RECOVER, REMEDIATE, REUSE:

The Untapped Potential of PFAS Soil Remediation

OUR SPEAKER TODAY

EUNAN KELLY
Head of Business Development Europe at CDE Group

At CDE, we work across two sectors and five strategic regions to pioneer industry-leading, world-changing engineering solutions.

For over 30 years, we have relentlessly innovated and co-created wet processing and waste recycling equipment – completing over 2,000 global projects – and we're only getting started.

Our purpose is **to create our best world, a ton at a time;** empowering our customers to transform over 230 million tonnes of C&D waste into reusable materials for the betterment of people, planet and their bottom lines.

THE SOIL WASHING APPROACH

PFAS Solutions

WASTE HIERARCHY
FOR THE CONSTRUCTION / REMEDIATION SECTOR

REMEDIATION COMPARISON – AVAILABLE METHODS

Field Deployed Treatment Technology	Suitability to Treatment Scenarios	Treatment Efficacy Versus Treatment Goals	Treatment Efficacy for Different PFAS[1]	Suitability to Soil Properties	Suitability to co-contamination	Potential Impact on Site Operations	Requirement for Ongoing Management	Technology Development / Commercial Availability	Cost in European Market (EUR/m3)	Durability & Residual Liability	Sustainability - Energy & Chemical Usage, Stakeholder[2]
Destructive											
High Temperature Incineration	Low volume / high concentration	Likely to achieve low thresholds	Effective across PFAS class	Significant pre-treatment likely required	Little effect from organics or inorganics	Off-site excavation / backfill only	Minimal	Established but limited availability & capacity	450- 2,000	Good assuming emissions treatment	Highly energy intensive with soil transport
Cement Kiln Incineration	Low volume / high concentration	Likely to achieve low thresholds	Effective across PFAS class	Significant pre-treatment likely required	Cement quality sensitive to co-contamination	Off-site excavation / backfill only	Minimal	Limited availability & capacity [3]	100 - 1,000	Good assuming emissions treatment	Highly energy intensive with soil transport
Thermal Desorption	On-site, range of soils	Achieve low thresholds if effective heating	Effective across PFAS class	Disaggregation for cohesive soils	Little effect from organics or inorganics	On-site application requires space & power	Minimal	Established but not for PFAS. Generally available	Incineration > thermal desorption > non-destructive	Good assuming emissions treatment	Highly energy intensive. On-site or off-site
Smouldering Combustion	On-site, range of soils	Achieve low thresholds if effective heating	Effective across PFAS class	Disaggregation / amendment cohesive soils	Organic co-contamination beneficial as fuel	On-site application requires space	Minimal	No full scale, available via limited vendors	Incineration > smouldering > non-destructive	Good assuming emissions treatment	Requires surrogate fuel
Non-Destructive											
Soil Washing	Wide range of scenarios	High % reduction maybe not most stringent thresholds	Broadly effective across PFAS class	Less suited to cohesive soils and concrete	Generally manageable, may increase cost /complexity	On-site application requires space	Minimal following validation of any reused material	Most track record for PFAS. Generally available	25-160	Good - need suitable material reuse & fines management	Lower energy inputs. Can reuse sands & gravels
Stabilisation / Solidification	Wide range of scenarios incl. waste pre-treatment	High % leachate reduction maybe not most stringent thresholds	Less effective immobilisation of short chain PFAS	Suitable to most soil types and concrete	May require pre-treatment, gross organic impacts challenging	Long-term management of stabilised soil	May require long-term monitoring	Several full-scale projects. Widely available	35-113 (Reagent dependant)	Increasing evidence of durability. Liability held.	Lower energy inputs. Can reuse materials
Pathway Management											
Landfilling	Wide range of scenarios	Rapid removal of source provided delineated	Effective across PFAS class	Suitable to most soil types and wastes	Generally manageable, may increase cost	Off-site excavation / backfill only	Minimal	Availability is very country specific	Country specific	Option to -pre-treat. Needs leachate management.	Transfer not treatment. Transport & resource cost.
Engineered Containment	Long-term access	Rapid isolation of source provided delineated	Effective across PFAS class	Suitable to most soil types and some wastes	Generally manageable, may increase cost /complexity	Long-term management / space for contained soil	Long-term monitoring and maintenance	Widely available	Life - cycle costs very high but spread over time	Long-term management and liability for contained soil	Less energy / reagents but containment not treatment.

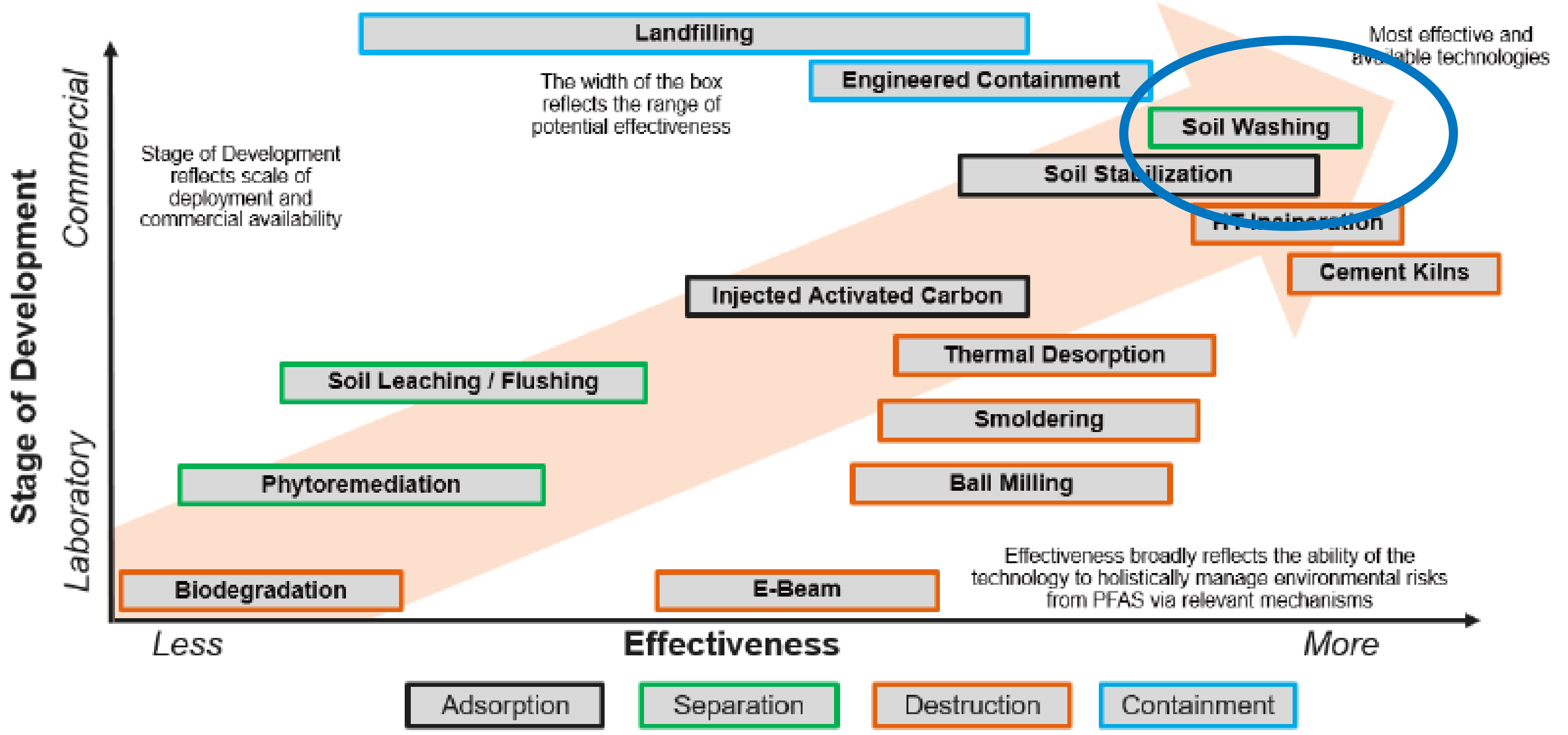
Source: Concawe Special Task Force on Soil and Groundwater – European Research Body

