gathering partners and associated partners of EU NWE regions and supported by EURELCO.
The ultimate goal of RAWFILL is to allow NWE public & private landfills owners & managers to implement profitable resource-recovery driven landfill mining projects.
RAWFILL develops a cost-effective standard landfill inventory framework (ELIF) based on existing inventories and experiences, an innovative landfill characterization methodology by geophysical imaging and guided sampling and an associated Decision Support Tool (DST) to allow smart LFM project prioritization. The whole concept will be demonstrated in 2 pilot sites in Flanders and France.
ELIF will be used to describe landfills not only in terms of environmental & risk issues, but will focus on available dormant materials, so that it will be possible to economically evaluate later the resource-recovery potential of each landfill. ELIF is the basis for our DST ranking tool and so a prerequisite to assess feasibility, business plan & business case for launching profitable landfill mining projects.
More information:
https://www.eurelco.org/single-post/2017/04/10/EURELCO-partners-win-Interreg-North-West-Europe-project-RAWFILL-1
http://www.spaque.be/0114/fr/1309/SPAQuE-leader-du-projet-europeen-RAWFILL?from=139&artid=596

Any general question?
Please contact SPAQuE – Marta Popova, m.popova@spaque.be

2. Request to landfill mining projects managers - Benchmark analysis of existing landfill mining initiatives

2.1 Why do we ask you some information?

We would like to perform a short benchmark analysis of the existing landfill mining initiatives, including main legal, technical & economic issues, focusing on how the raw material content of the landfill was estimated, the accuracy of the evaluation and its economic impact in the (positive or negative) experience results.
We would be pleased to receive from you any suitable information you agree to share related to above topic.
Shouldn't you in charge of supplying this information, please let us know who else we can contact!
We will of course invite you to share the results of RAWFILL through several events that we will organize in the next 3 years, and will send you a detailed summarized report of our works to thank you for your cooperation.

Should you be interested to become part of our Associated Partners team, do not hesitate to come back to us.

Please note we would appreciate to receive some information before 15th June.
The attached questionnaire is given hereunder.
Once again, we would like to thank you for supporting the emergence of a suitable landfill mining industrial sector!

2.2 The Request

Please note that only aggregated results will be published, without mentioning any origin of the data nor specific project information.
No information will be disclosed without your prior authorization.
Here is the information's we would be pleased to receive from your organization:

2.3 Questionnaire

Your organization:
Your name:
Position:
Mail:
Tel:
Name of your project:
Type of project (please select one):

- R&D How many m³ of waste are concerned?
- Pilot size How many m³ of waste are concerned?
- Real size How many m³ of waste are concerned?

Short description of the project:
Date start:
Date End:
Difficulties encountered:

- Legal issues (please describe):
- Technical issues (please describe):
- Economic issues (please describe):

How did you measure/evaluate the content of raw materials to recover in the landfill? (please give as much details as you can – that part of the benchmark is very important for us)

Which feed-back can you give us about that?

What would you recommend to do for a future project?

Would an enhanced landfill inventory structure as we propose to supply with RAWFILL be helpful for you?

Are you interested in the RAWFILL Decision Support Tool we would like to set up?

Thank you once again for your cooperation!

Any technical question? Please contact Ir. Renaud De Rijdt, renaud.derijdt@gmail.com