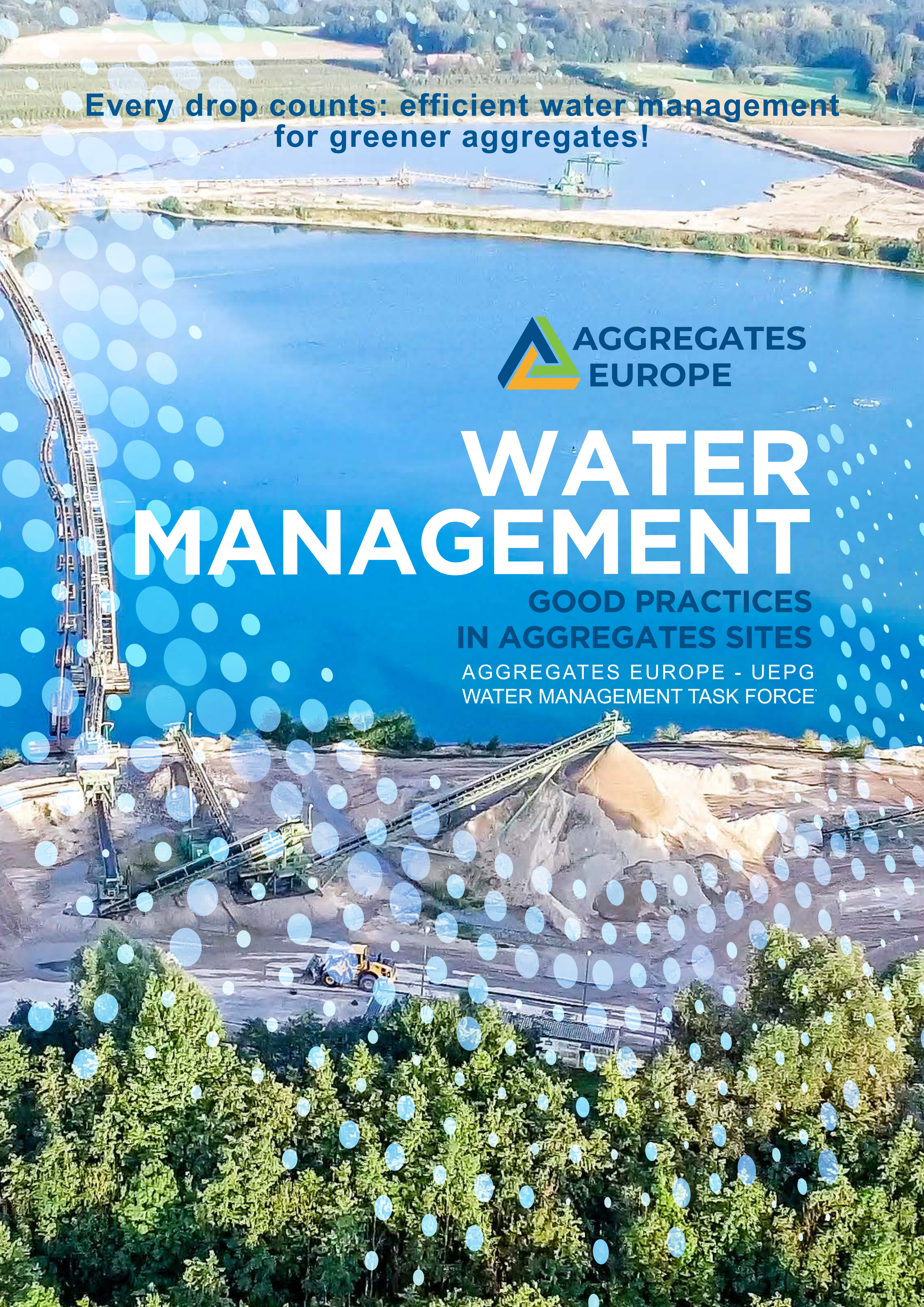

Every drop counts: efficient water management for greener aggregates!

AGGREGATES EUROPE

WATER MANAGEMENT

GOOD PRACTICES IN AGGREGATES SITES

AGGREGATES EUROPE - UEPG
WATER MANAGEMENT TASK FORCE

2025

AGGREGATES EUROPE

Environment Committee
Water Management Task Force
Chairman and Coordinator of the document: Dr. César Luaces Frades

Aggregates Europe - UEPG, as a member of the International Advisory Board of the ROTATE Project (GA #101058651), has contributed to the preparation, dissemination of this document by endorsing it by its Board and launching it under its umbrella.

R8TATE
CIRCULAR & CRITICAL RAW MATERIALS ECOLOGICAL ESSENTIAL

Horizon Europe research and innovation programme (N° 101058651)

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00 President foreword

Antonis Antoniou Latouros
President of Aggregates Europe – UEPG

Water is like aggregates; society direly needs it. Without water, there would not be life, and without aggregates, there would be literally nothing built around us. In fact, aggregates are the second most consumed materials on the planet... after water! As water is becoming a strategic good, water management turns out a growing topic for industries, including ours. Aggregates extraction needs water in several ways, which is why the topic of water management is to become paramount in the next decades.

This Guidance aims at updating the previous one dating back from 2011. It compiles the results and indicators from two research studies on water conducted by Aggregates Europe - UEPG between 2016 and 2019, covering 232 European sites across 11 countries.

It firstly recalls some facts, which are important to keep in mind when discussing water management in quarries and pits: the impact of the aggregates extraction industry on water quantity and quality is very limited. It also enumerates the positive contributions that our industry can have for societal needs, be it in terms of flood prevention or protection, creation of wetlands enhancing biodiversity, improvement of the water quality, etc. It thirdly illustrates said value-added by giving examples and sharing best practices.

In terms of water (as on other topics), aggregates extraction and sustainability can and should go hand in hand, especially in the frame of the EU Biodiversity Strategy for 2030 and the Montreal Biodiversity Convention 2022. Aggregates Europe – UEPG is determined to bring a significant contribution to enhancing water quality across Europe and ensuring that all kinds of human activities that need water can continue to use it responsibly.

Water is like aggregates; society direly needs it

This guidance represents our contribution to the goals of the European Commission's Clean Industrial Deal. We emphasise the importance of water resilience and sustainable water management as essential elements of Europe's industrial transformation towards sustainability.

01 Executive summary

Water is a critical resource for life and industry, including the aggregates sector, which is essential for construction and infrastructure. The Water Management Good Practices in Aggregates Sites guidance document provides a comprehensive framework to optimize water use, minimize environmental impact, and enhance sustainability in the aggregates industry. The guidance highlights that the industry's impact on water quantity and quality is limited and that responsible management practices can lead to positive environmental contributions.

This guidance underscores the dedication to supporting the objectives of the European Commission's Clean Industrial Deal, emphasizing the vital role of water resilience and sustainable water management in driving Europe's industrial shift towards sustainability. It compiles the results and indicators from two research studies on water conducted by Aggregates Europe - UEPG between 2016 and 2019, covering 232 European sites across 11 countries.

Key Contributions of the Aggregates Industry to Water Management

The aggregates industry plays a crucial role in water management through:

- Flood Prevention & Protection – Supporting river basin management by widening waterways, creating supplementary channels, and constructing flood defences.
- Water Supply – Extracting and managing groundwater responsibly to maintain water quality and availability.
- Basin Management & Dialogue – Engaging in collaborative efforts to manage water resources effectively.
- Rehabilitation & Biodiversity Conservation – Restoring quarries into wetlands and other ecosystems to support biodiversity.
- Water Quality Improvement – Utilizing natural filtration processes in sand and gravel deposits to enhance water quality.
- Circular Economy Contribution – Increasing water efficiency through recycling and reuse in quarrying operations.
- Commitment to Impact Minimization – Implementing strict regulations, best practices, and innovative technologies to reduce environmental effects.
- Leisure & Community Engagement – Repurposing rehabilitated sites for recreational use, such as lakes and wildlife areas.

European Water Policy & Regulatory Framework

The aggregates industry operates within a robust European regulatory framework, including:

- The EU Clean Industrial Deal, EU Green Deal & Zero Pollution Action Plan, which aims for efficient, clean and sustainable industrial processes.
- The Water Framework Directive & Groundwater Directive, ensuring that all water bodies reach "good status."
- The Circular Economy & EU Blue Deal, promoting sustainable water use and wastewater treatment.
- The Best Available Techniques (BAT) Reference Document, providing guidelines on managing waste and minimizing emissions.

Water Usage in Aggregates Sites

The aggregates industry primarily uses water for processing activities such as aggregate washing, dust suppression, site maintenance, and domestic needs. On average, 92 litres of water are consumed per ton of aggregates.

Approximately 81.4% of total water consumption is allocated to aggregate washing. Washing plants are present in 48% of sites, mainly in sand and gravel pits, where the average water consumption is 169 litres per ton when recycling systems are in place, increasing to 235 litres per ton in their absence. In contrast, 52% of sites do not wash their production, predominantly in hard rock quarries, where water usage is significantly lower at just 26 litres per ton.

The primary water source for aggregate sites is surface water (47%), followed by groundwater (33%). Notably, 53% of sites do not discharge water.

Only 39% of aggregate production involves washing, requiring efficient water management strategies. Of the total water withdrawn, 81% is clarified and discharged, with only 19% being consumed. Additionally, 50% of sites have implemented water recycling systems, achieving an average recycling rate of 87.6%.

Good Practices in Water Management

1. Aggregates Extraction Sites:

- Site Planning & Risk Assessments – Integrating water management into site development.
- Monitoring & Data Collection – Utilizing piezometers and real-time sensors to track water usage and quality.
- Minimizing Water Consumption & Pollution – Implementing closed-loop recycling systems, reducing erosion, and preventing accidental spills.
- Sustainable Extraction Techniques – Limiting groundwater depletion and rehabilitating quarry sites effectively.

2. Water Treatment & Recycling in Aggregates Plants:

- Settling Ponds & Reservoirs – Using natural or forced sedimentation for sludge separation.
- Thickening & Clarification Tanks – Enhancing sedimentation with chemical flocculants.
- Press Filters – Maximising water recovery and minimizing sludge volume.
- Wastewater Treatment & Sludge Management – Implementing best practices for sludge reuse in land restoration.

3. Digitalization & AI in Water Management:

- Real-Time Monitoring – Using IoT devices to track water consumption and pollution risks.
- Predictive Analytics – Employing AI-driven models to optimize water allocation and efficiency.

Water Management Plans for Quarries

A structured three-step approach is recommended for water management:

1. Knowing – Identifying site-specific water needs, sources, and constraints.
2. Managing – Implementing efficient water use strategies, monitoring systems, and pollution control measures.
3. Anticipating – Proactively addressing potential risks, improving staff training, and integrating drought management plans.

Conclusion

The aggregates industry has a limited negative impact on water resources but a significant potential for positive contributions through responsible water management. This guidance document serves as a blueprint for sustainable water use in the industry, aligning with European water resilience and sustainability goals and global environmental commitments.

By implementing the best available techniques, regulatory compliance, and innovative water management practices, the sector can enhance efficiency, protect ecosystems, and contribute to climate resilience.

02 Introduction

Water is a natural resource, a livelihood, and a vital marker that is affected by the disruptions caused by climate change.

Thus, it is essential to consistently improve water management as responsibly as possible.

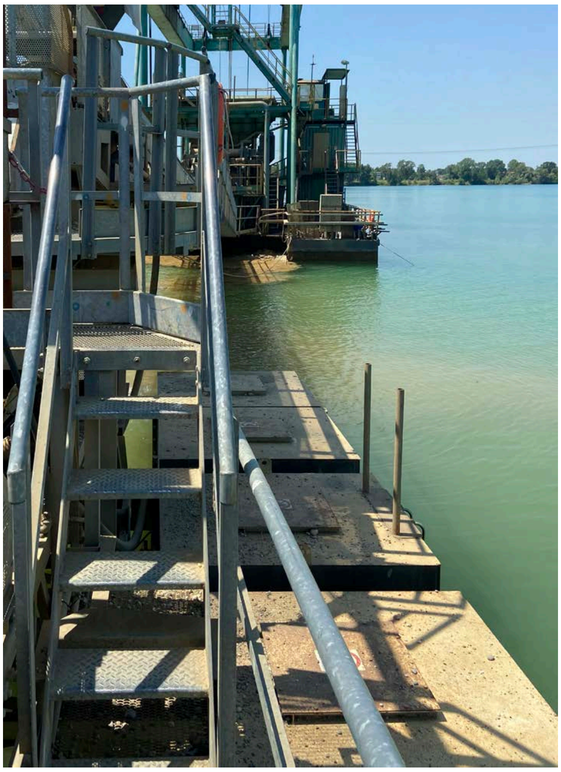
Sharing the best water management practices that European aggregates companies have implemented in the field in the diversity of European contexts exemplifies our industry's capability to contribute to Climate Change Adaptation and Mitigation.

It is an essential first step toward adaptation for an industry that contributes to the sustainable development of territories beyond valorising mineral resources necessary for construction.

2.1 General

Aggregate sites usually undergo a comprehensive Environmental Impact Assessment and a complex administrative process that evaluates the potential effects of the activity on both surface and underground water. This process imposes conditions to mitigate these potential negative impacts through permitting.

Hydrological and hydrogeological equilibria, aquatic ecosystems, water resources, space for watercourse mobility, and other factors must be considered. Then, good practices and best techniques are generally applied to manage them.



Aggregates extraction with a dredger. Holcim – Italy

By its nature, extracting aggregates is likely to cause environmental impact if proper practices are not followed during the activity. These practices should be defined based on the surroundings' specific characteristics and the site operation type.

Today, aggregate extraction can be considered within the current river basin plans (in some countries), and many countries have specific procedures for authorising it in riverbeds.

After extraction, the operator values the rehabilitation of the aggregates site imposed by the permits. Under guarantee with the administrative authority, restoring the site benefits the local community, nature conservation, and biodiversity status, usually beyond what it was pre-extraction.

In many European countries, a water management plan (for surface and groundwater) is included in the general planning of the extraction site, setting the principles for controlling water and preserving its quality.

2.1.1 A limited impact on water quantity

The aggregates extraction sector uses very little water. Indeed, good practices in aggregates sites to protect water quality and minimise water consumption through water efficiency and recycling are widely adopted.

2.1.2 A limited impact on water quality

The raw materials used for aggregates production do not contain any hazardous substances. It is important to note that the materials (crushed stone, sand, and gravel – S&G) that are extracted and processed are inert, as defined in EU legislation (Directive 2006/21/CE) in most cases. Furthermore, all permits for aggregates sites are based on a technical permit subject to an Environmental Impact Assessment. Therefore, the industry implements good practices throughout extraction and aggregates production.

Sand and gravel pit – Millery site - Lafarge - France

All this results in a very low risk of water pollution from aggregates sites compared to other industries. In practice, there is little risk of water being contaminated by hazardous substances.

As outlined in legislation, apart from requiring potential special authorization for the river basin, it will be mandatory to establish the necessary financial guarantees to ensure that the environment is rehabilitated following the completion of activities concerning hydraulic, ecological, and landscaping aspects.

The production of aggregates is mechanical, and in some cases, a crucial step in the process involves washing the extracted material with water, which is then clarified, recycled, and re-used to minimise consumption.

Nevertheless, water pollution may occur at various stages in the management of sludge. For instance, the failure of the discharge could cause spills and damage the surrounding environment. The effects of water pollution at aggregates sites could only be associated with pH levels, suspended solids, TSS (Total Suspended Solids), BOD (Biological Oxygen Demand), COD (Chemical Oxygen Demand), temperature, and colour. These impacts are clearly temporary and reversible but, above all, they can be anticipated and are technically manageable.

Rehabilitated areas in a sand and gravel pit – Millery site - Lafarge - France

2.1.3 A responsible Industry

The aggregate industry positively interacts with river basin management plans, ensuring that any impact on the water environment caused by the aggregate industry is limited. Indeed, the Aggregates Industry can provide flood storage capacity during times of high water levels and, thanks to good site management, can, in most cases, be a positive contributor to water quality and biodiversity.

As stated earlier, numerous preventive measures exist nowadays to allow us to control the various forms of impact on the environment.

Implementing such measures will depend on the specific circumstances of each site operation. Many of these actions require the company to conduct a preliminary technical study to determine their efficacy in those conditions.

In carrying out the project and evaluating the environmental impact that the quarrying activity is expected to have on the surrounding area, next to the extraction of aggregates, factors should be considered, such as cleaning the watercourse by removing cumulated sediments and the environmental restoration of the zone in such a way as to obtain sufficient guarantees as regards control and the return to normal of the zone after the activity has been completed.

Sand and gravel pit – La Loggia site – Zucca e Pasta - Italy

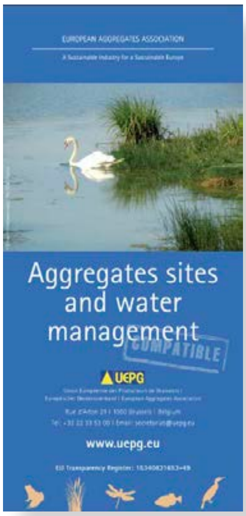
The most significant aspect regarding the environmental impact concerns the alteration or change of the habitat at the operating stage. This is mainly due to the visual impact and the loss of the vegetative layer on the banks of the areas near the water courses and, to a lesser extent, the fauna. Concerning watercourses, the impact of the activity should be studied on the biological assets in place in the area and, generally, on all the river's habitats that are present in the operational zone.

However, proper management and application of the preventive and corrective measures keep the impact under due control during the site's operation. Said measures will also ensure that the remaining impact is corrected during the phase of land restoration and reconditioning the river's watercourse. The implementation of these measures should be based on the nature of the activity being undertaken and the specific characteristics of the surrounding environment.

Proper management of the zone where operations are to take place is key, in addition to the preventive and corrective measures elucidated, appropriately arranging quarrying activity and demarcating those zones where extractive activity should not be allowed and the zones where this is actually possible and under what conditions.