REMEDIATION COMPARISON – DEVELOPMENT METHODS

Innovative Treatment Technology	Suitability to Treatment Scenarios	Treatment Efficacy Versus Treatment Goals	Treatment Efficacy for Different PFAS[1]	Suitability to Soil Properties	Suitability to co-contamination	Potential Impact on Site Operations	Requirement for Ongoing Management	Technology Development / Commercial Availability	Cost in European Market (EUR/m3)	Durability & Residual Liability	Sustainability - Energy & Chemical Usage, Stakeholder[2]
Destructive											
Ball Milling / Mechano-chemical	Low volume / high concentration	Potential to achieve low thresholds but variable results	Likely effective for wide range of individual PFAS. Limited data on byproducts	Significant pre-treatment likely required.	Limited data	Modular on-site application requires some space	Minimal. Treated soil likely requires reconditioning.	Field scale pilots completed. Units commercially available	69 - 630	Good assuming complete destruction achieved	Energy intensive with reagents potentially required. On site application limits transport.
High Energy Electron Beam	Low volume / high concentration	Limited data. Data suggests 78-99.5% destruction	No assessment of fluoride or byproducts to date	Significant pre-treatment likely required	Limited data. Appears suitable for hydrocarbon co-contamination	Containerised on-site application requires some space	Minimal. Treated soil likely requires reconditioning.	Laboratory assessment only to date	~357	Good assuming complete destruction achieved	Limited data.
Bio degradation	Theoretically high volume / low concentration. Low risk scenarios.	Slow kinetics and incomplete degradation observed to date	Limited assessment of precursors or byproducts. Assumed low efficacy.	Limited data	Limited data. Hydrocarbons may affect degradation products.	If technology developed to be effective, likely low impact	Long timeframes with associated monitoring	Laboratory assessment only to date	No data available	Dependant of performance. Liability held for long periods until complete	If advanced to be effective, likely sustainable and low impact
Non-Destructive											
Phyto remediation	Shallow contamination, low risk scenarios	Species / habitat dependant. Slow uptake. Not suited to stringent goals	More suited to shorter chain PFAS.	Soil / habitat must be suitable for desired plant species	Limited data. Potential biodegradation of organic co-contamination	On-site application requires large areas and long timeframes. Limits end use	Long timeframes with associated monitoring and harvesting of plants	Laboratory and limited field application only to date	No data available	Dependant of performance. Liability held for long periods until complete	Requires treatment of harvested plants which likely involves incineration.
In Situ Flushing	Wide range of scenarios, in-situ or ex-situ	Likely not suited to stringent goals. Reagents may enhance efficacy	Long chain and certain charged PFAS may be less well leached	Limited by soil permeability and heterogeneity.	Limited data. Soluble co-contamination likely also amenable.	Requires leachate containment system. Ex-situ requires space	Minimal	Laboratory and limited field application only to date	Estimated upper range of typical pump and treat cost	Dependant on level of reductions achieved	Lower energy inputs. Some minor reagent use.

Source: Concawe Special Task Force on Soil and Groundwater – European Research Body

REMEDIATION OPTIONS

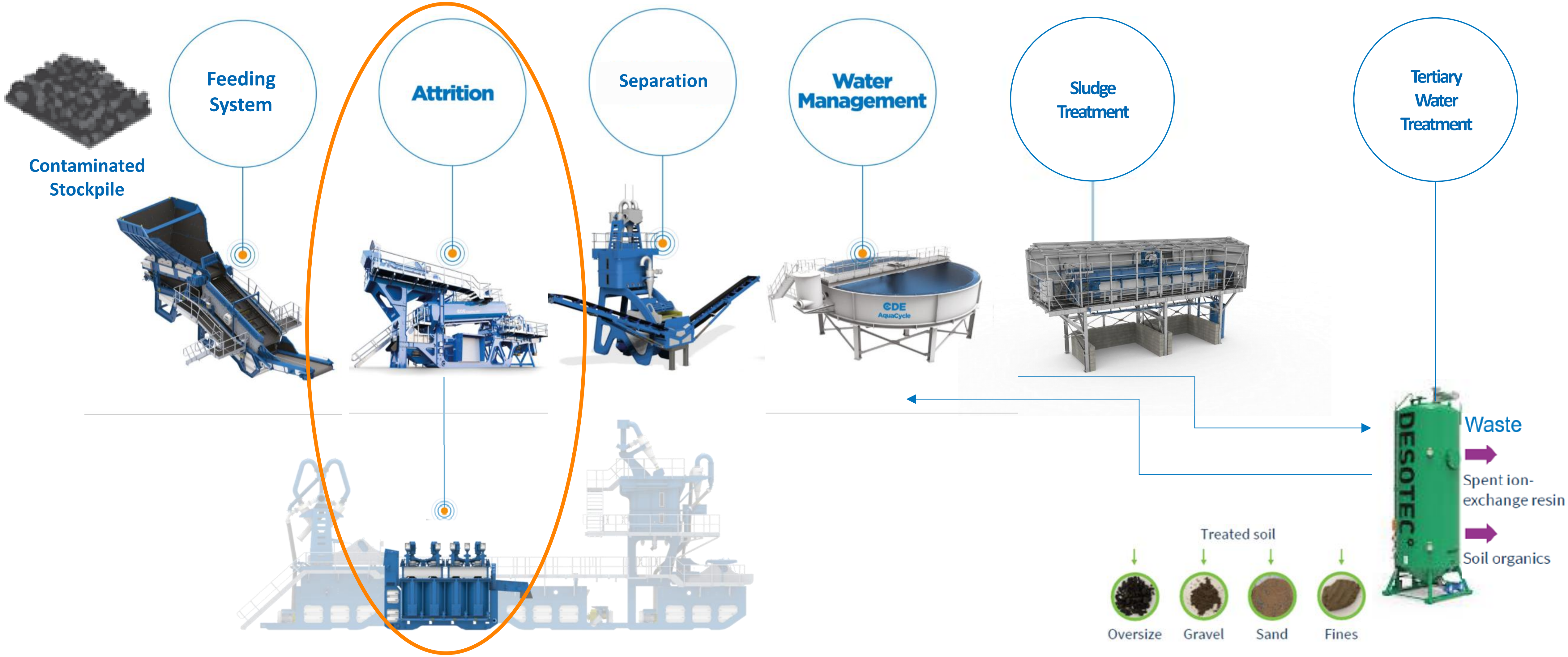


Source: Concawe Special Task Force on Soil and Groundwater – European O&G Research Body

SOIL WASHING SOLUTION

What’s next?

HOW SOIL WASHING WORKS



PFAS WASHING SOLUTION

CDE

- **Integrated systems**
- **Soil washing technology combined with water recycling**
- **Advanced water treatment to clean contaminated soils**
- **Produce a range of valuable outputs**

PFAS Washing Solution

Toughest on materials
Industry-leading durable primary feeding and screening system designed to deal with and prepare the most difficult materials.

PFAS Washing Solution

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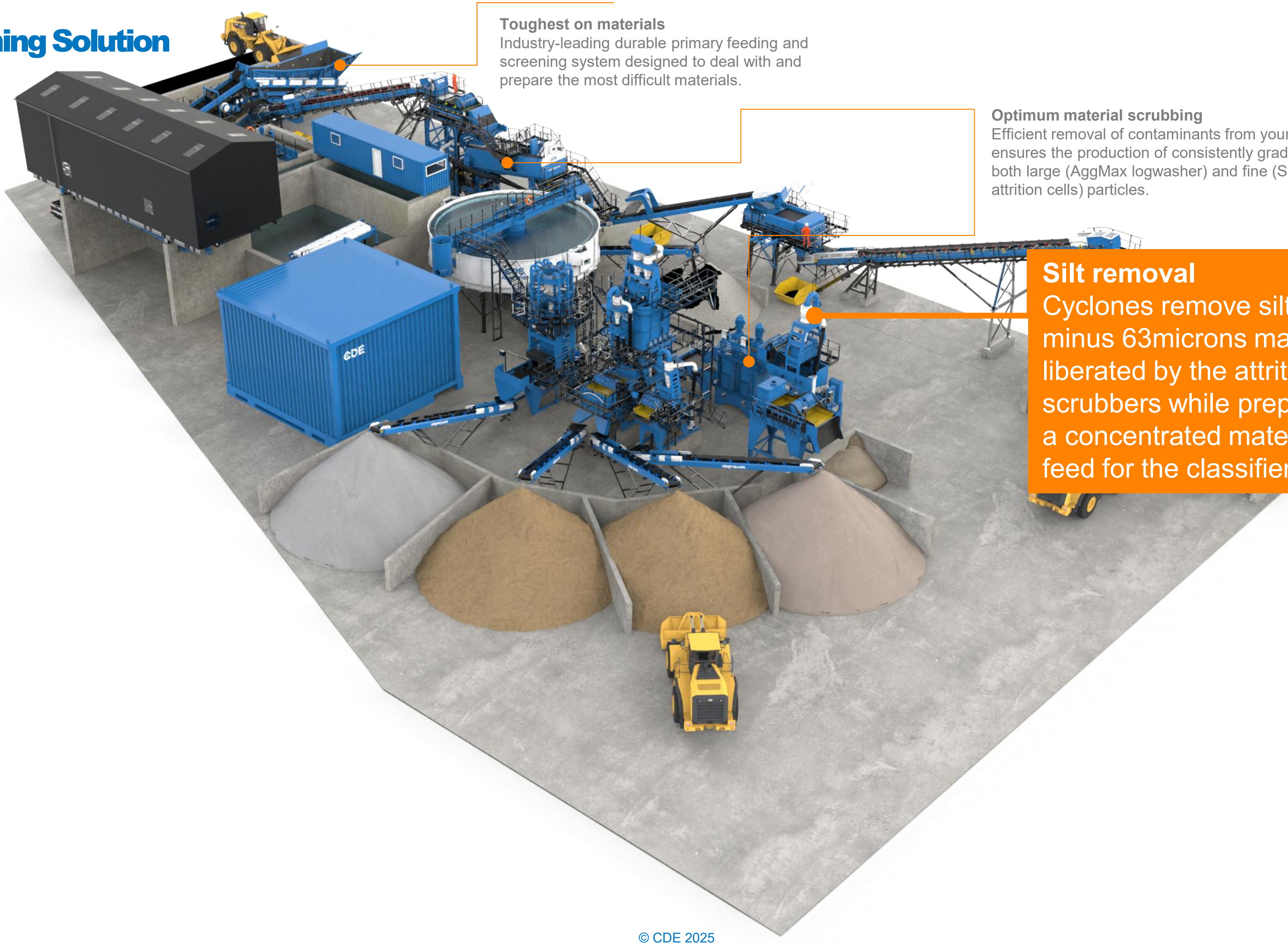
Industry-leading durable primary feeding and screening system designed to deal with and prepare the most difficult materials.

Optimum material scrubbing
Efficient removal of contaminants from your material feed ensures the production of consistently graded material on both large (AggMax logwasher) and fine (ShearClean attrition cells) particles.