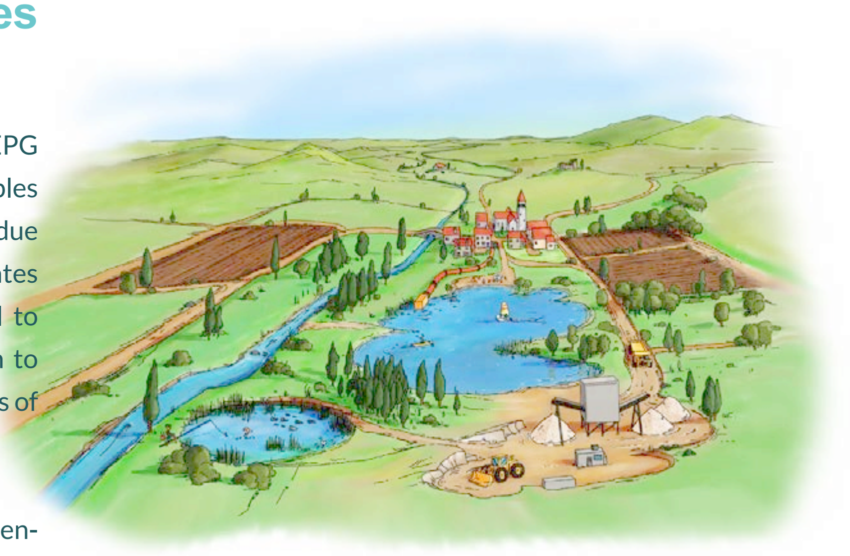
The alterations to the land that arise from the progress of site operations in themselves foment the appearance of new and diversified habitats, where both animal and vegetable species can find refuge, when management of the latter is appropriate. Moreover, adequately conducted extraction work that follows the established technical criteria can help control and regulate the river's watercourse.

2.2 Positive contribution to water of the aggregates industry



Aggregates Europe – UEPG has identified several examples demonstrating that, with due management, the aggregates industry has a big potential to have a positive contribution to water, in line with the policies of the European Commission.

These contributions are essential actions for climate change mitigation and adaptation.



Positive contribution to water of the aggregates industry

Flood prevention and protection	Water supply, storage capacity and water table reinjection	Basin management and dialogue	Rehabilitation, creation of wetlands and biodiversity conservation
Improvement of water quality	Contribution to the circular economy	A permanent commitment to minimise impacts	Leisure

2.2.1 Flood prevention and protection

Our industry is a staunch ally of administration bodies managing the river basins when it comes to guaranteeing that the watercourse has the capacity to allow floodwaters to pass along it, using techniques such as widening the course or creating supplementary watercourses, cleaning the channel and building defences against floods, to protect the population and the infrastructures.

In that last sense, quarries could also be an excellent location for firefighters to pump water when fires occur (lorries, helicopters, ...) or to train them in diving to human rescue.

2.2.2 Water supply, storage capacity and water table reinjection

Dewatering by pumping pure groundwater, by means of extraction boreholes drilled at chosen places around a quarry, or by pumping water from the sump at the bottom of the extraction site not only facilitates the extraction but also preserves water resources and allows for their rational use, increasing resource efficiency.

In several countries, quarry operators' disciplined approach has led to close cooperation with drinking water suppliers, meeting all the quality requirements for human health. It also contributes to the rationalisation of water intakes for the above-mentioned suppliers.

Due to the storage capacity, the aggregates industry can act as a temporary water reservoir, in drought periods, not only for human needs but also to feed watercourses at risk.

The collection of water from different sources makes the aggregates quarries a candidate for water table reinjection, where water quality is high and the hydrogeology makes it possible.

2.2.3 Basin management and dialogue

In many countries, the aggregates sector is acting as a proactive industry participating in river basin management.

2.2.4 Rehabilitation, creation of wetlands and biodiversity conservation

Quarries and gravel pits may be restored to create a natural environment intended to enhance and preserve both the flora and the fauna typical of water-centred environments. Plans should be ready for the restoration process in the zone prior to the initiation of site operations. In this way it will be possible to facilitate restoration work as well as saves on costs in the process.

A sign of sound environmental practices at many of the active quarries and gravel pits is the biodiversity they have there, which shows that quarrying crushed rock and minerals is not harmful to the environment but may even be beneficial. It is very common to find numerous species that stay from the beginning of operations or that have colonised the site and live normally alongside the site equipment and the work being carried out.

Aggregates sites facilitate the hydrological connection of areas, water courses and habitats in a targeted way to facilitate water movement and also the promotion of species of interest for biodiversity.

Grey heron (Ardea cinerea) surveying a settling pond amidst ongoing operations – France

Water management is an opportunity for biodiversity. The techniques used to protect the biodiversity must be adapted to each individual situation and type of existing habitat according to the cataloguing of existing species. The task falls to the company of deciding what procedures to apply in each case.

Cleaning water pond – Sand and gravel pit – El Tomillar site – Hormisoria, S.A. - Spain

Quarries and gravel pits are ideal places for ensuring biodiversity net gain on a longer term, thanks to an environment generated by them. In just a few years after the extraction, a wide variety of aquatic and land-based habitats can be created.

2.2.5 Improvement of water quality

Aggregates (sand and gravel) are a natural filter that are widely used for water filtration to improve water quality and good chemical status.

Moreover, the contribution of aggregates sites to good chemical status is proven by water supply activities. Several independent scientific studies have described that the water chemical status can be improved thanks to a well-managed aggregates site.

2.2.6 Contribution to the circular economy

Resource efficiency is a priority in the use of water in aggregates sites and many companies are applying good practices to minimise consumption. For example, the recirculation of recycled used water is generally applied.

Countries, companies, and sites participating in the Aggregates Europe – UEPG survey

	2016		2019		Total	
	Companies	Sites	Companies	Sites	Companies	Sites
Belgium	3	3	1	9	4	12
Cyprus	1	1	1	1	1	2 (1)
France	3	18	1	4	4	22
Germany	13	13	9	17	17	30 (5)
Italy	-	-	1	8	1	8
Malta	-	-	1	1	1	1
Romania	2	2	-	-	2	2
Slovakia	-	-	1	1	1	1
Spain	40	60	32	43	59	103 (10)
Sweden	3	3	-	-	3	3
United Kingdom	2	3	2	45	2	48 (3)
Total	67	103	49	129	95	232 (19)

2.2.7 A permanent commitment to minimise impacts

Quarrying operations inevitably impact the surrounding water; environmental problems can result if appropriate mitigation is not in place.

With developments in environmental legislation and the need for compliance, potential environmental effects of quarrying need to be understood and managed within this framework.

Between 2016-2017 & 2019-2020, the Aggregates Europe - UEPG Water Management Task Force conducted surveys on 232 extraction sites across Europe, reporting on water use in the aggregates sites, with the participation of 11 countries. The results of these studies are integrated in this Guidance, to make a practical reference to the real situation of the industry, reinforcing the recommendations given in this document.

Of course, despite a high response rate, the results of these surveys are only used in this document to illustrate good practices across Europe, because the different territorial, regulatory, etc. contexts do not make the cases universally applicable per se.

This Aggregates Europe – UEPG guidance document offers solutions to environmental problems encountered by the aggregates quarrying industry, with particular emphasis on surface water and groundwater. An online database on water management case studies from aggregates companies across Europe is available on the website of Aggregates Europe – UEPG[1].

Even if drainage and dewatering of the sites are two fundamental activities that are part of the productive process of any aggregate quarry, this Aggregates Europe – UEPG guidance document deals only with the water management used for the processes involved in the treatment of the raw materials to obtain aggregates.

2.2.8 Leisure

Former quarries and pits may be restored for recreational purposes like sailing, bathing, nature observation, etc., thus participating to water management.

Rehabilitated sand and gravel pit for leisure – VICAT – France

[1] https://www.aggregates-europe.eu

03 European water policy background

3.1 EU Clean Industrial Deal

The European Commission's Clean Industrial Deal emphasises the importance of water resilience and sustainable water management as integral components of Europe's industrial transformation towards sustainability. Key initiatives related to water within this framework include:

- Water Resilience Strategy: Scheduled for publication in the second quarter of 2025, this strategy aims to enhance Europe's capacity to manage water scarcity and address climate-related challenges. It underscores the necessity for Member States to improve water management practices, increase water efficiency, prevent pollution and promote sustainable usage to ensure a resilient water supply.
- Integration with the European Green Deal: The Clean Industrial Deal builds upon the objectives of the European Green Deal, which provides the primary framework for water policy in Europe. This includes protecting water resources, ensuring clean drinking and bathing water, and maintaining healthy freshwater and saltwater ecosystems. The Water Framework Directive plays a pivotal role in achieving these goals.
- Circular and Resilient Economy: A core objective of the Clean Industrial Deal is to foster a circular and resilient economy that supports sustainable production and consumption. This involves promoting water reuse, enhancing water efficiency, and integrating water considerations across various policies and funding mechanisms.

By incorporating these water-focused initiatives, the Clean Industrial Deal seeks to ensure that Europe's industrial sectors not only advance towards decarbonisation but also contribute to the sustainable management and resilience of water resources.

3.2 EU Green Deal, Zero Pollution Action Plan and EU Biodiversity Strategy

The EU Green Deal (EGD) sets ambitions for zero pollution in order to protect our natural environment, supporting the overall objective of having a sustainable EU by 2050. The EGD describes a series of actions to move towards a clean, circular economy, restore biodiversity and cut pollution. To achieve this, the EGD sets out ambitious policy initiatives including the: Chemicals Strategy for Sustainability, Zero Pollution Action Plan, Farm to Fork Strategy, EU Biodiversity Strategy for 2030, and EU Strategic approach to Pharmaceuticals in the Environment.

The EU Biodiversity Strategy for 2030 foresees legally binding nature restoration targets where small water units, wetlands, rivers, lakes, alluvial habitats will need to be restored to good ecological status. Measures will need to be completed on 30% by 2030, 60% by 2040 and 90% by 2050. The European Aggregates Industry can contribute to the restoration 25.000 km of rivers, the recreation of lakes and small water units (i.e., Life Ribermine project).

3.3 Water Framework Directive and Groundwater Directive

The public, the economy, and nature all need 'non-polluted' water, with a minimum of harmful substances in rivers, lakes, coastal and ground waters. Despite improvements in legislation, governance and heavy investment, European waters continue to face a wide range of significant pressures, including pollution, alterations to their surrounding physical landscape, water scarcity and floods.

To tackle these pressures, EU water directives and regulations in place, monitor pollutants and establish mandatory standards to protect EU waters.

The Water Framework Directive (WFD) aims to ensure that all surface and groundwater (including transitional and coastal zones) bodies achieve "good status".

A water body is classified as having an overall good status only if both its chemical status and its ecological status (or quantitative status for groundwater bodies) are rated at least as good.

Regarding chemical status, Article 16(2) of the WFD requires a list of Priority Substances (PS) to be established for surface waters. These PS are those which present a significant EU-wide risk to the environment and require further action. The proposed list of PS should also identify Priority Hazardous Substances (PHS). Considered as hazardous are those PS which are toxic, persistent, and liable to bio-accumulate or which give rise to an equivalent level of concern.

Good chemical status is achieved if the concentrations for all substances on the PS list are below the Environmental Quality Standards (EQS) in surface water, established under the Environmental Quality Standards Directive (EQSD). The pollution from PS must be progressively reduced, while for PHS discharges, emissions and losses must be ceased.

The EQSD aims to protect the surface waters from chemical pollution by setting standards for PS, complementing the requirements of the WFD. The Directive establishes EQS at a level aiming to protect the aquatic environment and human health against long-term exposure (expressed as annual average concentration) and short-term exposure (expressed as maximum allowable concentration). The Directive covers 45 PS including (heavy) metals, industrial chemicals, pesticides and unintentionally formed substances.

The WFD requires that the list of PS is reviewed every six years. It also requires Member States to develop an inventory of emissions, discharges, and losses for selected substances.

The Groundwater Directive (GWD), adopted in 2006, expands the WFD requirements to groundwater quality and protection. It provides the list of relevant pollutants and groundwater quality standards, as well as substances, which Member States (MS) should consider when setting threshold values for pollutants, which put groundwater bodies at risk. The GWD includes provisions for the assessment of groundwater chemical status, assessment of pollutant concentration trends, the point of trend reversal, and the setting of measures to prevent or limit inputs of pollutants into groundwater.

For both surface and ground waters, a watch list mechanism has been developed to facilitate the identification of substances (including emerging pollutants) which may pose a risk at EU level. If these substances are deemed to pose a significant risk, then EQS are set for these substances in surface water, and water quality standards (including threshold values) are set for groundwaters. For surface waters, the Watch List is mandatory and is updated every two years. For groundwater the Watch List process is voluntary and identifies new or emerging substances which could be added to the Annex I and II of the GWD within the 6-year review cycle of the annexes.

3.4 Circular Economy

The European Commission states that half of total greenhouse gas emissions and more than 90% of biodiversity loss and water stress come from resource extraction and processing. To address this, the European Green Deal launched a concerted strategy for a climate-neutral, resource-efficient, and competitive economy. Scaling up the circular economy from front-runners to the mainstream economic players will make a decisive contribution to achieving climate neutrality by 2050 and decoupling economic growth from resource use, while ensuring the long-term competitiveness of the EU and leaving no one behind.

To fulfil this ambition, the EU needs to accelerate the transition towards a regenerative growth model that gives back to the planet more than it takes, advance towards keeping its resource consumption within planetary boundaries, and therefore strive to reduce its consumption footprint and double its circular material use rate in the coming decade.

This Circular Economy Action Plan provides a future-oriented agenda for achieving a cleaner and more competitive Europe in co-creation with economic actors, consumers, citizens, and civil society organisations.

This progressive, yet irreversible transition to a sustainable economic system is an indispensable part of the new EU industrial strategy.

The new Water Reuse Regulation will encourage circular approaches to water reuse. The Commission will facilitate water reuse and efficiency, including in industrial processes.

And that is where this guidance fits to contribute to a resource efficient, minimal, and circular use of water.

3.5 Strategy for Climate Change Adaptation: Floods & Droughts

The objective of the Floods Directive (2007/60/EC) is to establish a framework for the assessment and management of flood risks to reduce the negative consequences that floods pose to human health, the environment, cultural heritage, and economic activity in the European Union.

While there isn't a standalone Drought Directive, the existing framework within the WFD, complemented by strategic communications and guidelines, provides a robust foundation for addressing drought-related challenges within the EU. To further support these efforts, the EU has developed Guidelines for Drought Management Plans. These guidelines assist member states in integrating drought preparedness and response strategies into their river basin management plans, promoting a harmonised approach to drought risk assessment and management across the EU.

3.6 EU Blue Deal

The EU Blue Deal is a strategic initiative launched by the European Economic and Social Committee (EESC) to establish a comprehensive and sustainable water policy across Europe. Recognising water as a fundamental human right and a vital public resource, the Blue Deal aims to address pressing challenges such as water scarcity, pollution, and infrastructure deficiencies. Key components of the initiative include promoting water-efficient technologies, enhancing water infrastructure, ensuring equitable access to clean water, and integrating water considerations into all EU policies. By prioritising water resilience and sustainability, the EU Blue Deal seeks to safeguard water resources for current and future generations, aligning with broader environmental and economic objectives.

3.7 Water & Sustainable Development Goals

Water plays a crucial role in achieving the Sustainable Development Goals (SDGs) set by the United Nations Agenda 2030. SDG 6 (Clean Water and Sanitation) specifically aims to ensure universal access to safe and affordable drinking water, adequate sanitation, and sustainable water management. However, water is also interconnected with other SDGs, including SDG 2 (Zero Hunger), where irrigation and sustainable water use are essential for food security, and SDG 3 (Good Health and Well-being), as clean water reduces the spread of waterborne diseases. Furthermore, SDG 13 (Climate Action) highlights the need for resilient water management to mitigate the impacts of climate change, such as droughts and floods. Achieving water sustainability requires efficient water governance, investment in infrastructure, pollution control, and innovative technologies to ensure that water resources are preserved and equitably distributed for future generations.

3.8 Best Available Techniques (BAT) Reference Document for the Management of Waste from Extractive Industries

In the development of this Guidance, the Best Available Techniques (BAT) Reference Document for the Management of Waste from Extractive Industries has been used as reference to confirm that the proposed techniques are suitable to guarantee the prevention of emissions to water (surface and groundwater) and water status deterioration, and to foster the right usage and consumption of water.

04 Definitions

The official definitions for surface water and groundwater, in Directive 2000/60/CE, are:

1. "Surface water" means inland waters, except groundwater; transitional waters and coastal waters, except in respect of chemical status for which it shall also include territorial waters.
2. "Groundwater" means all water which is below the surface of the ground in the saturation zone and in direct contact with the ground or subsoil.

4.1 Groundwater

Groundwater, contrary to what one could be led to believe, is not contained in underground caverns. This is indeed mainly interstitial water, contained in certain porous rocks, somewhat like in a sponge. As far as possible, operators try to keep the lowest extraction level of their quarry above the ground water table. The hydrogeological conditions, or the nature of the mineral to be extracted, however, do not always allow this to happen and extraction below the water table can also occur.

Aggregates extraction under water table – UNICEM

Pumping pure groundwater through strategically placed extraction boreholes around a quarry not only facilitates mineral extraction but also helps conserve water resources and promote their efficient use. This approach enhances resource efficiency and, in some countries like Belgium, has fostered strong collaboration between quarry operators and drinking water suppliers.

Limestone quarry – Antoing site – Carrières d'Antoing – Belgium

The management of groundwater, and its influence on quarrying permits, however, remains a continuous concern to quarry operators. As is often the case, the groundwater pumped in the quarry may be little affected by the working of the quarry and, as far as possible, this water (the so-called pumping water), is fed back into the aquifer under strict quality control.

Since groundwater is a significant natural resource, it is protected by several European / National / Regional / Local regulations that limit the discharge of specified substances (Directive 2006/118/EC).

Many countries have groundwater protection plans classifying aquifers and aquifer vulnerability.

Quarry developments by their nature remove topsoil and overburden materials within the extraction area. These activities may change aquifer recharge characteristics and increase the aquifer vulnerability if technical preventive measures are not implemented. Depending on the depth of the quarry relative to the surrounding groundwater regime, groundwater control or dewatering measures may also have to be incorporated into quarry operations. The impact of these activities, if any, on the groundwater resource can be mitigated by appropriate quarry planning and design, together with operational practices.

Sand and gravel pit – Bellegarde site – Lafarge – France

The principal changes in the groundwater regime which may arise are:

- The removal of topsoil, overburden and mineral, and replacement, possibly in combination with imported materials, which may change:
  - The quality of the infiltrating water recharging the aquifer.
  - The timing and relative rates of aquifer recharge and surface water flows.
- Dewatering of workings or diversion of surface water courses that may, in taking water from one place and discharging it in another :
  - Change the supply of water to abstractions and spring fed surface water courses and wetlands.
  - Lead to settlement of the ground surface, buildings, etc.
  - Change the quality of the water before discharging it.
- Discharges may cause physical and chemical contamination.

Many of the above changes are inherent in a planning permission allowing minerals to be extracted, but in many cases the changes can be ameliorated by appropriate operational practices. Pointers on best practices are set out below.

4.2 Surface water

Surface water is critically important in mineral processing. Process water is usually obtained through surface water and water releases flow naturally into the surface water compartment. Furthermore, some mineral extraction is conducted underwater, by means of dredging. Strict rules apply all over Europe when it comes to water release.