PFAS Washing Solution



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Cyclones remove silt and minus 63microns material liberated by the attrition scrubbers while preparing a concentrated material feed for the classifier tanks.

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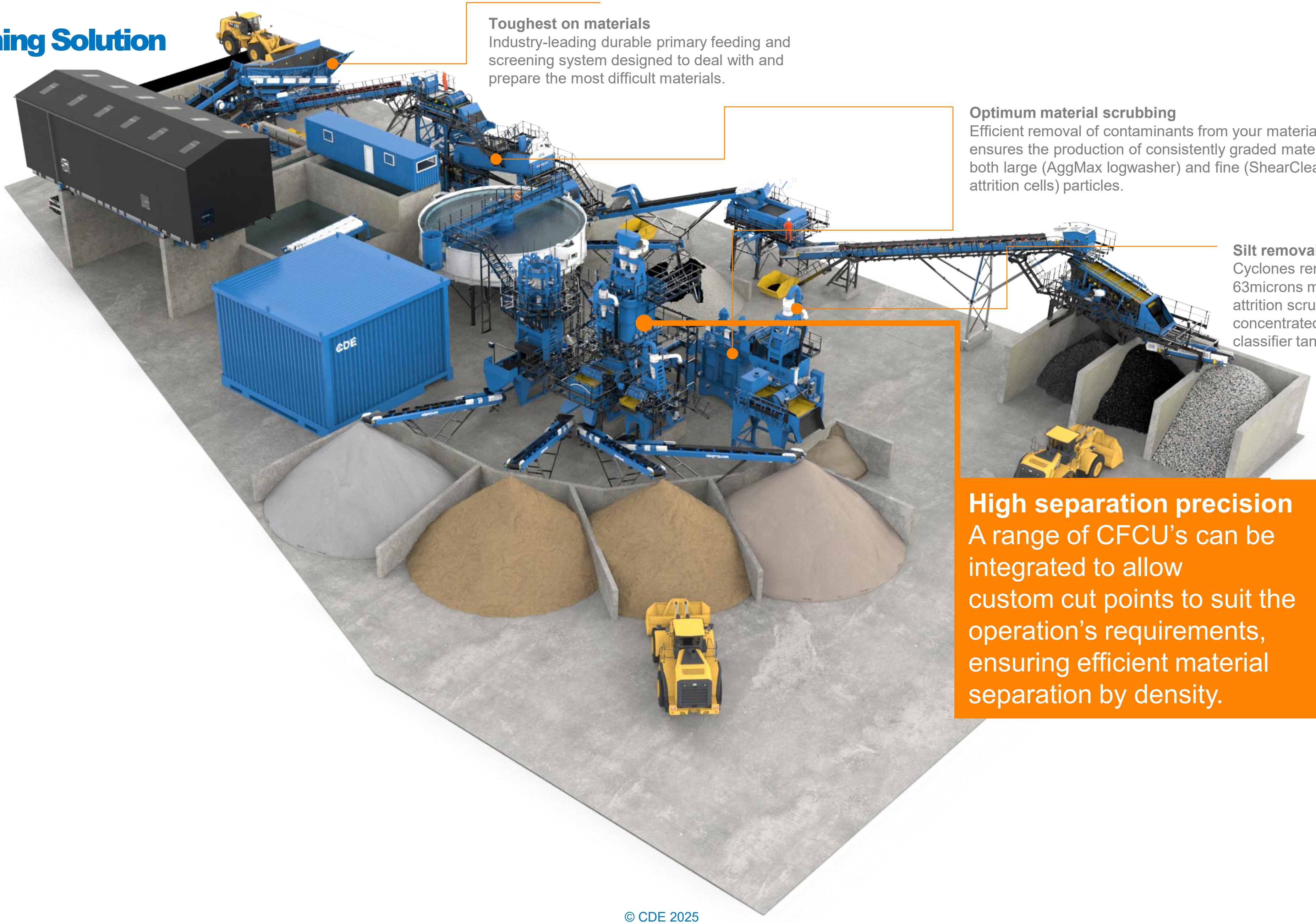

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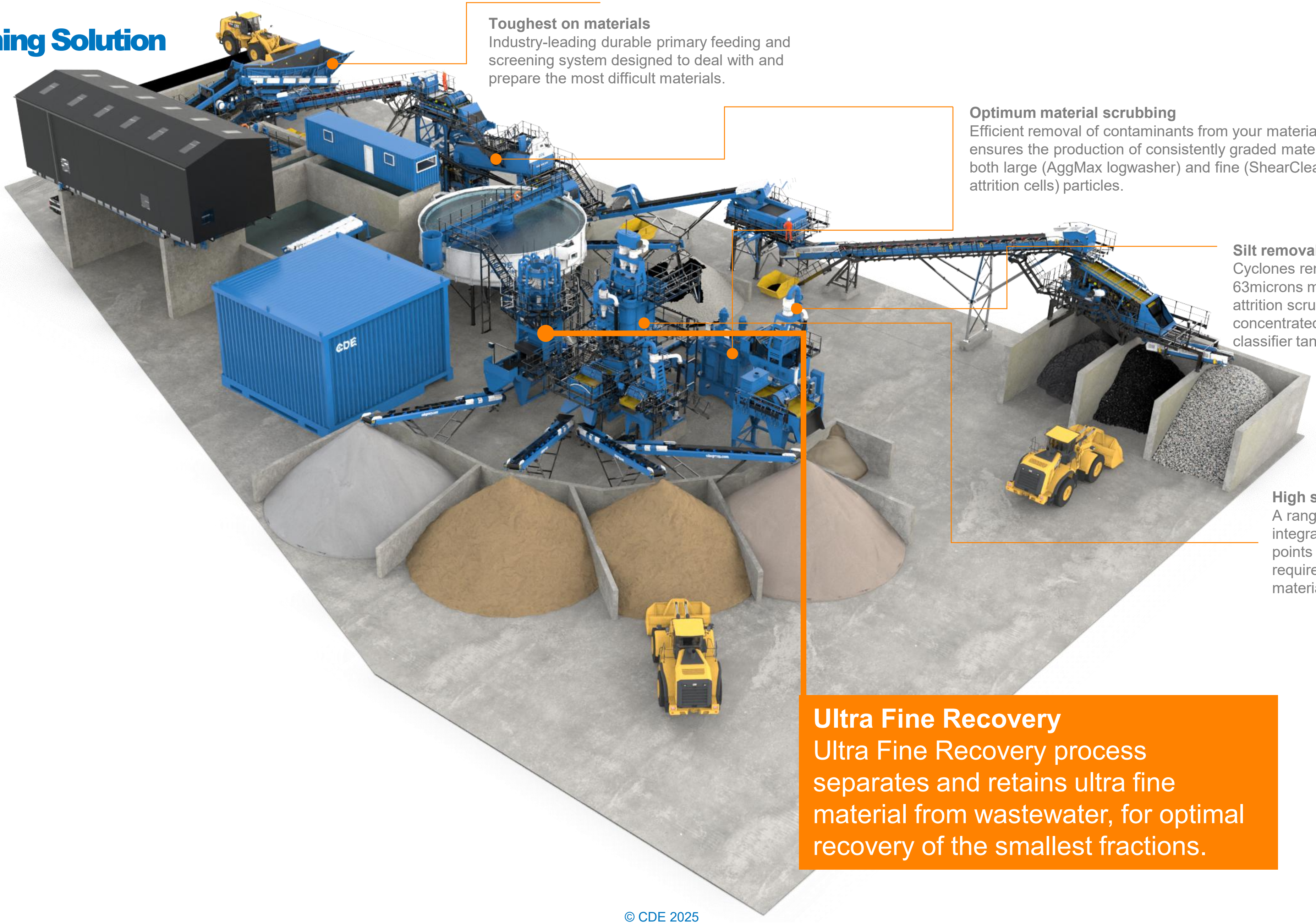

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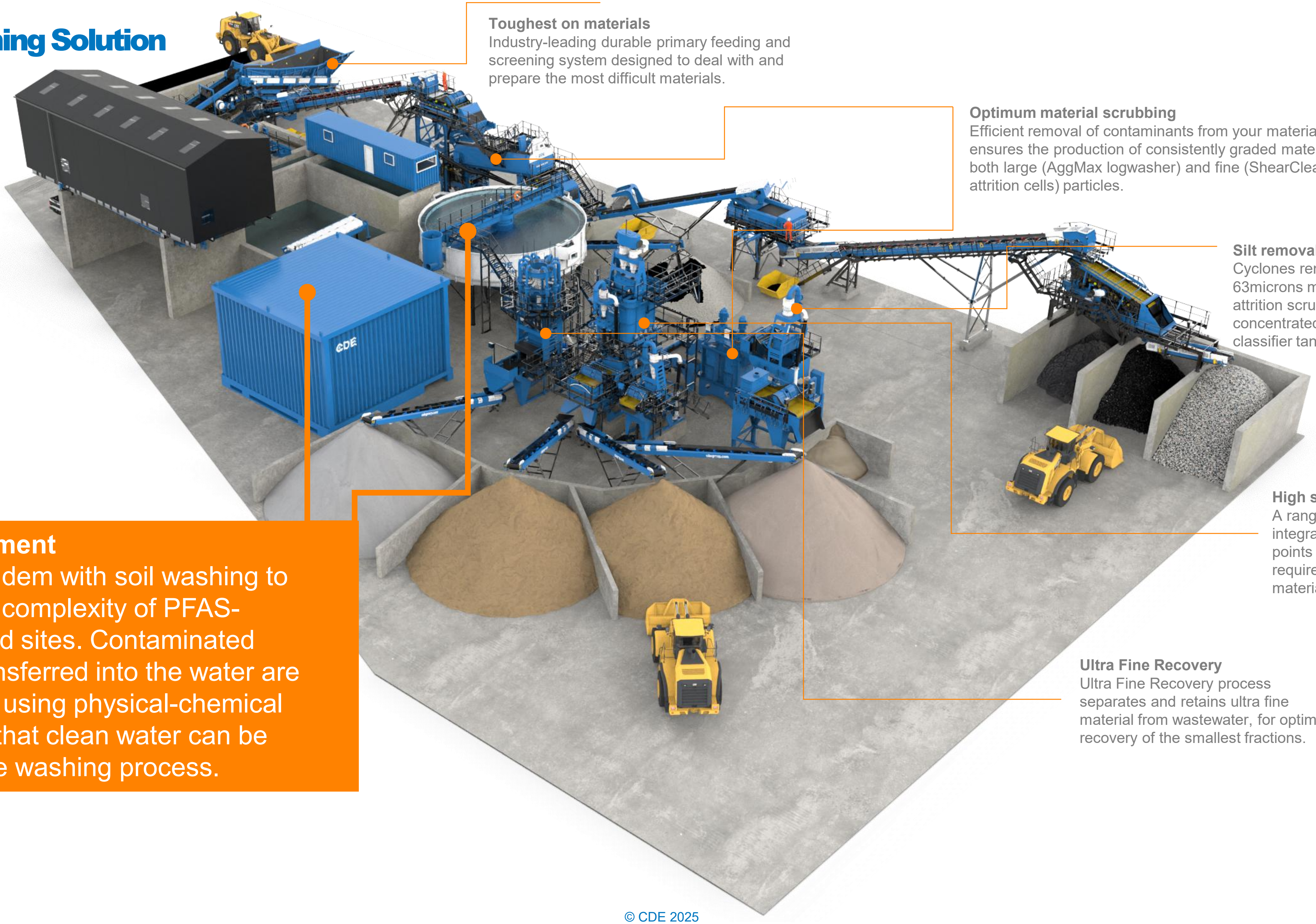

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Water treatment
Works in tandem with soil washing to manage the complexity of PFAS-contaminated sites. Contaminated particles transferred into the water are then treated using physical-chemical systems so that clean water can be reused in the washing process.