It must be noted that the extraction of aggregates releases none or very few substances, the concern being more at the level of the physical characteristics of the water than of its chemistry. For aggregates sites, standard measurement of the quality of water is generally based on three parameters: the pH, the TSS (Total Suspended Solids) and BOD (Biological Oxygen Demand).

Regarding the latter parameter, one can note that the organic pollution induced by mineral extraction is extremely reduced, but that, on the contrary, the suspended solids content could be significant due to processes involving water, i.e., cutting, washing, and separating out of stones and clay.

Concerning pH, its value in water is closely linked to the type of raw material (petrography of the geological levels exploited in the quarry) and precise values are difficult to give. The extraction of some eruptive and metamorphic rocks containing sulphides could lead, in the absence of preventive measures, to acid drainage affecting the water quality.

Depending on the characteristics of the water bodies, the thresholds applied to water effluents vary according to country, region, and even to local circumstances. Maximum and minimum values for the three main parameters range from 20 to 100 mg/l for TSS, from 40 to 125mg/l for BOD, and from 5 to 11 for pH.

Accidental spillage can also be of concern in the context of surface water, mainly in relation to hydrocarbons used in quarries or plants. In order to prevent accidental spillage, the efforts of manufacturers and quarry operators have resulted in new technological advances. Standard oils, for example, used for hydraulic circuits of shovels and loaders are gradually being replaced by biodegradable ones in order to avoid long-term pollution in case of spillage.

Leakage-free areas are also being created to store fuel, oils and wastes related with.

Pre-release treatment of wastewater is a commonly applied rule, even creating situations where the quality of the outgoing water is better than that of the incoming water.

With regard to process water, its usage in the extractive industry is very important and diverse. In many cases, aggregates production cannot be achieved without water. Most existing operations now employ closed-circuit systems: used water passes through sedimentation ponds before being clarified and returned to the process. This results in an extremely modest net consumption of water and in a very effective water resource management. The resulting sludge is often fed back into the process or recycled as secondary products (i.e., limestone powder for agriculture and ceramics).

Water-related investments are certainly one of the significant items in the environmental accounting for aggregates extraction. These investments generally have a “stepladder” profile, being related to the purchase and maintenance of water treatment and recycling equipment. The building of water treatment units represents, overall, a major investment.

The main potential effects of an aggregates site on the surface water regime are to:

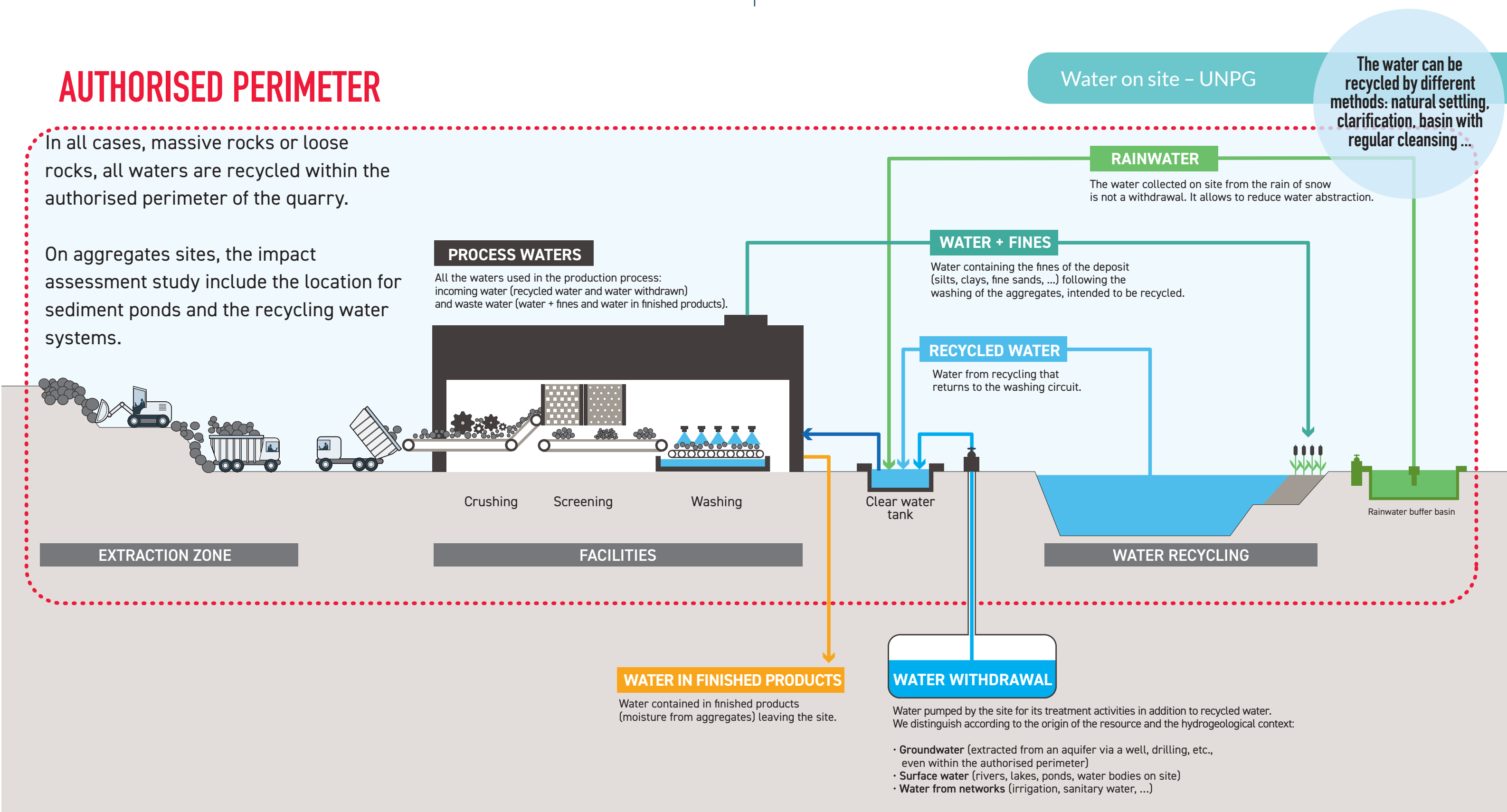
- Alter the surface over which water flows.
- Change the pattern of surface water flows.
- Reduction of the surface water regime because of lack of recharge from groundwater or seepage from the stream bed or decreased catchment.
- Increase because of discharge or increased catchment which may increase scour and be too great for points of limited capacity downstream,
- Change the quantity and physical and chemical quality of those flows.

The number and seriousness of problems vary significantly with the depth of working compared to the water table, the extent of dewatering, the nature of the rock and overburden and the method of working. The main problems are changes in surface water flows and their contamination by particulate matter. Examples on current best practice to prevent these effects are set out below.

05 Water in the aggregates sites

On aggregates quarries, sand and gravel sites and material treatment plants, there are other streams of water in addition to those included in the production process. As such, we can enumerate water needed for the maintenance of the site, for the use of personnel (domestic water), of natural origin (rainwater and drainage water), etc. These waters should be accounted and monitored.

Sand and gravel pit – FdA – Spain



5.1 Water withdrawal

The source of water which can be found in aggregates extraction sites – quarries or gravel pits – varies substantially:

- Quarry drainage waters (underground and harvested rainwater), depending on the characteristics of the site (weather, nature of aquifers, geology, morphology of the extraction zone, ...)
- Withdrawal of ground water by drilling.
- Withdrawal of surface water (rivers and other watercourses).
- Public / private supply network.

- Recycling water in a closed-circuit following settling (ponds, settling tanks / thickeners, ...). In such a case inflow of water to the circuit are required, these becoming less as the efficiency of the process improves.

According to the Aggregates Europe – UEPG survey (see reference 10), in terms of percentage of sites, the main sources of water are: 40% public / private supply; 36% ground water; 30% surface water; 11% harvested rainwater; 9% quarry drainage water used; 5% None. Most of sites have more than one source of water. Public / private supply is mainly for domestic uses.

However, by looking at the water volume by source, it is clear that surface water (47%) is the main source. It is very relevant to point out that the water volume withdrawn from ground water is 33%. Other main sources are quarry water used (4%) and harvested rainwater (4%).

5.2 Water consumption

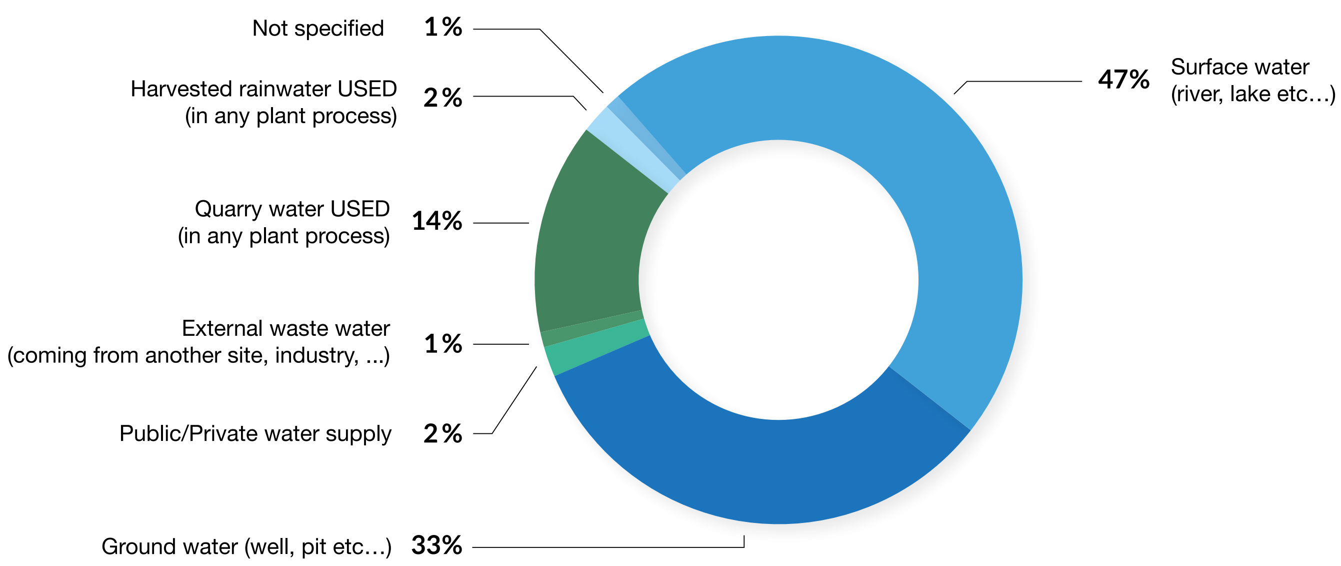
Water consumption on aggregate extraction sites can vary significantly depending on circumstances such as whether the treatment process is wet or dry, local weather, etc. The main activities that might need water are:

- Washing aggregates (wet process).

Water washing process for aggregates – UNICEM

- Dust prevention (spraying the facilities, washing down the tracks (automatically or with a moving cistern), watering the cargo on lorries, cleaning the installations, lorries etc.)

Water withdrawal by source in percentage of volume – AE – UEPG



Water spray in tracks for dust prevention – UNICEM

- Ancillary installations (laboratory, workshops, changing rooms).

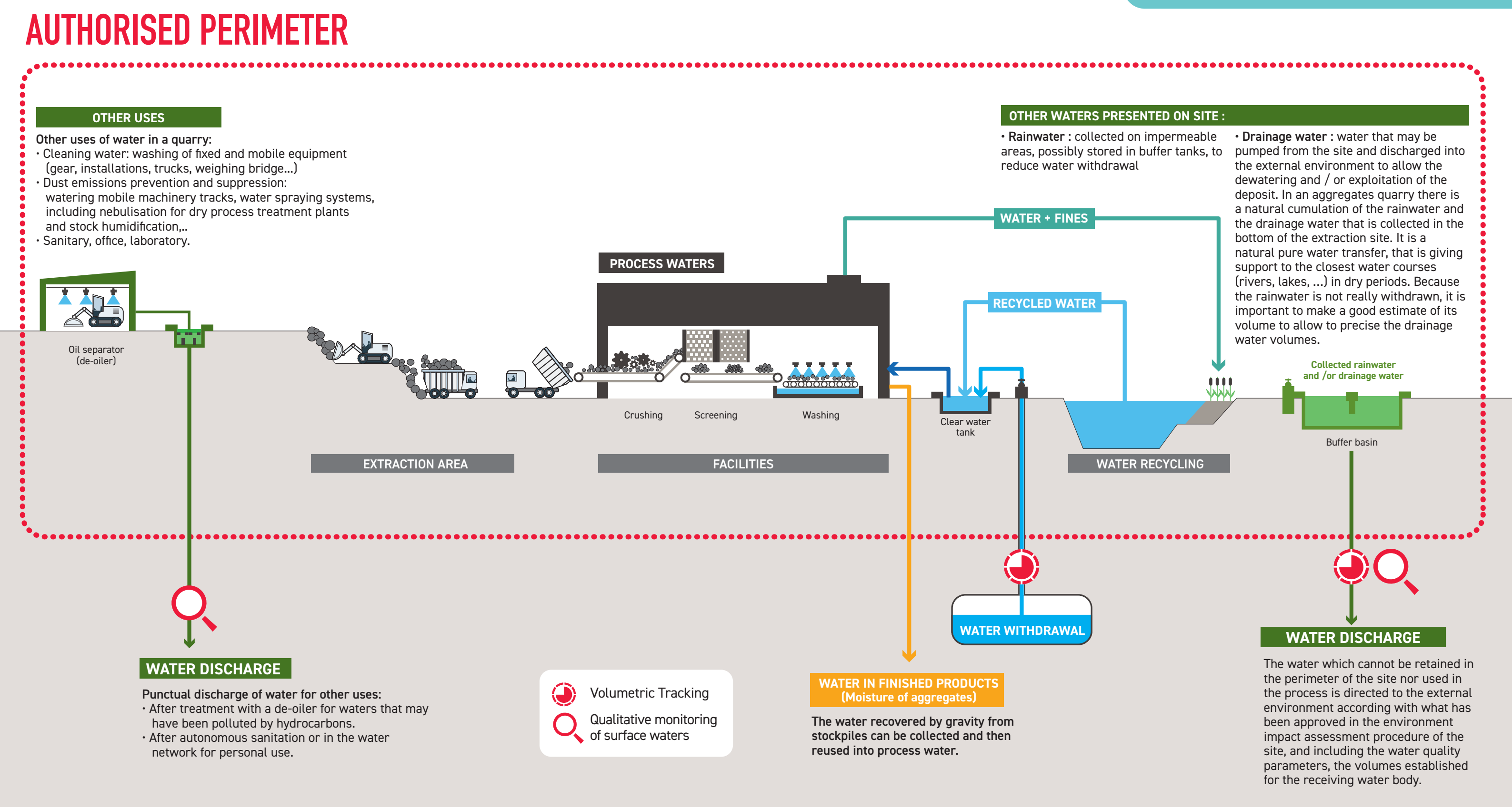
Producing aggregates in wet processing is normally done in a closed circuit, meaning that the most common way to employ processing water is to re-use it. This operation is combined with restoration, refilling extraction holes with the sludge generated.

According to the Aggregates Europe - UEPG survey (see reference 10), the net water balance by type of source is showing that aggregates sites are making a transfer of water from groundwater and from public / private supply network to surface water courses (rivers, lakes, ...).

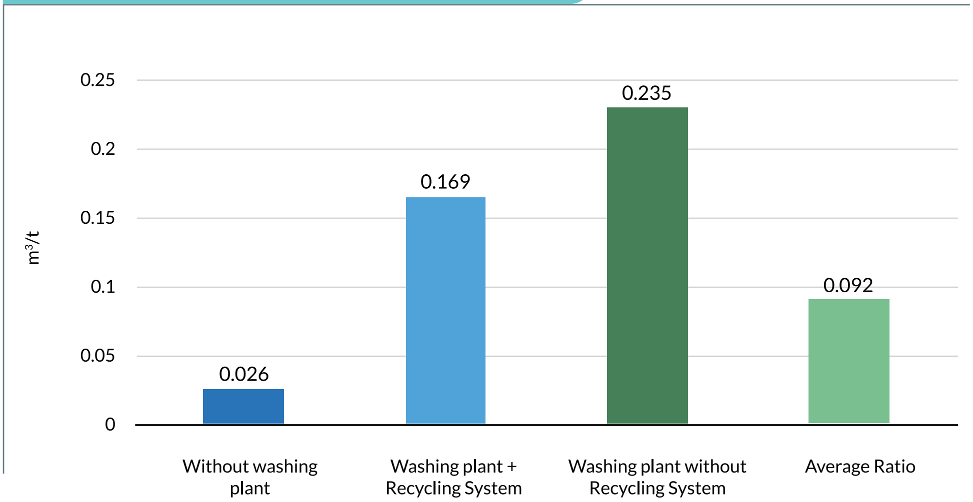
In terms of water consumption, only 19% of water withdrawal is consumed in many different uses on site and 81% is clarified and discharged.

Concerning the specific water consumption by ton of aggregates, it is clear that it is much higher when aggregates are washed. In the absence of a washing plant (52% of the sites), the average consumption is 26 litres by ton. With a washing plant, the average water consumption raises to 169 litres by ton of aggregates.