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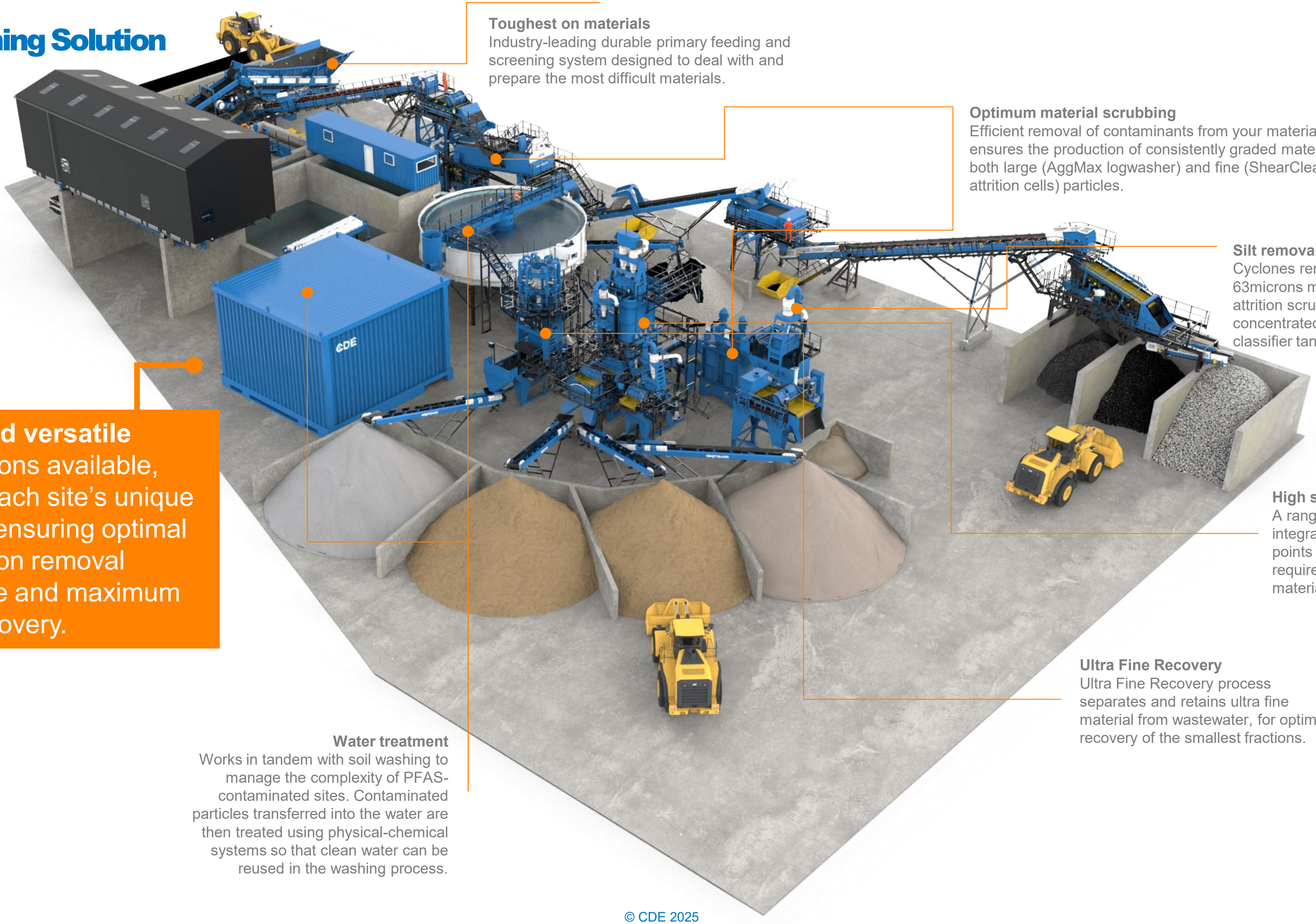

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Modular and versatile
Various options available, tailored to each site's unique conditions, ensuring optimal contamination removal performance and maximum material recovery.

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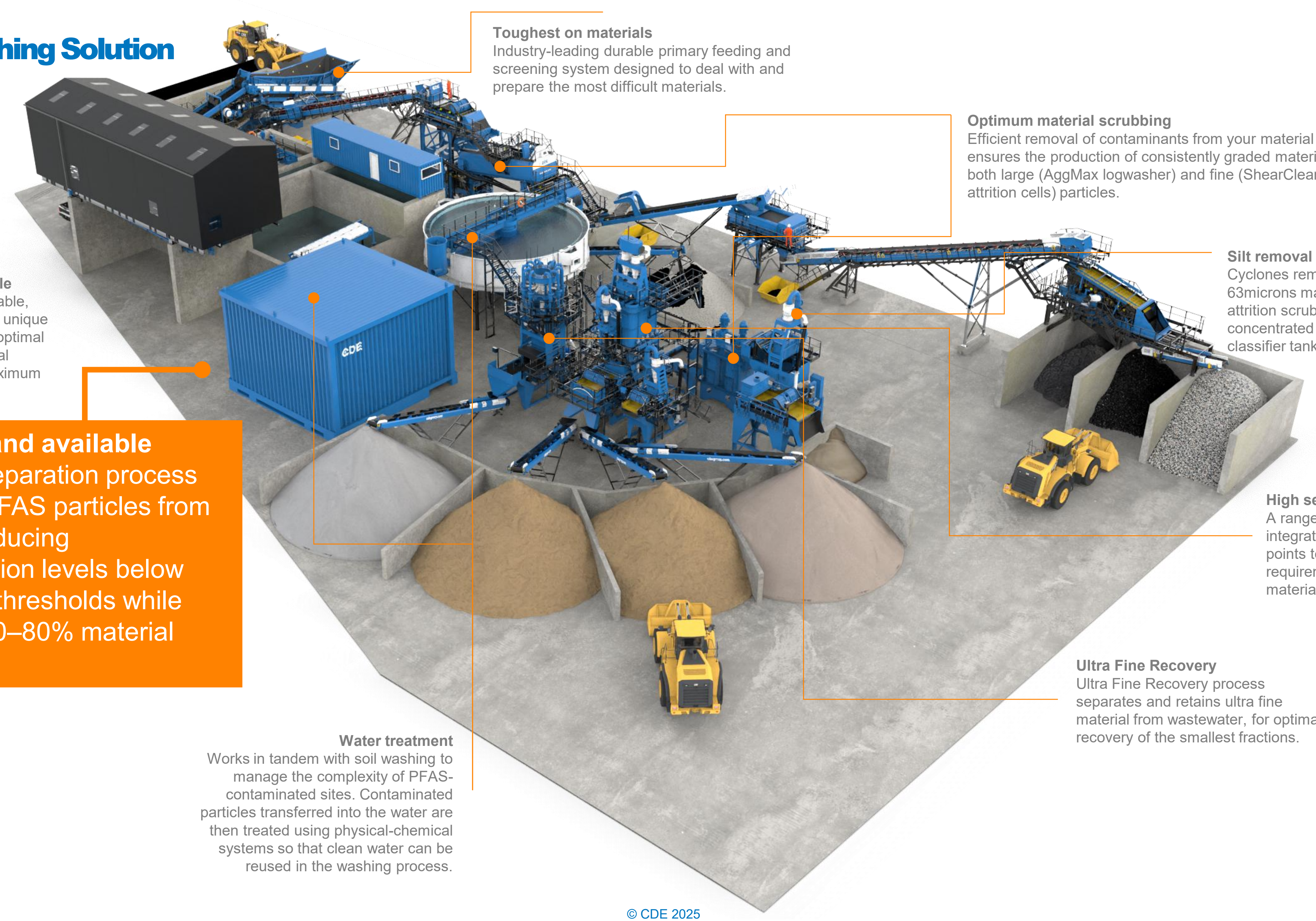

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Effective and available
Physical separation process removes PFAS particles from the soil, reducing contamination levels below regulatory thresholds while enabling 70–80% material recovery.