Water cycle on site – UNPG

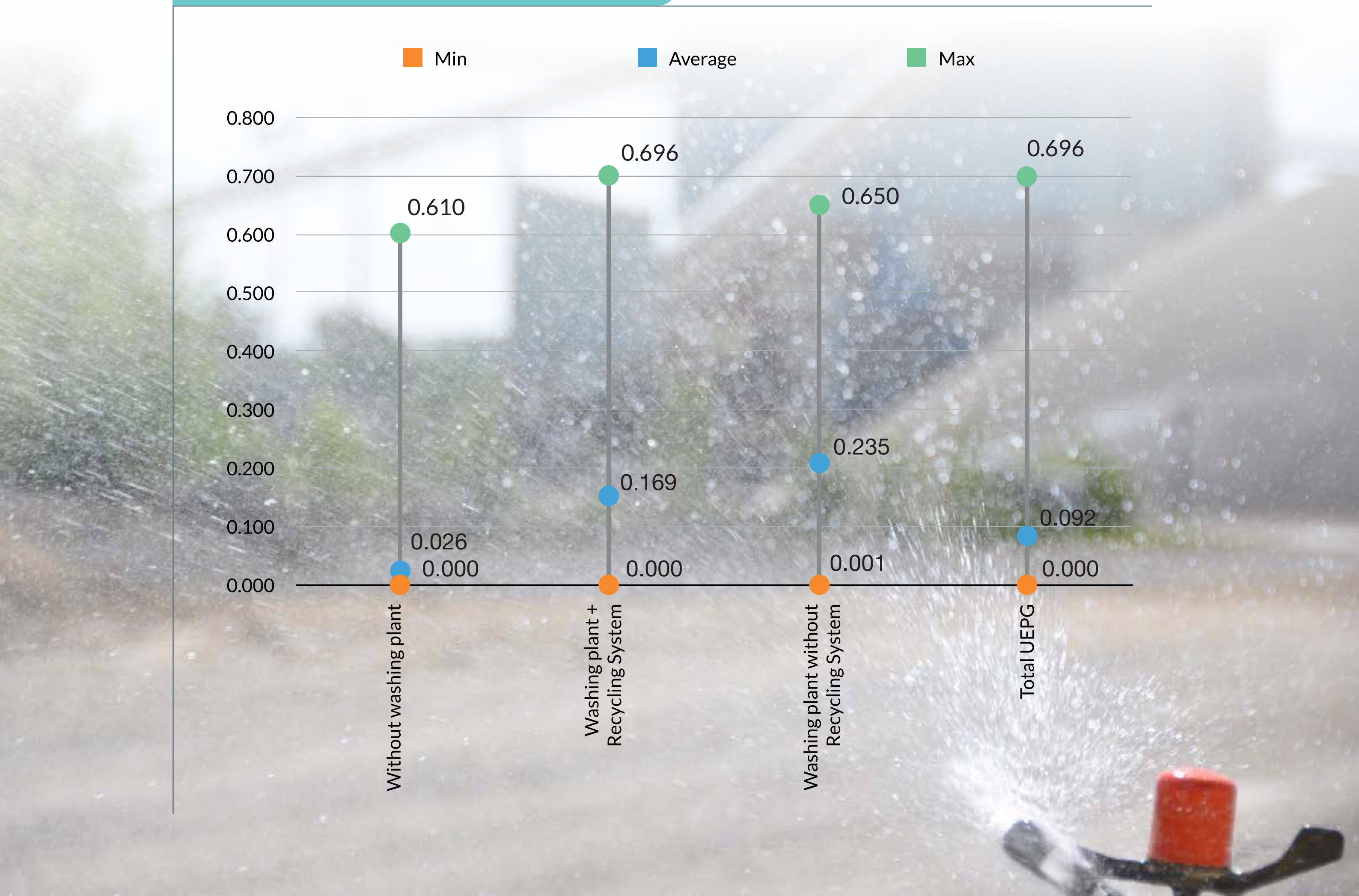


Water consumption in m³ by produced ton of aggregates.
Relationship with washing plant – AE – UEPG



If the washing plant does not have a recycling system, the value is much higher: 235 litres by ton of aggregates. The global average, for this study is 92 litres of water consumed by ton of aggregates (0.092 l/kg).

Water consumption in m³ by produced ton of aggregates.
Relationship with washing plant – AE – UEPG



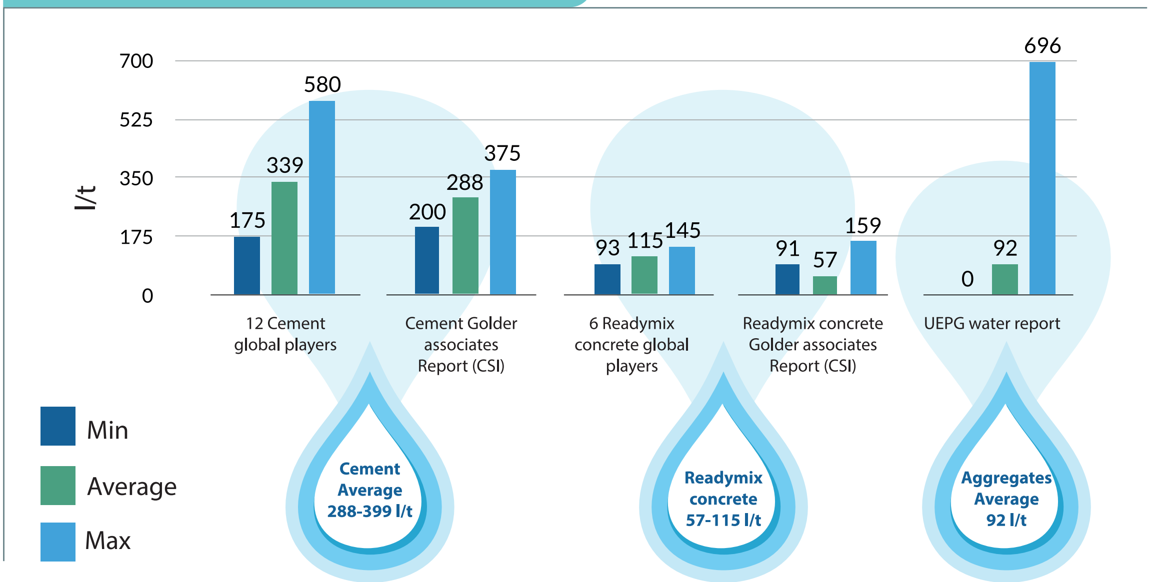
When washing operations are occurring, there is an important variability of water consumption by ton (from near zero to 700 litres by ton).

Water consumption for product manufacturing – Different sources

Compared to water consumed for the production of other common goods, the values for aggregates are quite reasonable as it is shown in the graphic. Nevertheless, water management efficiency always needs to be improved.

Due to the nature of the aggregates production process, it is possible not to consume water in some types of sites. Nevertheless, the variability of the results is showing an important room for improvement in water management.

Water consumption in litres per ton of product for cement, ready-mix concrete and aggregates – Different sources



5.3 Water uses

According to the Aggregates Europe – UEPG survey (see reference 10), water uses are subject to many different factors that are specific of each extraction site:

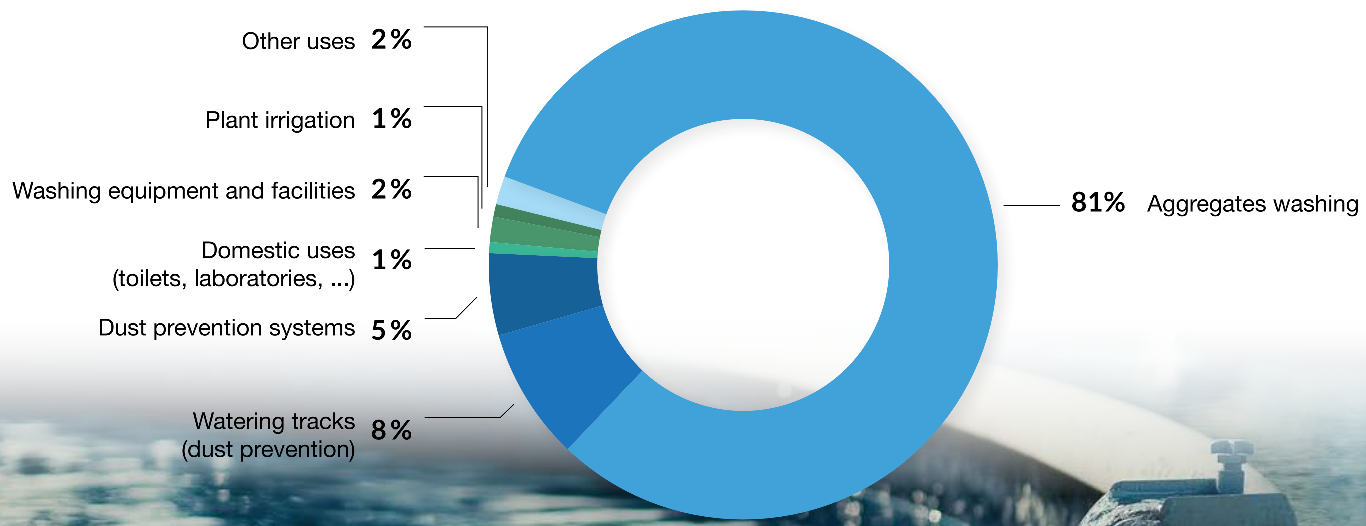
- Type of sites: Wand and gravel pit vs hard rock quarries.
- Type of process: Washing plant or not.
- National influences: Dry / wet weather (dust control + irrigation).

More relevant uses in terms of percentage of sites that are using water for these purposes are: 47% watering tracks (dust prevention); 46% aggregates washing; 40% domestic uses; 37% dust prevention systems; 29% washing machinery; 21% plant irrigation.

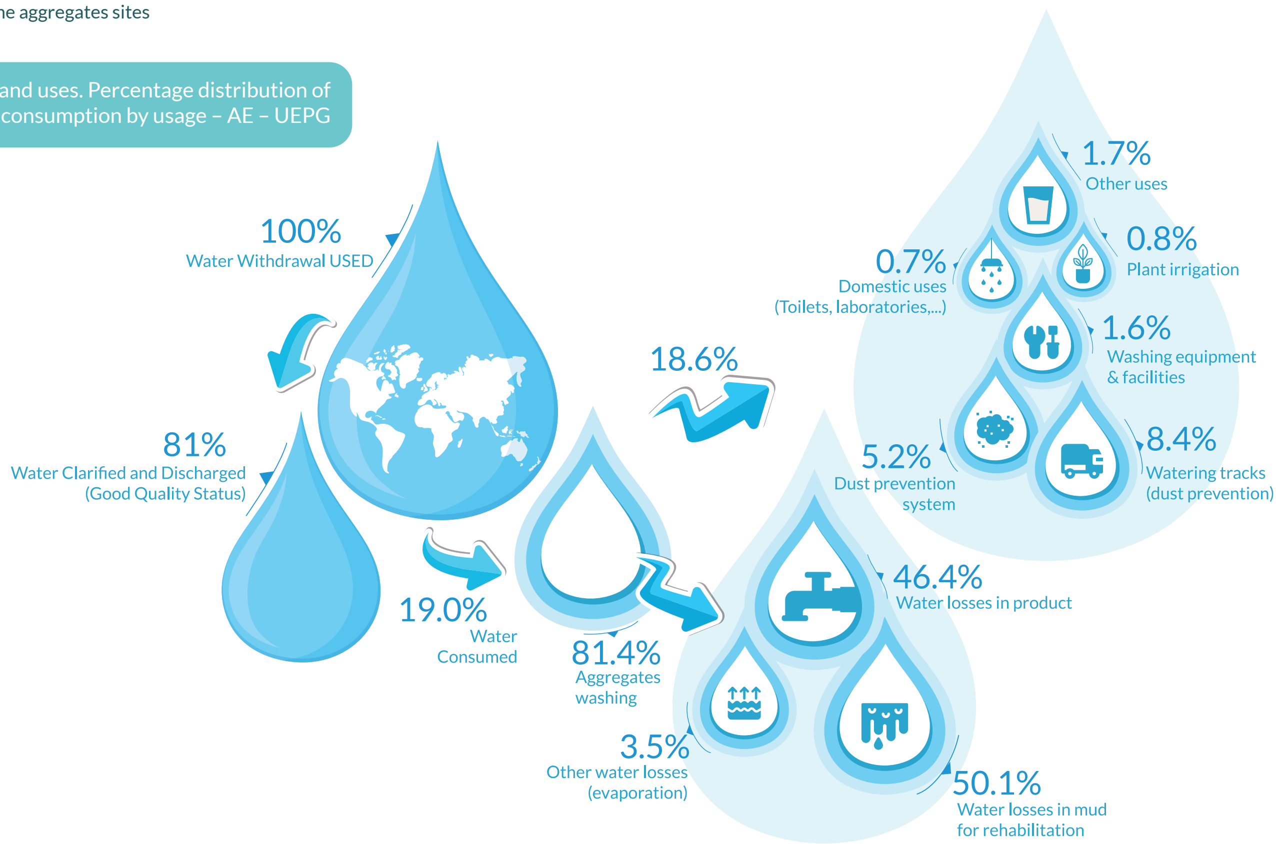
But in terms of volume of water consumed by type of usage, aggregates washing is largely the main one with around 81.4%. This specific water consumption is linked to water losses in products (wet products) with 46.4% of this amount, and with water losses in mud for rehabilitation (coming from water recycling systems) with 50.1% of this particular amount. Evaporation is estimated at 3.5%

Dust prevention is representing 14% (watering tracks (8.4%) and other dust prevention systems (5.2%)). Washing equipment and facilities (1.6%), plant irrigation (0.8%) and domestic uses (0.7%) are other uses not very relevant in terms of water volume.

Percentage distribution of water consumption by usage – AE – UEPG



Water cycle and uses. Percentage distribution of water consumption by usage – AE – UEPG



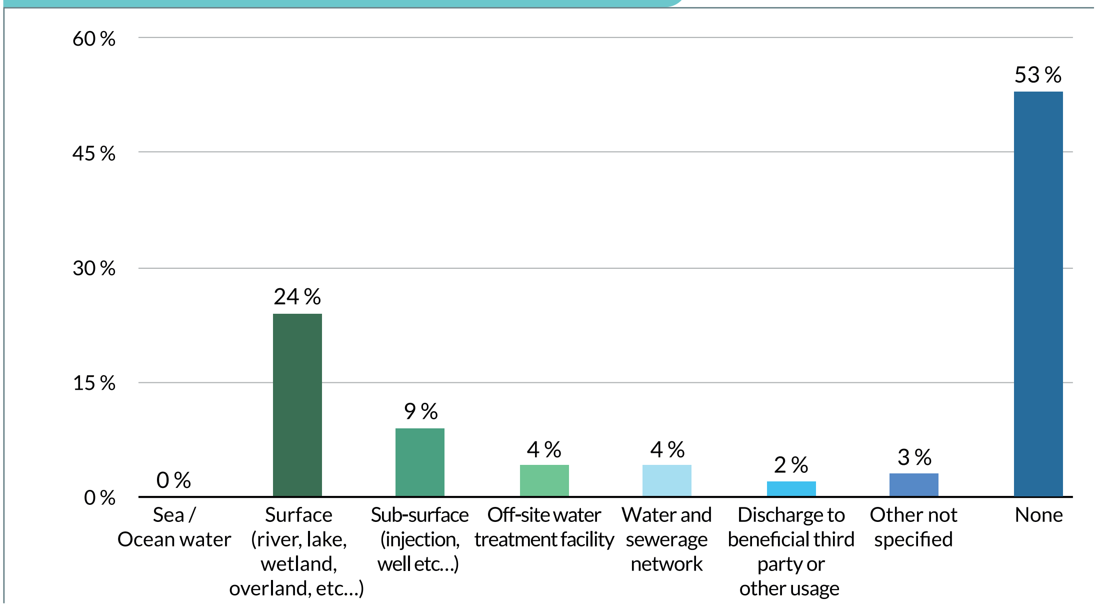
In terms of water consumption, only 19.0% of water withdrawal is consumed and 81.0% is clarified and discharged. The figure above explains the water cycle and uses in the aggregates sector.

5.4 Water discharges

According to the Aggregates Europe – UEPG survey (see reference 10), the main destinations of water discharges are (in percentages of sites): 24% surface water; 9% groundwater. 53% of sites made no discharge of water.

Water discharges, when they exist, are subjected to strict requirements in terms of origin, volume and quality parameters. Depending on national legislation and the specific circumstances of each site, the water discharges from aggregates sites could be limited.

Water discharge by destination (percentage of sites) – AE – UEPG



Looking at the water volume of the discharges by destination, it is clear that surface water (92%) is receiving the huge majority of them.

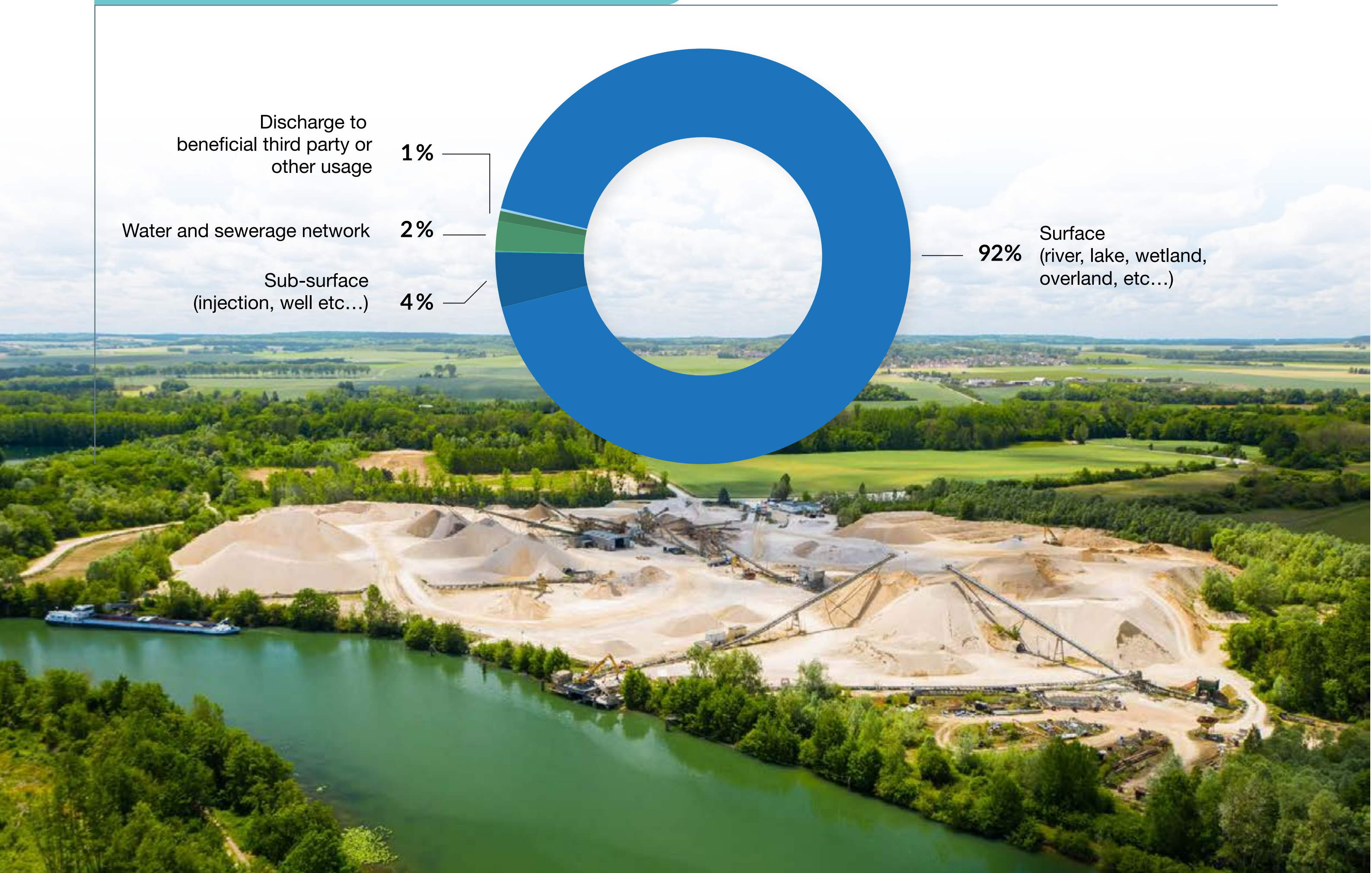
It is important to note that only 4.3% of the discharged water volume goes to groundwater. The remaining portions are directed to the water and sewerage network (2.3%) and allocated to third parties for beneficial use (0.8%).

Discharging into public networks is virtually non-existent[2] and in a small percentage of cases there is discharge into watercourses[3], rivers or streams with the proper authorisation and measures taken to comply with limits on liquid waste emissions. Run-off water follows a similar procedure, whereas waste domestic water is sent to closed deposits which are regularly emptied or benefit from autonomous sanitation via a micro-station. Thus, water discharges, especially from rock quarries often represent low flow support for rivers. In some cases, these discharges can be collected to supply raw water to public networks, as it is the case in the French quarries of the Avesnois-Boulonnais basin.

It should be pointed out that aggregates extraction does not involve the release of hazardous substances and instead it is more a question of temporary modifications being caused to the physical characteristics of the water (which should be avoided and can be prevented) than changes to its chemical composition. This type of effluent does not contain pollutants such as cyanides or heavy metals and their components.

[2] Due to the location of sites.
[3] It requires specific permit in most of EU countries.

Water discharge by destination (percentage of volume) – AE – UEPG



06 Aggregates water management statement

The aggregates industry is responsibly and actively improving water management in quarries and treatment within the framework of the Directive 2000/60/EC.

- Aggregates quarrying is nowadays considered within the current river basin plans (in several EU countries) and, in the case of extractive work on riverbeds, many countries have specific procedures for authorising it.
- Extractive activity is strongly regulated and for which administrative authorisation is required, where consideration is given to the possible unfavourable ecological impact in granting this and appropriate guarantees are required for turning the environment back to normal.
- Our industry is a staunch ally of the bodies from the administration that manage the river basins when it comes to guaranteeing that the watercourse has the capacity to allow floodwaters to pass along it, as appropriate and having the proper authorisation, using techniques such as widening the course or creating supplementary watercourses, cleaning the channel, and building defences.
- Aggregate operations are normally subject to Environmental Impact Studies and complex administrative processing that considers possible effects on surface and groundwater, generally good practices and best techniques are applied in managing it, it being possible to cite, by way of example, here the recirculation of process water, optimising consumption up to very high levels and, in most cases, not carrying out any discharge. For some years now the different Associations have made an enormous effort to bring in these concepts to be implemented by companies in the sector.
- In aggregate quarrying rocks involved are almost always inert and in practice, with a proper management, there is no risk of water being polluted by hazardous substances.
- It should be noted that, as with all natural resources, the location of aggregates is determined by nature itself. This implies that the place where aggregates can be found is where they can be quarried and where the aggregate extraction industry can be located. For this reason and against the backdrop of the development of new River Basin Management Plans, access must be guaranteed to a natural resource such as aggregates are without imposing new restrictions.

The key objectives are to protect existing surface water courses and to optimise the requirements for water extraction through best water management practice. The national regulations specify water quality standards. There is an obligation for operators to comply with.

Sand and gravel pit – La Rinconada site – Hanson Heidelberg Cement – Spain

07 Key principles of water management in aggregates sites

Reused water - Marble quarry – Cehegin site – Various companies – Spain

Taking into consideration the following principles of water management can lead the aggregates operator to be successful in preventing impacts of the activity on water and groundwater:

Key principles of water management in aggregates sites

Prevention of water pollution	Implement water efficiency strategy using water in a rational way	Extraction plan must be sustainable over different hydrological cycles	Implement structural consolidation actions
Deterioration of water quality must be prevented wherever possible and minimised	Water recycling	Once the activity is over, to leave assured the free flow of waters along their course in conditions similar to those originally found	Maintain sludge ponds or reservoirs properly
Measures to control possible spillage of fuel, oils, etc.	Water users within the site must be provided with water of a quality as poor as possible	Control underground water levels as well as the quantity and quality of refill flows for aquifers	Protect and maintain the state of the banks of watercourses that border onto the site
Not to dump slime from washing into rivers	Losses of water and consumptive use of water must abe minimised	Avoid making variations in the course of water in aquifers and remove leakage seepage points	Ensure watercourses are protected and erosion is limited
	Offset and detect leaks	Set up a drainage network for water	Control the stability of extraction waste and quarry backfill

- Ensure that all possible opportunities for the prevention of water pollution have been identified and applied.
  - Deterioration of water quality must be prevented wherever possible and minimised where complete prevention is not possible.
  - To establish measures to control possible spillage of fuel, oils, etc., always use collection pans when the handling of such supplies is done and have anti-pollution kits in sufficient quantity (absorbents, floating socks, etc.) in sensitive zones close to watercourses and policed zones.
  - Not to dump slime from washing into rivers, storage only in settling ponds set up beforehand so that the solids settle and the water floats.
- To implement water efficiency strategy using water in a rational way and avoid using it improperly and wasting it, which also contributes to operating savings, especially for energy:
  - To promote water recycling for jobs such as watering down tracks and vegetation, cleaning the plant, etc.
  - Water users within the site must be provided with water of a quality as poor as possible (but good enough) that it does not cause significant user, water quality, product quality or process related problems.
  - Losses of water and consumptive use of water must be minimised.
  - To maintain the installations properly to offset and detect leaks.

- The extraction plan must be sustainable over the life cycle of the quarry or sand and gravel pit and over different hydrological cycles:
  - Once the activity is over, to leave assured the free flow of waters along their course in conditions similar to those originally found.
  - To control underground water levels as well as the quantity and quality of refill flows for aquifers where these might be affected by extractive activity.
  - To avoid making variations in the course of water in aquifers and remove leakage seepage points.
  - To set up a drainage network for water, wherever it comes from, on the site and in the treatment plant, on circulation routes and in the aggregate's storage area; the digging perimeter ditches makes possible the recovery of rainwater while improving traffic safety conditions.
- To implement structural consolidation actions:
  - To maintain sludge ponds or reservoirs properly.
  - To protect and maintain the state of the banks of watercourses that border onto the site.
  - To ensure watercourses are protected and erosion is limited.
  - To control the stability of extraction waste and quarry backfill.

In addition to the measures listed above, to ensure proper water management that is used in the process there should be guarantees of a system for it to recirculate to achieve better results in water consumption and withdrawal.

One of the systems for collecting and treating sludge that might be generated is using settling ponds or reservoirs, which come in several different types. This system makes use of the quarrying pit in such a way that the water used filters through and subsequently, by means of collection systems, the clean water emerges again to go on to be reused. The sludge produced can be left in place forming wetlands, taken away to be treated and reused in the restoration phase or to be sold as by-product.

To improve the efficiency of process water recycling, other options are based on flocculants[4] treatment systems: the sedimentation process is accelerated to concentrate the fines in suspension and obtain clarified water. Such installations generally make it possible to achieve process water recycling rates of around 80% (especially depending on the types of clay present in the deposit).

It is becoming more and more common that after a clarifier, the thickening of the sludge is carried out by filter presses or centrifuges (when the fines are not abrasive). The aim is to dry the sludge produced in the process and thus manage to reduce its volume and thereby recover almost all the water used in the process (>90% recycling efficiency).

The special conditions of each site (type of deposit, nature of the rocks extracted, water chemistry, hydrogeology, etc.) will in any case be what determinates which of the measures set out above should be employed, as not all of them complement each other or can be applied simultaneously. Whatever the case, the best practices should be selected by the aggregates producer so as to ensure the aims set out are achieved.

Flocculants dosage facility – Sand and gravel pit – Various companies - Spain

[4] According to suppliers' technical information, flocculants are inert and the expected concentration in water effluents is very low.

08 Water quality management

8.1 Measurement of effluents in the aggregates industry

The control of water discharge quality parameters is not always necessary nor compulsory.

Both national and European regulations have established emission limit values for water discharges.

It is noted that the specific emission limit values will be determined by the nature of the treated effluent to be discharged and the receiving surface waters. These limits will normally be specified in the conditions attached to the associated Discharge Licence.

When authorised dumping exists, flows have to be controlled as does the quantity of effluent, pursuant to the conditions of the authorisation so as to determine whether the ceilings in values are being respected that are laid down in regulations.

According to the Aggregates Europe - UEPG survey (see reference 10), 41% of the sites in this study do not have water discharges. Other sites discharge to underground or to external wastewater facilities. That explains that only 18% of total sites do measure the quality parameters in their discharge. Considering the sites with water discharges, 28% are controlling it. Two thirds of the sites (66%) with water discharges to surface courses are taking care of their water quality parameters.

The total suspended solids particles (TSS/TSP) are the most common element in effluent from aggregates treatment plants from quarries and gravel pits.

Most often, the following parameters should be considered (withdrawals and discharges):

- pH.
- Solids in suspension, TSS (Total Suspended Solids).
- B.O.D. (Biological Oxygen Demand).
- C.O.D. (Chemical Oxygen Demand).
- Temperature.
- Colour.
- Hydrocarbon.

In very few cases other substances like Ammonium, metals and conductivity are measured. In the aggregates industry, the risk of water contamination from persistent pollutants such as Per- and Polyfluoroalkyl Substances (PFAS) is very limited, as their use is minimal and is progressively decreasing.

Next table shows a general good chemical status of discharged water.

The conclusion of the study is that with a good water management, this should not be an issue for aggregates sites.

Water discharge quality parameters – Aggregates Europe – UEPG

	WATER DISCHARGE QUALITY PARAMETERS					
	pH	Total suspended solids (TSS)	Biological Oxygen Demand (BOD)	Chemical Oxygen Demand (COD)	Other (Ammonium)	Other (Conductivity)
Min	7.0	<2	<5	5	1.0	
Max	11.1	310.0	35.0	340.0	<5	
Average	7.9	42.0	11.8	65.5	1.3	627.1

8.2 Piezometers network

Another methodology to ensure that quarries operate as safely and as productively as possible is continuous and ongoing monitoring of the water bodies within and adjacent to the site, especially in terms of their water level, flow direction and quality. The main instrument used for this purpose is the piezometer.

Piezometers determine the status of bodies of water by measuring the height to which a column of water rises against gravity. They also allow pumping to collect water for analysis. These instruments collect vital data about the status of accumulated water in the site, and especially any potential changes that may increase operating risks.

Data collected by an array of piezometers deployed throughout a site makes it possible to establish underground flow maps that can guide engineers, help them spot potential risks developing, and then deal with them efficiently while they are still easily manageable.

Control points can be prepared in strategic places around the site to control the influence of the site on groundwater, when needed.

8.3 Digitisation and Artificial Intelligence for water management

The use of digital tools and artificial intelligence (AI) is transforming water management in aggregates quarries, enhancing efficiency, sustainability, and regulatory compliance. Advanced sensors, IoT (Internet of Things) devices, and AI-powered analytics allow real-time monitoring of water levels, quality, and flow rates in extraction sites. These technologies enable quarry operators to detect leaks, optimize water use, and predict potential water-related risks, such as flooding or contamination. AI-driven models can analyse historical and real-time data to forecast water demand, ensuring optimal allocation and reducing unnecessary extraction from natural sources.

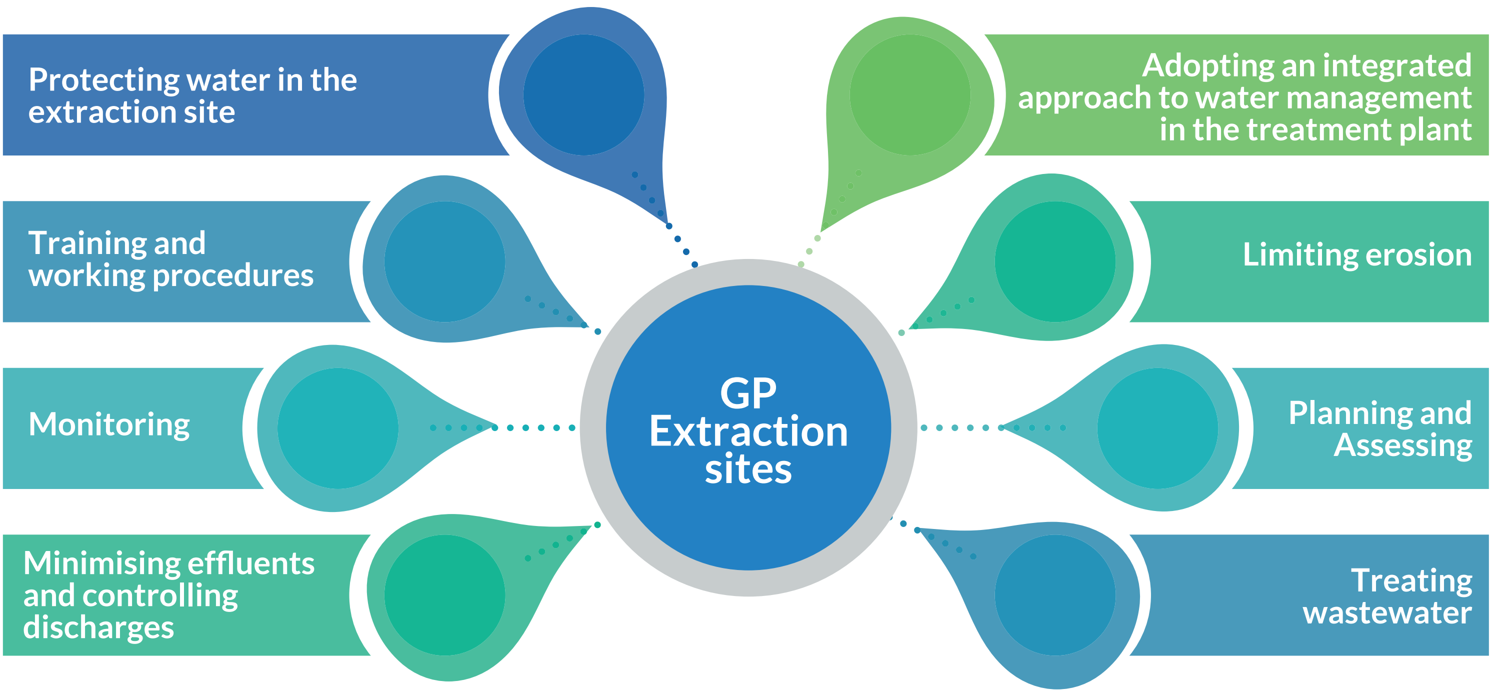
Furthermore, AI-powered systems facilitate automated decision-making, helping quarry managers comply with environmental regulations by maintaining sustainable water usage. Remote sensing and satellite imagery provide detailed insights into water bodies, helping prevent overuse and minimizing ecological impacts. Machine learning algorithms can also enhance water recycling efficiency by optimizing treatment processes, reducing reliance on freshwater sources. By integrating these digital solutions, quarry operators can achieve cost savings, improved operational safety, and reduced environmental footprints, contributing to a more sustainable and responsible extractive industry.

09 Good practices in water management in aggregates extraction sites

The process water circuits of the aggregate treatment and washing facilities are designed for recycling. The water from the washing process of the materials is charged with fine mineral inert particles. These waters are recycled by natural decantation, or any other appropriate method described in the impact assessment, in accordance with the legislation.

Being consistent with the key principles referred to in chapter 7, the following good practices could be implemented by aggregates operators in the extraction site, in order to prevent or minimise the effects of the activity on groundwater and surface water.

Good practices in water management in aggregates extraction sites



The specific circumstances of the extraction site – size, place, geology, etc. – will lead to select the more useful and suitable good practices to be applied for each case:

- Planning and Assessing:
  - Plan to minimise potential problems as well as to meet authority conditions.
    * Effluent treatment systems should be designed, constructed, and maintained in accordance with the existing regulations of the country.
- Optimise the location and extent (plan area and depth) of the workings to ensure that there is no significant impact on groundwater resources.
- Where applicable define and assess the hydrogeological regime around the quarry and its environs.
- Provide replacement water supplies, where quarrying activity is found to adversely affect local water supplies.
- Design water management system, including dewatering flows, in an integrated way covering:
    * Flow balancing by sumps and pumping.
    * Control of particulates by settlement in sumps and lagoons.
    * Control of water chemistry.
    * Oil and scum removal.
    * Use of water in processing plant and treatment of effluent including vehicle washing water.
    * Containment of spillage from storage and processing areas.
    * Use of water in dust control.
    * Use of appropriate water to counteract groundwater lowering, e.g. In nearby pools.
    * Regular cleaning and maintenance of water system.
- Monitoring:
  - Monitor baseline before design and planning application. Undertake a baseline survey and establish a monitoring system.
  - Monitor during operations:
    * Groundwater levels.
    * Neighbouring abstractions.
    * Quantity and quality of recharge flows.
    * Neighbouring land, crops, ecology for incipient problems.

- Establish surface water monitoring stations both down and upstream of the site, if necessary.
- Training and working procedures:
  - Training the staff on best operational techniques is a very effective way to prevent water pollution.
  - Clear working procedures have to be implemented.
- Protecting water in the extraction site:
  - Control surface water run-off:
    * Minimise obstruction of flood flows by inappropriate placing of mounds of overburden or waste.
    * If it is proposed to store overburden or solid inert waste for restoration purposes, then it should not be stored in the vicinity of watercourses.
  - Provide an appropriate drainage system to minimise surface water run-off into the quarry works.
    * This drainage system has to be designed according with the scale of the site and with its specific conditions.
    * Depending on the conditions a drainage system may not be necessary.

Draining system – FdA – Spain

  - Leave adequate margins/buffer zones around water courses, and other sensitive areas.
    * Maintain effective filtration layers between aquifers.
    * Provide an appropriate buffer zone to ecological habitats that would be affected by any significant change in the groundwater regime.
  - Use of appropriate water recharge or other practical measures, where it is demonstrated that the quarrying activities have the potential to impact on surface water levels in nearby streams, rivers, or lakes.
  - Use codes of practice for temporary sterile mounds and slope stability.
  - Provide for recharge of aquifers and surface water regimes, where necessary.
  - Encase polluting backfill in impermeable material or dilute it with inert fill.
  - Ensure blasting practice minimises the risk of occurrence of nitrate / ammonia residues by proper blast design and implementation, appropriate disposal of any excess explosives and selection of the appropriate type of explosives.
- Limiting erosion by:
  - Rapidly vegetating exposed areas.
  - Vegetating the surfaces of overburden and topsoil mounds.
  - Progressively restoring worked out areas, where practical.
  - Limit areas of topsoil / overburden stripping exposed at any one time.
- Adopting an integrated approach to water management in the treatment plant, including:
  - Implement good practices for the management of cleaning water.
  - Secure a regular cleaning and maintenance of the water management system.
  - Provide pollution control measures in relation to fuel and chemical storage.
    * Safety containers to all fuel / chemical storage tank areas. Use spill pallets to store drums of chemicals and oils (including waste oils).