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Works in tandem with soil washing to manage the complexity of PFAS-contaminated sites. Contaminated particles transferred into the water are then treated using physical-chemical systems so that clean water can be reused in the washing process.

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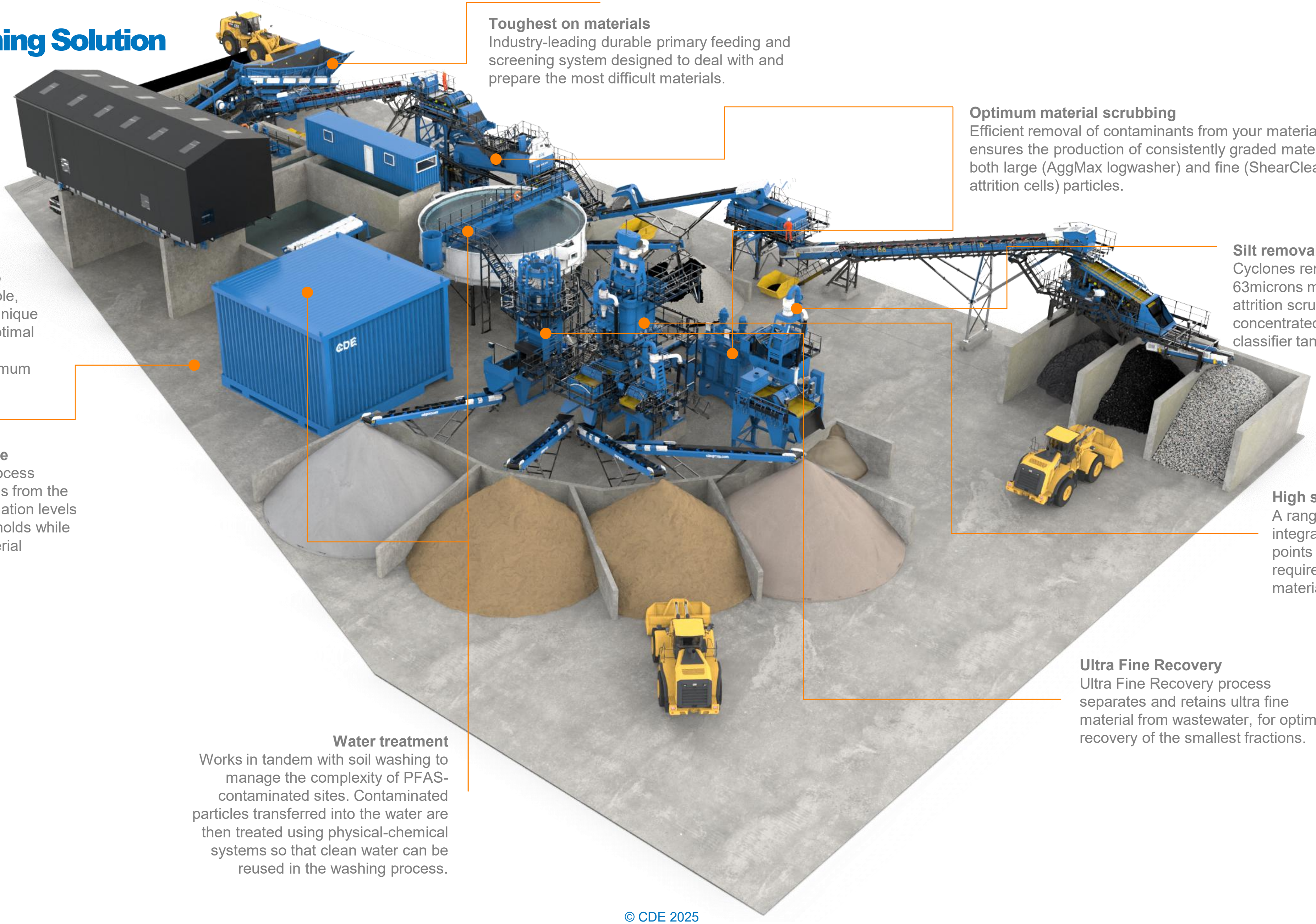

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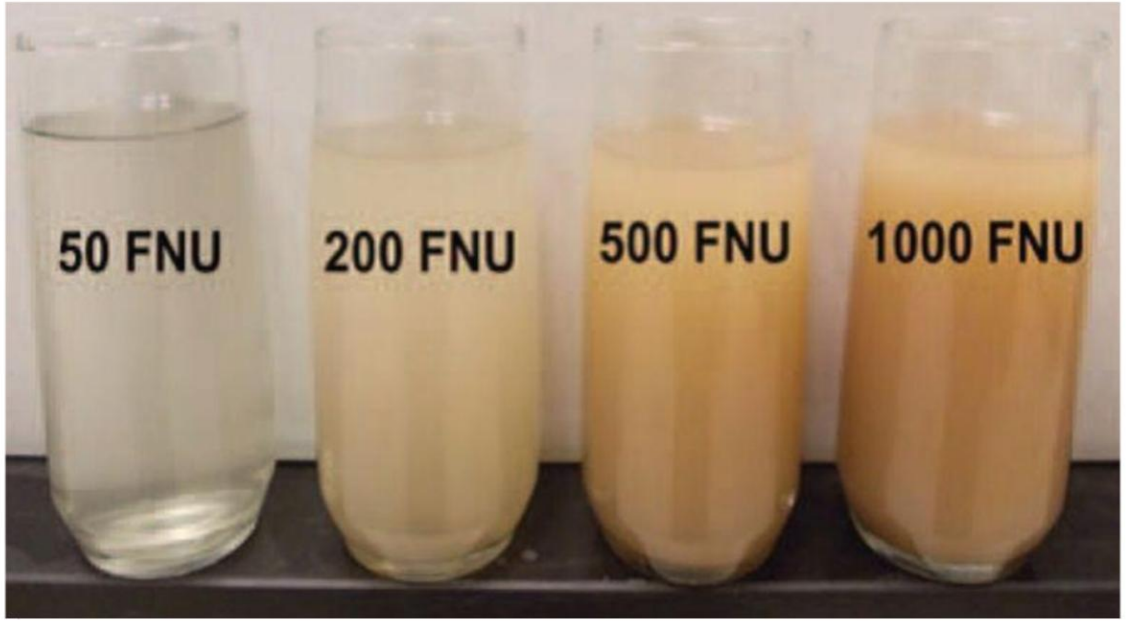
HOW SOIL WASHING WORKS / TREATMENT PROCESS