* Impervious bases for oil / chemical stores and wet process plant.
* Spillage control equipment on site (booms and suitable absorbent materials, etc.) to contain any accidental spillage.

Anti-pollution kit for machines – UNICEM (D. Collonge)

* Ensure all surface run-off from areas used for refuelling is directed to an appropriately sized hydrocarbon interceptor prior to discharge.
* Where practical provide closed water systems to reuse process and mobile equipment or wheel wash water and conserve water resources by abstracting water for 'top-up' only.

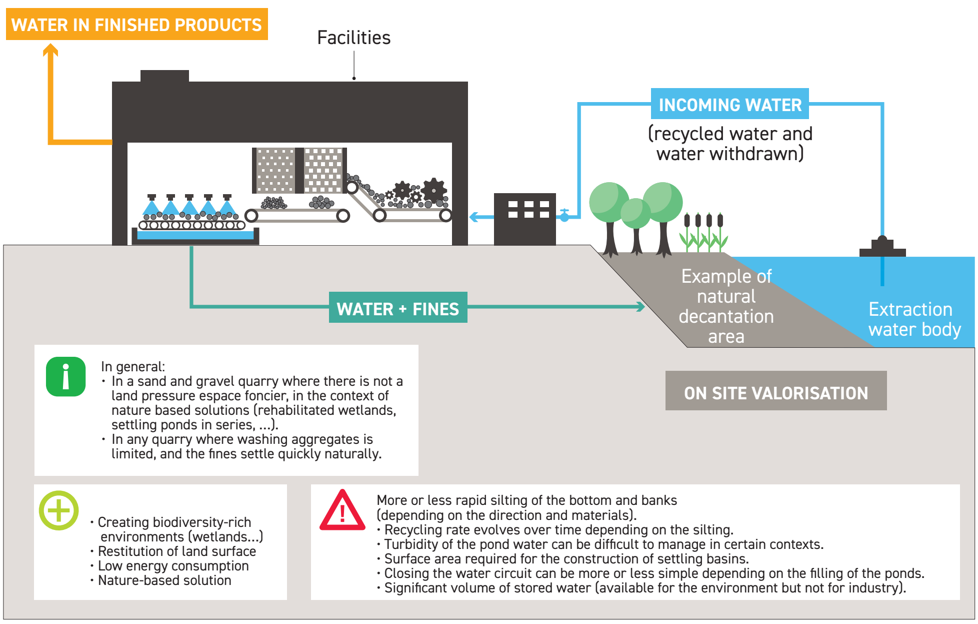
- Optimise use of water in dust suppression / control systems.

- Treating wastewater by:
  - In sites with high concentrations of suspended solids and limited space for settlement lagoons, forced solid separation methods using thickening tanks should be employed.

Thickening tank and press filter – Sand and gravel pit – Terrassa site – Haymsa – Spain

Natural decantation by gravity – UNPG

NATURAL DECANTATION BY GRAVITY



- Design excavation voids and ponds for wastewater clarification and suspended solids decantation to cope with all reasonable anticipated conditions, by ensuring that:
  * They are adequately sized.
  * The retention time is adequate, and if necessary, enhancing settlement by use of flocculants or mechanical means.
  * Excavation voids are adequately sealed with an impermeable material.
  * Regular cleaning and maintenance can be carried out.
- Control of by settlement in sumps and lagoons.

• Minimising effluents and controlling discharges:
- Obtain a discharge licence for any discharge of treated effluent to groundwater or surface water courses.
- Where a discharge licence is required, undertake a surface water quality baseline study to assess water quality in the receiving surface waters.
  * Undertake an aquatic survey where discharge of effluent is to surface waters.
- Consider not dewatering or, if unavoidable, dewatering progressively in cells and reduce the inflow of water by sealing.
- Provide appropriate location for discharge of groundwater (where this is being dumped and not re-used).

10 Good practices in water management in aggregates treatment plants

10.1 General description

Water management in the aggregates production process can be handled using one of the following systems:

- Optimise use of water in processing plant and treatment of effluent including vehicle washing water.

Good practices in water management in aggregates treatment plants

Optimise use of water in processing plant and treatment of effluent including vehicle washing water	Other
Settling systems	Making a study of the dumping point, where this exists
Recycling systems	Regular supervision of water quality (processing and dumping)
Drying system	Mobile fuel tanks double skinned
Waste spillage prevention systems	**Water reuse plan** Minimise the consumption (or purchase) of good quality water Minimise the pollution effect of the site and its impact on the surrounding environment. Minimise water losses from the water reticulation system and maximise reuse opportunities. Save cost
Treatment	
Substance replacement	

TECHNIQUE	TECHNICAL SPECIFICATIONS	OBSERVATIONS
SETTLING SYSTEMS	Solids in suspension are settled in ponds or small reservoirs (under 2 m high).	This is the most widely used system in the sector. Require careful study of volumes for dimensioning.
	The solids in suspension are settled in settling tanks (containing flocculants).	Require careful study of volumes for dimensioning.
RECYCLING SYSTEMS	Closed circuit with transfer to tanks from where pumping takes place.	Water recycling Decrease in specific consumption of new water per ton.
DRYING SYSTEM	Drying of sludge settled using press filters or centrifuges which cakes up and can be removed or reused.	Water content < 25%.
	Filter band presses.	Rarely used. High flocculants consumption Higher maintenance cost.
WASTE SPILLAGE PREVENTION SYSTEMS	Protected tanks for hydrocarbons and other lubricating materials, etc.	Holding pans for spillages.
	Protected area for maintenance work, washing and fuel supply.	Hydrocarbons separator.
TREATMENT	Chemical treatment of water if there is a change in its quality (acid quarry drainage, etc.).	Not common as this is not normally an issue.
SUBSTANCE REPLACEMENT	Replacing traditional hazardous lubricant substances.	Increasingly more commonly found. Encouraged by equipment manufacturers.

Thickening tank – Sand and gravel pit – Valdocarros site – Tramsa – Spain

Pumping system for cleaned water – El Porcal site – Aripresa – Spain

Other aspects to bear in mind are those described below:

- Making a study of the discharge point, where this exists.
- Regular supervision of water quality (processing and dumping).
- If oil storage or dispensing is proposed then details of the management of fuel, oils, lubricants, and hydraulic fluids, including fuel transport and dispensing, use of mobile fuel pump, storage, bounding of fuel tanks, off site maintenance of vehicles, and emergency provisions should be submitted. The type of fuel storage facility should be designed such that it is self-bounded, including the hoses, and stored in a secure compound to avoid vandalism. Mobile fuel tanks should be double skinned and with all pumps and hoses contained. All vehicles and plant should be regularly inspected, with particular emphasis on hydraulic hoses, for fuel and oil leaks. An oil spill kit (absorbents, floating socks, etc.) should be maintained on site in sufficient quantity.

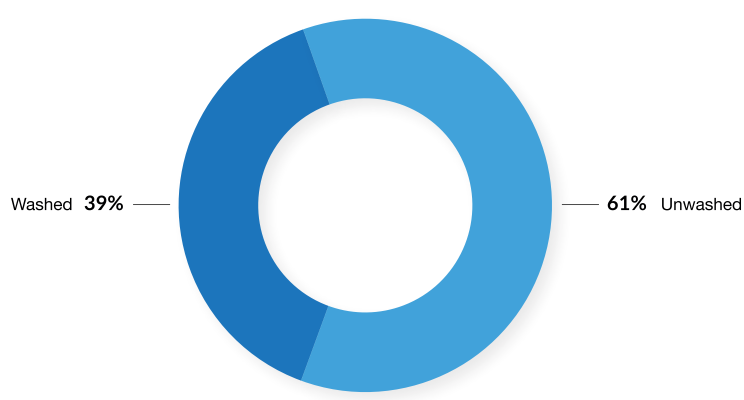
A water reuse plan is a very important good practice leading to a better water management: The development of water reuse and reclamation plans is typically undertaken for one or more of the following motivating reasons:

- To minimise the consumption (or purchase) of good quality water from outside (from a water service provider or from a water resource).
- To minimise the pollution effect of the site and therefore its impact on the surrounding environment.
- To minimise water losses from the water reticulation system and maximise reuse opportunities.
- To save cost (water pricing and waste discharge charges will often drive this).

10.2 Estimation of the use of the good practices

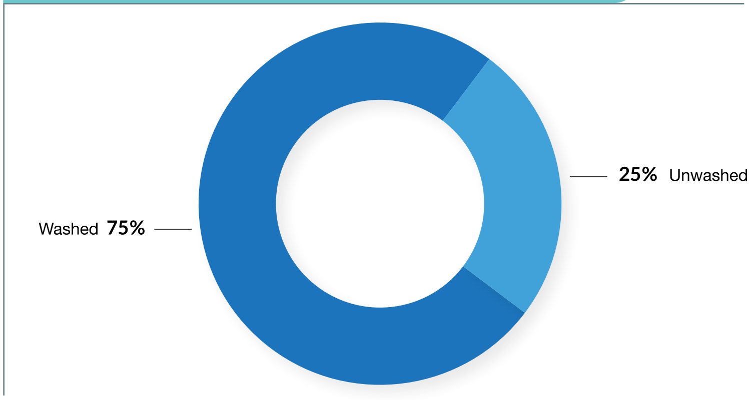
According to the Aggregates Europe - UEPG survey (see reference 10), 39% of the aggregates production is washed to separate inert fines and clays, to obtain high quality products meeting legal technical requirements for the different end uses.

Percentage of washed production relative to total production – AE – UEPG

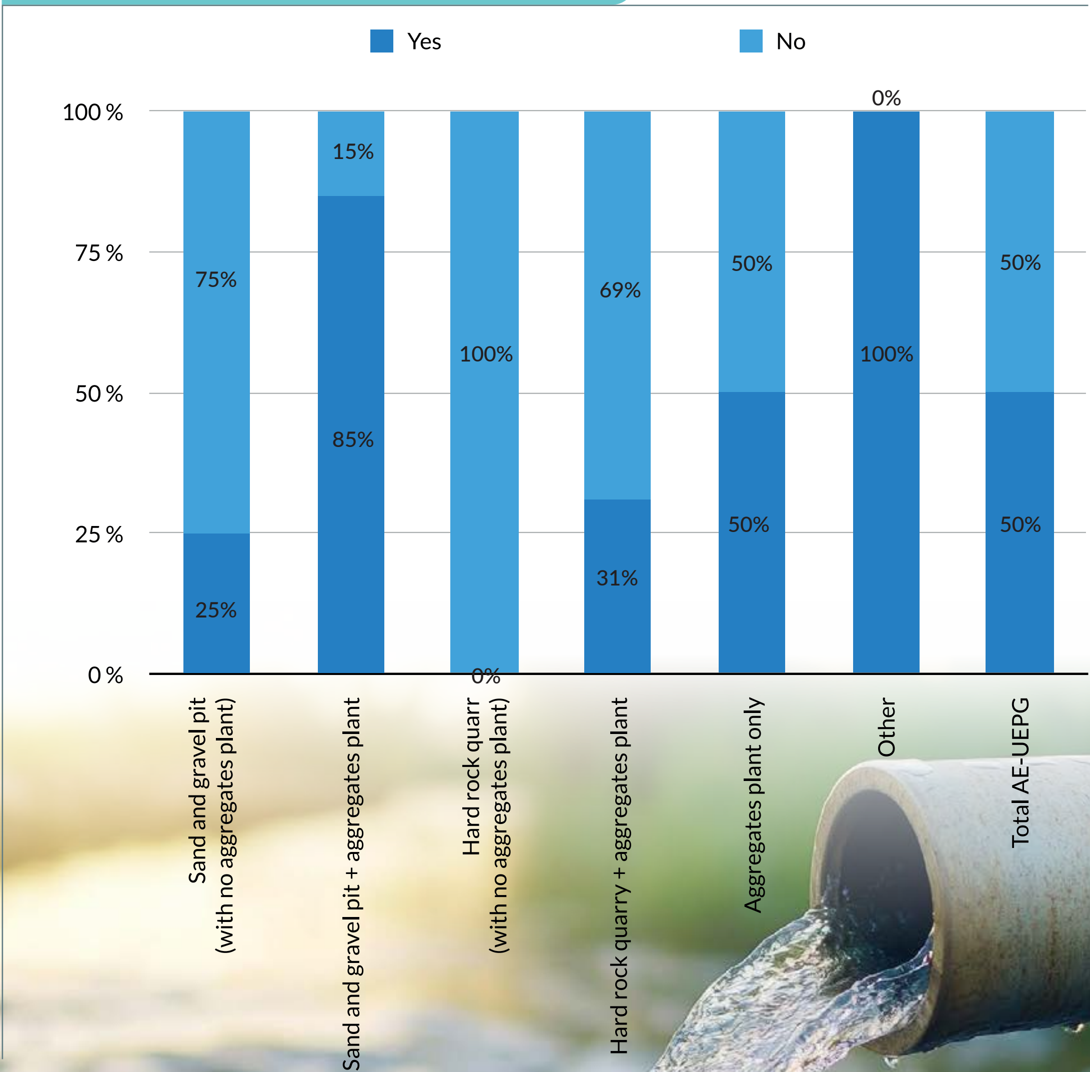


For those sites with washing plants, the majority (75%) of the production is washed, while 25% does not need to be washed.

Percentage of washed production relative to production of sites with washing plants – AE – UEPG

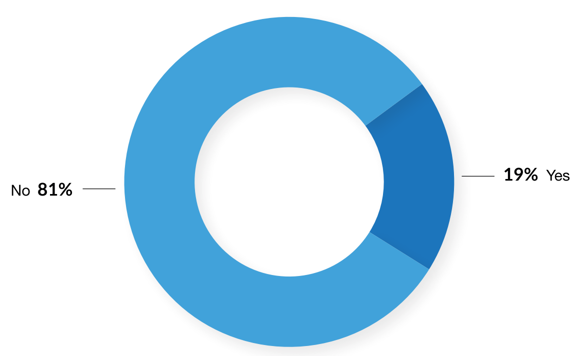


Percentage of sites with washing plants categorized by site type – AE – UEPG

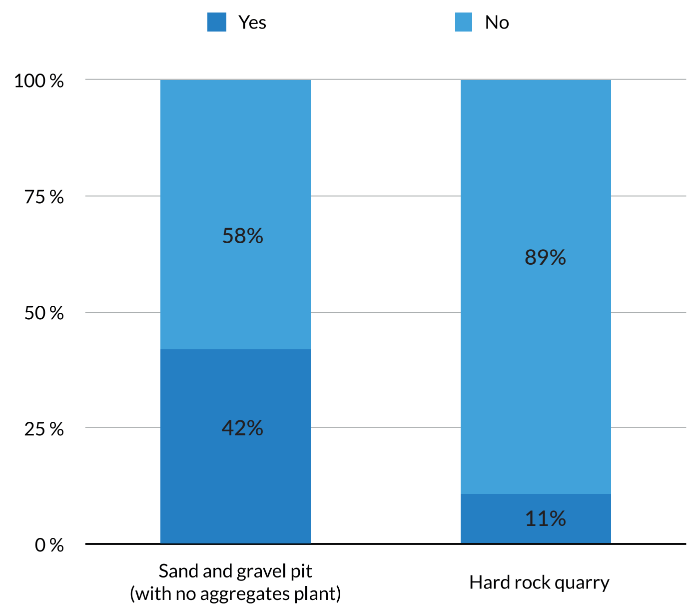


The vast majority (98%) of sand and gravel pits have washing plants while about 1/5 (21%) of hard rock quarries have it. There are slight differences between countries.

Percentage of sites with water management plans– AE – UEPG



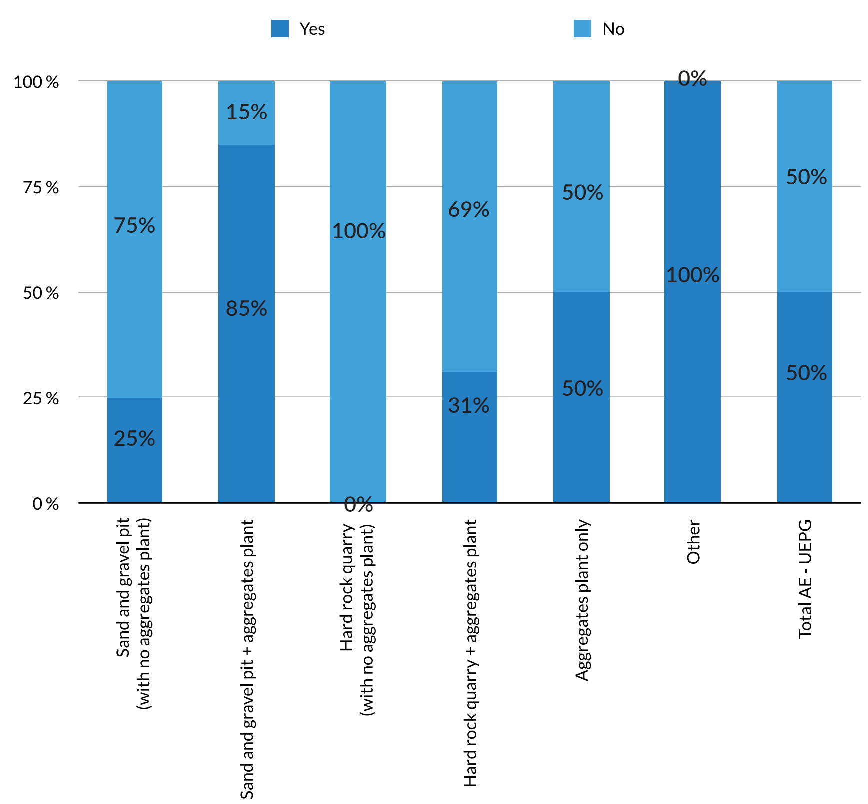
Percentage of sites with water management plans categorized by site type – AE – UEPG



19 % sites have developed water management plans on a voluntary basis, to even improve the efficiency of the process. Those figures increase to 32% when washing systems are in place. 42.4% of sand & gravel pits have water management plans, while this is happening in 11.3% of hard rock quarries. Again, there are not relevant differences between countries.

That is showing clearly that water issues are much more relevant for sand and gravel pits than for hard rock quarries.

Percentage of sites with water recycling systems – AE – UEPG



About 50% of the aggregates sites have water recycling systems: around 85% of sand and gravel pits and 1/3 (31%) of hard rock quarries.

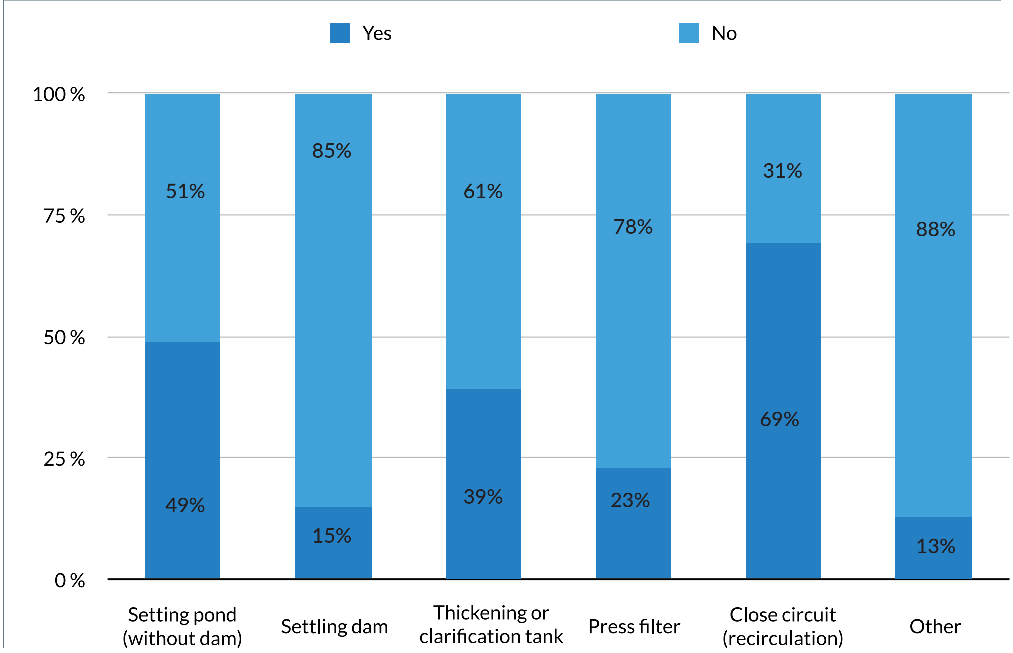
In the sites with recycling systems most common elements are close circuit (recirculation) (69%) and settling ponds (49%).

The average recycling ratio (87.6%) is high. Systems in place in sand and gravel pits are more efficient (90.7%) than those in place in hard rock quarries (79.2%).

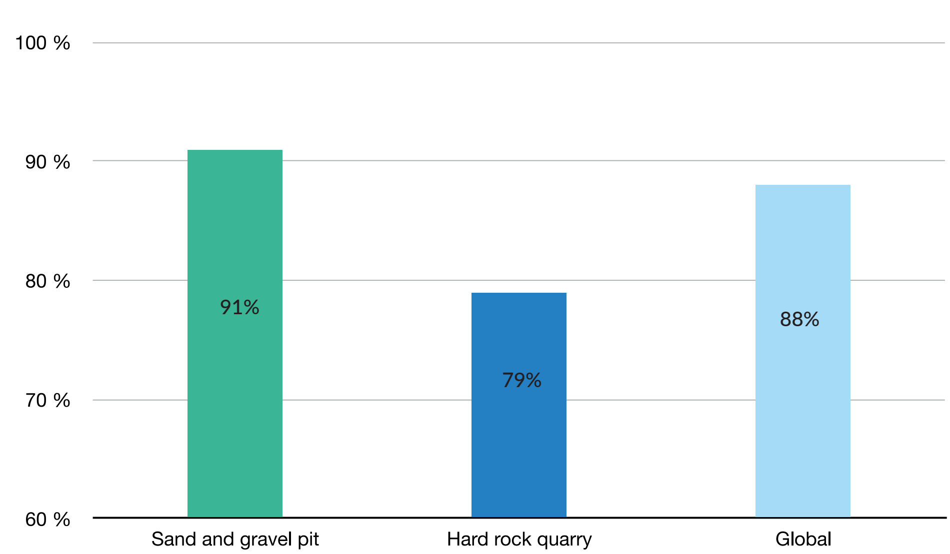
The recycling ratio between countries is quite similar (93.8% - 82.5%).

There are not many differences of efficiency between recycling systems in place (92% - 82%).

Percentage of elements of the water recycling systems– AE – UEPG



Average recycling rate based on implemented water recycling systems – AE – UEPG



11 Wastewater treatment

A type of waste that is often associated with treatment processes in aggregates sites that feature the washing of inert matters clays, is wastewater with suspended inert particles like clay, mud, sludge.

This type of waste is also produced in the form of liquid, pulp, or slurry due to other operations such as the collection of water from:

- Drain and waste-pipe networks for surface and underground water.
- Treatment plant and equipment cleaning systems.
- Treatment and finishing systems for end products.
- Transport systems for the mineral resource.

Such water is collected and processed, normally using the following systems, either separately or in combination with several others:

WASTEWATER TREATMENT

- Settling pond or reservoir using natural sedimentation
- Settling pond or reservoir using forced sedimentation
- Forced sedimentation cell
- Thickening or clarification tank
- Press Filter
- Flocculants

WASTEWATER TREATMENT AND COLLECTION SYSTEMS	Settling pond or reservoir using natural sedimentation	Settling pond or reservoir using forced sedimentation	Forced sedimentation cell	Thickening or clarification tank	Press Filter
Washing sludge	x	x	x	x	x
Drainage and waste-pipe networks for surface and underground water	x				
Systems for cleaning the treatment plant and equipment	x	x	x	x	x
Systems for treating and finishing end products		x	x	x	x
Transport systems for the mineral resource	x	x			

11.1 Description of the washing and classification equipment

Different equipment in the treatment plant is used for washing and classification to separate the washed sand and gravel from the pulp fraction (wastewater and sludge and mud). The combination between them depends on the specific composition of the aggregate, of the clay and fines in the pulp and also depends on the design of the wastewater circuit. These equipment are:

- Washing drums (scrubbers) are commonly used for the vigorous washing of rocks, gravels, and minerals with coarse grain-size distribution, as well as for the preparation, homogenization and scrubbing of materials which will be later treated by wet process.

Washing drums

- Log washers are indicated to liberate hard plastic clay, friable soil and soft materials from coarse aggregates and rocks not exceeding 75/100 mm size. The main feature of this equipment is the twin shaft fitted with replaceable abrasion resistant paddles to encounter the toughest duty.

Log washer in operation

- High frequency and conventional screens. This type of equipment is indicated for the fine classification of materials by means of inclined vibration screens and high frequency screens available in various models.

Diverse models of high frequency screens for precise sorting process

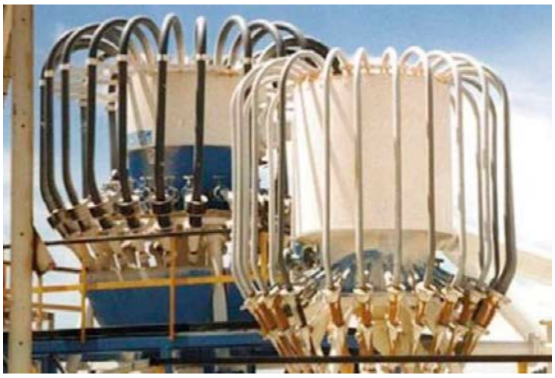
- Dewatering screens are similar equipment to conventional screens though its screen panel bottom is arranged in a soft upward slope towards the discharge end. They are applied for sand dewatering, to obtain constant final moisture of dewatered sand and to filtrate very fine products.

Dewatering screen – Gravel dewatering and filtration of fine materials - Montpouillan - France

- Hydro cyclone compact plants have been designed for the efficient operation of sand washing and classification, as well as for other process treatment, such as fines and ultra-fines recovery and to obtain production of two sands. Its compact design enhances remarkable advantages to the final user, namely: quick assembly, easy operation, low-cost maintenance and reduced occupying space.

Integration of two cyclones for washing and classification processes in a quarry site

- Hydro cyclones designed for fines and ultra-fines recovery either in self-supporting construction of polyurethane or polymers or in mild painted steel shell construction with liners in different types of natural rubber in accordance with application. Its modular system enables the exchange of parts between different types and sizes of hydro cyclones, providing quick and easy replacement.



Hydro cyclones – Fines and ultra fines recovery – Readily replaceable modules

- Sieve bends can be no-motion or high frequency vibration types, specially designed to achieve fine classifications between 0,25/2 mm. Main applications: silica sand and concrete sands, industrial minerals sizing and pre-dewatering equipment in miscellaneous applications.

Operational sieve bend – Effective classification of fine materials

- Hydro classifiers. There are two common types: The one-cell equipment is used for the up-stream classifying of materials in the range 0,2/2 mm, in which sand particles followed a vertical track. The multi-cell equipment is applied to obtain several particle size materials, which they settle following a parabolic flow.

Hydro classifier – Process for aggregates

- Other equipment in aggregates plants:
  - Waterwheels are used for washing sand and have a low efficiency. Frequently used in the past, they are now substituted by more efficient systems.

Waterwheels. Largely replaced by more efficient alternatives due to their limited performance

  - Spiral classifiers, not very common in aggregates treatment plants are suitable for the separation of fine particles and liquid from coarse particles.

Spiral classifier – Seldom used in the aggregates industry.

11.2 Description of wastewater collection and treatment systems

11.2.1 Settling pond or reservoir

- The pond is usually made by using an excavation pit, for which reason it is not classed as a mineral waste installation. The requirements for authorisation of these are in proportion to the normally low risk they present.
- Reservoirs are actually mineral waste installations. Depending on their features they can

be Category A due to the risks for people and the environment deriving from their sitting and the way they are built. They are subject to more stringent requirements than pit ponds.

11.2.1.1 With natural sedimentation

- They hold larger volumes of water than other options.
- The location of reservoirs and also, though to a lesser degree, ponds, has to be studied carefully and attention paid to:
  - Their shape and estimated size and considering the minimum surface impact.
  - Preventing environmental impact.
  - The geological features of the site.
  - Drainage capacity.
  - Minimisation of transport and dumping costs.
  - Integration with the landscape and, in the case of a permanent structure, later restoration of it.
- The characteristics of sludge and effluent have to be considered in designing the settling reservoir.
- Construction calculations for any installation of this type have to be made thoroughly to ensure it is stable at any time from its initial phase through to when it is abandoned and including its operational phase.
- Safety and security measures are required to guard against unauthorised access or accidental falls.
- Normally the sedimentation period is very long, and it is years before the ponds are abandoned.
- Not a very efficient system as regards recovering water, which implies greater specific consumption and less recirculation.
- The cost of pumping will depend on the relative location of the pond and the point where the sludge is generated, as well as the density of the slurry.
- In general, it is the cheapest system.
- When run-off water or that from the phreatic level is collected, this makes it possible to recycle it for other tasks within the process (washing, sprinkling, cleaning, etc.)

11.2.1.2 With forced sedimentation

- It requires a smaller surface area.

Sludge concrete ponds – Sand and gravel pit – FdA - Spain

- Ponds can be a land pit to be restored, a system of artificial, interconnected ponds requiring sludge to be handled, or they can also be reservoirs.
- Needs lower volumes of water than the previous option.
- Safety and security measures are required to guard against access or accidental falls.
- Flocculants are used to force sedimentation and cut down on the time needed to handle the resulting slurry.
- The resulting slurry has variable water content.
- The time needed for handling the matter is shorter.
- The cost of the flocculants and the machinery to handle the resulting slurry.
- Use of the slurry for restoration work.

Sludge concrete forced with flocculants decantation cells – Sand and gravel pit – FdA – Spain

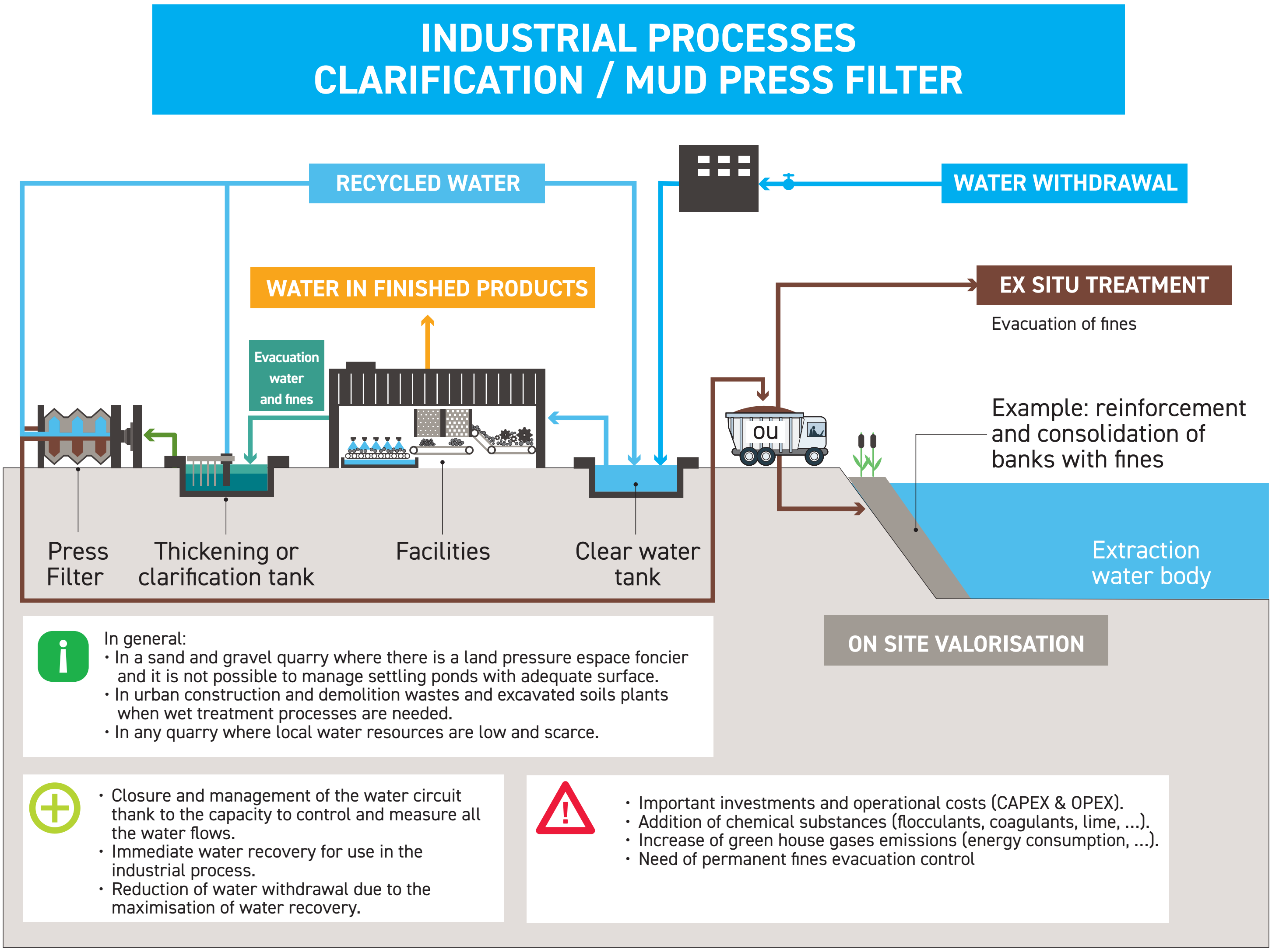
11.2.1.3 Forced sedimentation cell

- A variant of the preceding type, where the additives have a greater capacity for separating the solid from the liquid phase.
- The cell is normally made using an excavation pit or even at ground level and so it is not classed as a mineral waste installation. The requirements for authorising it are in proportion to the low risk they usually present.
- Their design allows the access of machinery to remove the dried slurry.
- The resulting slurry can be removed using a loading shovel in just a few hours.
- Very efficient from the point of view of water consumption.
- The cost of the flocculant and the machinery to handle the resulting slurry are high.
- The slurry is used for restoration works.

11.2.2 Thickening or clarification tank

- The thickeners / clarifiers are highly effective to separate solid/liquid at very high rates and treat wastewater produced in the washing process of sands and minerals. The sludge, clay and fine particles are accumulated in the bottom of the unit, as concentrate slurry, to the point of discharge while the clarified effluent flows continuously through a peripheral launder located in the top of the tank.

Industrial processes. Clarification / mud press filter – UNPG



- The recycled water is directly recovered for the process by the upper perimeter of the tank. Once clarified, the waters are poured by gravity into the lung tank and from there they are sent on to the plant to be reutilised in the process of washing the mineral resources.
- After the water clarification process has finished, and in consequence of it, slurry is formed of concentrated sludge in the depths of the thickener which is dried to convert the slurry into a solid and transportable product.
- This is a treatment and not an accumulation system and is therefore not a waste installation as defined in Directive 2006/21/EC.
- Normally this is preceded by a drainer system.
- Requires a small surface area.
- Requires lower volumes of water.
- Uses flocculants to force sedimentation and reduce the time required for handling the resulting slurry.
- Systems are easy to monitor and optimise the consumption of flocculant by continuously or periodically measuring the clarity of separated water.
- The slurry left over has almost constant water content.
- The recirculated water has more homogeneous characteristics.
- The time needed to handle the slurry is shorter.
- Downstream the tank can be connected to a filter press, a natural sedimentation pond or it can be used directly on restoration according to circumstances.
- Safety and security measures are required to guard against access or accidental falls.
- Greater initial investment but better performance in terms of water and energy consumption.

11.2.3 Press Filter

- Generally associated with a thickening tank.
- The automatic filter presses are being used for the dewatering of sludge generated in the sand washing treatment. The sludge from the thickener underflow is subject to a solid/liquid separation process at high pressure to obtain a cake with low moisture content and reclaim the wastewater. A filter press is used for the sludge drying process. The drying process is used for the thickened slurry to reduce its volume. As a result, it cakes up and the caked products have a minimal water content meaning they are appropriate for using in restoring spent extraction zones.

Filter press – Dewatering sludge and wastewater recovery process

Introduction of different new equipment in washing processes of aggregates: Cyclones, vibration wringers and thickening tank – Sand and gravel pit – Eral – Spain

- Acts by compressing the slurry obtained in a previous phase involving the separation of solid matter and water.
- An easy-to-handle caked product is obtained.
- Almost all the water is recovered.
- Heavier initial investment but better returns in terms of water and energy consumption.

COMPARISON OF WASTEWATER TREATMENT SYSTEMS

TECHNIQUE	TECHNICAL SPECIFICATIONS	COST (10^3 €)		OBSERVATIONS
		INVESTMENT*	OPERATING*	
Settling systems	Solids in suspension are settled naturally in ponds or small reservoirs (less than 2m high).	Variable	Low	Water content ≈ 40% this is the most widely used system in the industry.
	Solids in suspension are settled in settling or clarification tanks (using flocculants).	100-125	Low	Water content ≈ 40%
Closed circuit systems	Closed circuit with transfer by gravity to a thickening tank from where it is pumped on for settling.	Variable	Low	Water content < 20 %
	Drying of sludge settled using filter presses which leave cakes for removal or re-use.	40-50	Variable	Water content < 20 %
Drying systems	Filter band presses.	100-125	High	Seldom used. Very high consumption of flocculants. High maintenance.
	Drying of sludge using chemical additives in chambers. An easily mechanically handled solid mass is formed to be removed or reused	30-50	Medium	Very high consumption of flocculants.

(*) Investment and operating costs depend on the flow to be treated and the characteristics of the sludge.

As far as the profitable reuse of sludge is concerned, the following alternatives are worth noting:

PROFITABLE REUSE

- Washing sludge
- Surface and underground water drainage and waste-pipe networks.
- Systems for cleaning the treatment plant and equipment.
- Systems for treating and finishing end products.
- Transport systems for mineral resources.

Recovery of water to be used in:
- The treatment processes.
- Dust control systems.
- Sprinkling systems for revegetated areas.
- Work equipment cleaning.

Recovery of the solid phase to be used as:
- Material for restoration (refilling or improving the ground.
- By-product.
- Raw material for other processes (recovering clays).

The remaining water has properties similar to the original to the extent that the quarry processes that take place on aggregate sites do not produce changes in its chemical composition. The only objective is to reduce the amount of suspended matter so as to be able, in most cases, to reuse the water within the process.

With respect to this point, the efficiency level nowadays in a modern plant can be well over 90%, which means it is possible to ensure sound management of that most prized of resources, water.

11.2.4 Flocculants

Flocculants are chemical compounds (inorganic and organic), soluble in water, which act by binding particles together, like a glue, thus creating larger particles, with a higher sedimentation velocity, so that they settle faster. This reduces the settling time, which results in a reduction of the surface area required for clarification or thickening.

End of water control cycle by flocculant, causing the sludge to flocculate and settle at the bottom

Nowadays, organic-based polyacrylamide type agents, made up of a reinforced polymeric double chain and the corresponding amide to obtain a water-soluble compound, are the most common. There are 3 types: non-ionic, anionic, and cationic.

Recent studies have been carried out on some types of flocculants used in water treatment (including those for human consumption) based on polyacrylamide (acrylamide polymer) and which may include traces of acrylamide, in order to determine the possible toxicity derived from this last substance. They conclude that residual concentrations of acrylamide in water and sludge are generally below detection limits and that these traces always degrade very rapidly in the presence of oxygen, eliminating any risk to health or the environment (UNPG, 2016).

In the clarification of effluents from aggregate washing, the most commonly used are high molecular weight anionic types.

The optimum concentration in the effluent to be treated should be in the order of 5-10% solids by weight, since, if it is higher, the consumption of flocculant would increase, which is exponential with the concentration of solids in the effluent. The flocculation performance also depends on the nature of the fines (some colloids may require the addition of other substances such as coagulants).

To establish the type of flocculant to be used in each case, laboratory sedimentation tests must be carried out to determine which flocculant performs best in terms of speed of sedimentation, better floc consistency and higher concentration of thickened solids. Generally, several types of flocculants are tested simultaneously, about 3 or 4 types, in order to quickly select the best performing ones.

11.3 Safety and stability of dams

Wastewater dams need to be designed for the site life and shaped at the initial stage. This reduces the need for reshaping dams at a later stage and so avoids costly earthworks and double handling.

The placement of waste on steep slopes is to be avoided when possible, so as to reduce the risk of land slide and dam failure, particularly in areas of high rainfall and areas prone to landslides, earthquakes, and tremors.

Small sludge dam

Embankments of a dam are shaped during the building stage so that slopes are gentle enough (15 to 20 degrees, or 27% to 36%) to reduce erosion and to allow vegetation to become established and so reduce the negative visual impact of unsightly waste rock.

A major factor in the design of dam embankments is stability, from a geotechnical point of view. Factors influencing this geotechnical stability include:

- Embankment height.
- Embankment slopes.
- Strength of the embankment and degree of compaction.
- Permeability of the embankment and groundwater position in relation to it.
- Strength and compressibility of the embankment foundations.

The type of dam embankment to some extent dictates the system of sludge discharge to be adopted. For example, embankments that are designed as water retention structures are made of low-permeability materials and sludge are discharged well upstream of the embankment.

11.4 Water management in dams

Different steps have to be checked in a sludge dam:

- Avoid pollution of groundwater and surface water.
- Collect and treat the polluted water and leachates.
- Minimise the water volume that require treatment.

Measures used to control seepage from wastewater dams include:

1. Controlled placement of sludge is the most cost-effective method of controlling seepage.
2. Foundation grouting involves injecting fluidized material and is only effective if there is highly permeable rock beneath the impoundment or in areas with high-permeability zones.
3. Foundation cut-offs are necessary when soil foundations are sand or sand and gravel. A significant reduction in seepage may be achieved by construction of an earth fill cut-off or a slurry trench cut-off wall. They may be applied to extremely weathered rock such as laterite, highly permeable rock.
4. Clay liners on geomembranes can be effective in areas where the storage is located in an area of high permeability, particularly in karstic rocks. They are susceptible to cracking on exposure to the heat (by sun), which can increase permeability.
5. Underdrains below the sludge should be constructed. The drains act to attract the seepage water and discharge it to a collector system, ideally for recycling to the process plant.

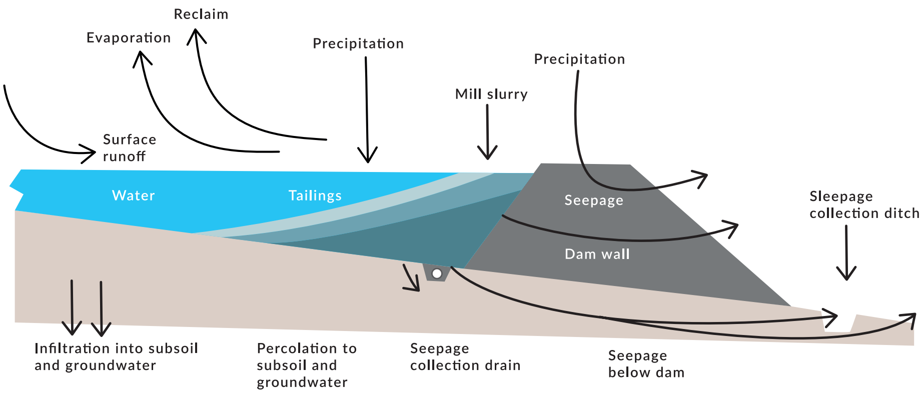
Some methods of collecting and treating this seepage are required, such as:

- Toe drains.
- Pump wells.
- Artificial wetlands.

6. Artificial liners are used to line waste disposal facilities, often with provision for drainage layers beneath the membranes to collect any leachate, which leaks past the first. However, these liners do not seem to be always appropriate for all sludge disposal situations (such as in case the groundwater is confined and spouting out).

The control of the water balance in the system should include process water, wastewater, storm water run-off, precipitation, seepage from impoundment and into the ground, and evaporation.

Water gains and losses at a terrestrial impoundment



- Minimise percolation to subsoil and groundwater, by low permeability of the substrate and low permeable cover.
- Minimise seepage through the impoundment wall.
- Collect seepage by a collection and treatment system.
- Minimise influx of surface runoff by trenching and by-passing the sludge depository.
- Maximise circulation of process water.
- Minimise infiltration of water into the sludge dam.

11.5 Design of sludge dams and waste-rock facilities in terms of prevention of impacts in water quality

The location of sludge dams and waste-rock facilities is a good and effective way to prevent impacts on water quality.

The determination for locating dump depends on the topography, drainage systems, water bodies, etc. and aims at minimising dump instability and (surface and underground) water pollution.

A sufficient area around dumps, especially in the case of rocky waste facilities, provides space for bunds or trenches to collect (when produced) acid water runoff, for the placement of dams to collect seepage (leachate), runoff and sediments, and for the necessary monitoring and treatment facilities.

Terrestrial embankments (dams) in areas subject to earthquakes or landslides are particularly vulnerable. Foundation conditions (rock or sediment type, compaction rate, etc.) are important in terms of safety, environmental protection, reducing risks of seepage and groundwater pollution.

It is important that the impoundment is designed with future closure in mind, so that it will remain stable, secure, and virtually pollution free, with little maintenance required.

12 Water management plans for quarries

In many European countries a water management plan (surface and groundwater) is included in the general planning of the quarry setting the principles of how water will be controlled and how its quality preserved.

The structuring of a water management approach can be summarised in three stages: knowing, managing, and anticipating.

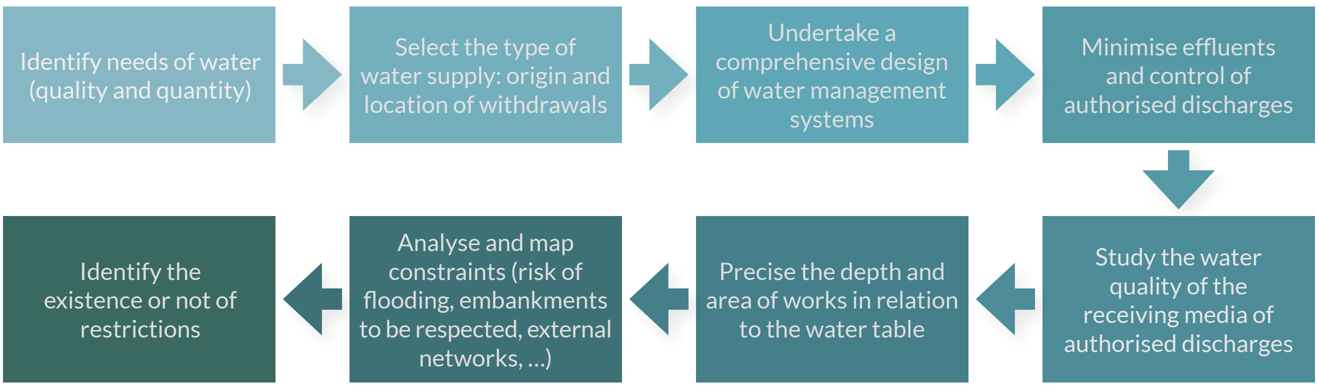
A three steps approach

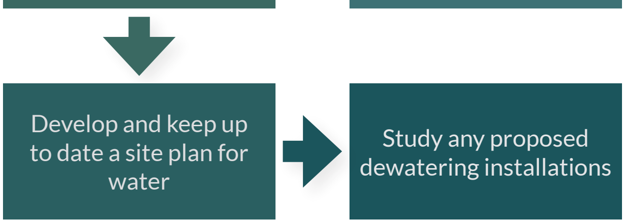
12.1 Knowing

The operator has to evaluate the elements related with the water framework of the site. In particular:

- Identify needs (quality and quantity) for operation throughout its exploitation.
- Select the type of water supply: origin and location of withdrawals.
- Undertake a comprehensive design of water management systems.
- Minimise effluents and control of authorised discharges.
- Study the water quality of the receiving media of authorised discharges, in order to know their initial state and the evolution of their quality throughout the life cycle of the site.
- Precise the depth and area of works in relation to the water table.
- Analyse and map constraints (risk of flooding, embankments to be respected, external networks, ...)
- Identify the existence or not of restrictions (regulatory or other) and other users on the resources withdrawn.

1st step: to know





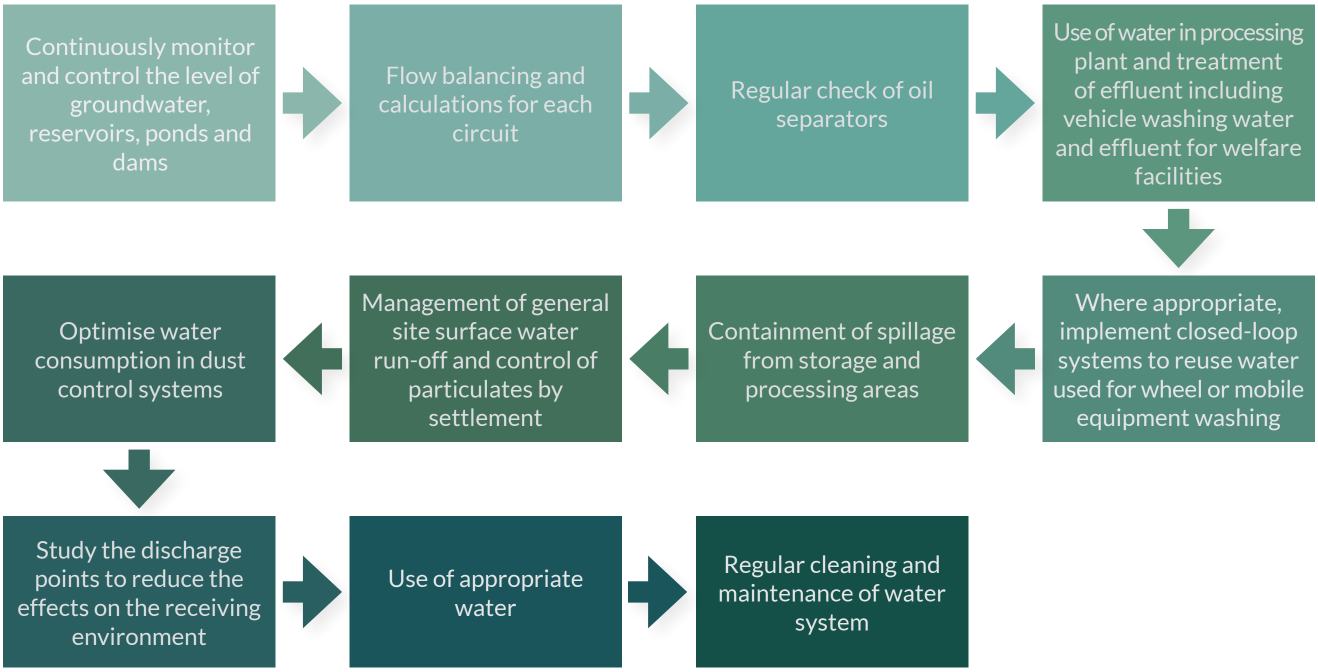
- Develop and keep up to date a site plan showing all surface water features and all water engineering works.
- Study any proposed dewatering installations.

12.2 Managing

It is essential to carry out a survey of any existing water features at the site. All existing natural water features should be protected and retained wherever possible and where engineering works are proposed.

- Containment of spillage from storage and processing areas.
- Management of general site surface water run-off to save the volumes taken from the environment, and control of particulates by settlement in sumps and lagoons.
- Optimise water consumption in dust control systems.
- To study the discharge points in order to reduce as far as possible the effects on the receiving environment.

2nd step: to manage



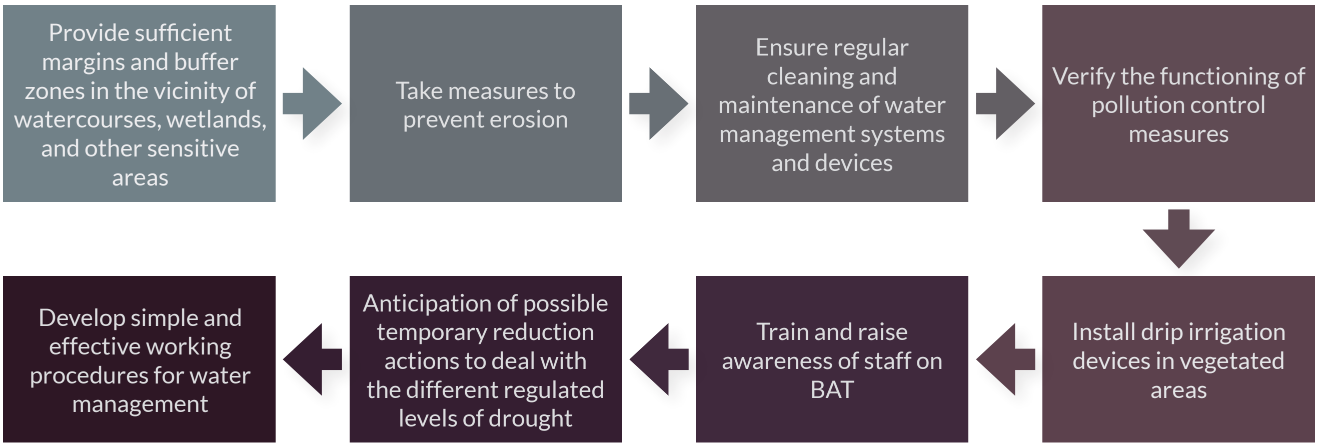
- Continuously monitor and control the level of groundwater, reservoirs, ponds and dams and the composition of effluents: water flow and quality controls.
- Flow balancing and calculations for each circuit.
- Regular check of oil separators and removal of oil and scum.
- Use of water in processing plant and treatment of effluent including vehicle washing water and effluent for welfare facilities. Where appropriate, implement closed-loop systems to reuse water used for wheel or mobile equipment washing.
- Use of appropriate water to counteract groundwater lowering, e.g., in nearby pools.
- Regular cleaning and maintenance of water system.

12.3 Anticipating

Other complementary good practices that can be integrated in the water management plan to prevent or minimise the effects of the activity on groundwater and surface water are listed:

- Verify the functioning of pollution control measures at fuel and chemical storage areas.
- Install drip irrigation devices in vegetated areas.
- Train and sensitise staff on best operating practices to prevent water pollution, reduction of water withdrawals in the event of drought and for proper management.

3rd step: to anticipate



- Provide sufficient margins and buffer zones in the vicinity of watercourses, wetlands, and other sensitive areas.
- Take measures to prevent erosion.
- Ensure regular cleaning and maintenance of water management systems and devices.
- Anticipation of possible temporary reduction actions to deal with the different regulated levels of drought; identification of alternative resources, even alternative treatments (lime, etc.) and the feasibility of their use, even partial.
- Develop simple and effective working procedures for water management.

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2025

AGGREGATES EUROPE

Environment Committee
Water Management Task Force
Chairman and Coordinator of the document: Dr. César Luaces Frades

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ROTATE
CIRCULAR ECOLOGICAL ESSENTIAL & CRITICAL RAW MATERIALS

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AGGREGATES EUROPE

Aggregates Europe - UEPG aisbl
General Secretariat
Square de Meeûs 40
1000 Brussels
Belgium

secretariat@uepg.eu
www.aggregates-europe.eu

EU Transparency Register: 15340821653-49

Executive Summary

Water Management Guidance

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