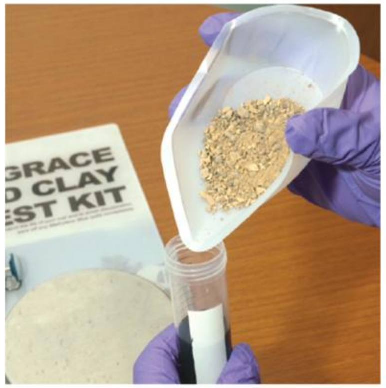
Experiences gathered from other applications within the wider industry

Concrete Sand Specification (Europe)
MBV – target is 1.4g/ 100g
e.g. CDE French Projects – 0.08g / 100g

FRAC
Turbidity - ≤ 250FNU – 100FNU
MBV - ≤1.0g /100g
Crush Resistance = 350-700 bar

Glass Sand
Uniform particle size – 150-650μm
SiO_2 - +95%
Fe_2O_3 - <0.030%





PFAS WASHING RESULTS

Norway / Sweden / Switzerland / Belgium / Australia

Feed Material ≤ **60µg / kg**

+2mm Aggregates = **<1µg / kg**
0-2mm Sand = **<3µg / kg**
0-0.200µm = **3-5µg / kg**
0-0.063µm Filter Cake = **20 - 30µg / kg**

Feed Material ≤ **100µg / kg**

+2mm Aggregates = **<1µg / kg**
0-2mm Sand = **<3µg / kg**
0-0.200µm = **3-5µg / kg**
0-0.063µm Filter Cake = **30 - 40µg / kg**

Stoff	Enhet	Steinliveien 0-2	0-2 Steinliveien
Arsen (As)	mg/kg TS	5,7	5,2
Bly (Pb)	mg/kg TS	21	30
Kadmium (Cd)	mg/kg TS	< 0,20	< 0,20
Kvikksølv (Hg)	mg/kg TS	0,024	0,029
Kobber (Cu)	mg/kg TS	21	35
Sink (Zn)	mg/kg TS	77	74
Krom (Cr)	mg/kg TS	22	25
Nikkel (Ni)	mg/kg TS	28	31
Alifater C5-C6	mg/kg TS	< 7,0	< 7,0
Alifater >C6-C8	mg/kg TS	< 7,0	< 7,0
Alifater >C8-C10	mg/kg TS	< 3,0	< 3,0
Alifater >C10-C12	mg/kg TS	< 5,0	< 5,0
Alifater >C12-C16	mg/kg TS	< 5,0	< 5,0
Alifater >C16-C35	mg/kg TS	13	12
Alifater >C12-C35	mg/kg TS	13	12
Alifater C5-C35	mg/kg TS	13	12
THC >C5-C8	mg/kg TS	< 5,0	< 5,0
THC >C8-C10	mg/kg TS	< 5,0	< 5,0
THC >C10-C12	mg/kg TS	< 5,0	< 5,0
THC >C12-C16	mg/kg TS	< 5,0	< 5,0
THC >C16-C35	mg/kg TS	120	100
Sum THC (>C5-C35)	mg/kg TS	120	100
SUM THC (>C12-C35)	mg/kg TS	120	100
PCB 28	mg/kg TS	< 0,0015	< 0,0015
PCB 52	mg/kg TS	< 0,0015	< 0,0015
PCB 101	mg/kg TS	< 0,0015	< 0,0015
PCB 118	mg/kg TS	< 0,0015	< 0,0015

Tilstandsklasser for forurenset grunn

	Ikke detektert
	Tilstandsklasse 1
	Tilstandsklasse 2
	Tilstandsklasse 3
	Tilstandsklasse 4
	Tilstandsklasse 5
	Over klasse 5
	Under normverdi
	Over normverdi
*	Konsentrasjoner overstiger grenseverdier for inert avfall

CERTIFICATIONS

- Many countries extensively repurpose excavation waste / inert soils / muck away into high-quality construction materials, mitigating **sand scarcity** whilst avoiding **unnecessary emissions**.
- Early adopter sites in Australia and Belgium are now **repurposing** once contaminated PFAS soils **into valuable construction aggregates**.
- Leading recycling wash plant projects process materials that continually meet **international concrete sand and other construction product standards**.

DA Mattsson	Sweden	CD&E	250tph
Posillico	USA	Contaminated Soils	250tph
Brewster's	Scotland	CD&E	250tph
Tom Wilhelmsen	Norway	CD&E	250tph
Thompsons	Scotland	CD&E	250tph
Hercal	Spain	CD&E	250tph
Malcolm's	Scotland	CD&E	200tph
Rutura	USA	CD&E	200tph
Hardford	USA	Contaminated Soils	200tph
Sodextra	France	Contaminated Soils	200tph
AF Gruppen	Norway	Contaminated Soils	200tph
AF Gruppen	Norway	Contaminated Soils	150tph
Pellichet	France	CD&E	150tph
Val'deau Mat	France	CD&E	200tph
Spiess	France	CD&E	
SRC	England	CD&E	150tph
Repurpose It	Australia	Rail Ballast	150tph
SRC	England	CD&E	150tph
SRC	England	CD&E	100tph
Sheehan's	England	Contaminated Soils	100tph
Wiltshire Concrete	England	CD&E	100tph
Lingenheld	France	Contaminated Soils	100tph
Gerschwiler	Switzerland	CD&E	100tph
Adriansson	Sweden	CD&E	100tph
Chambers	England	CD&E	100tph
FEES	Germany	Contaminated Soils	100tph
TECO NAAN	Israel	CDW	100tph
Gaskells	England	CD&E	100tph
Poullard	France	CD&E	100tph
ACC Eurovia	France	Contaminated Soils	100tph
Better Grow	Australia	Contaminated Soils	100tph
Brockelbank	England	CD&E	80tph
SRC	England	Contaminated Soils	80tph
JCK	Isle of Man	CD&E	80tph


KONTROLLRÅDET

SERTIFIKAT

Produksjonskontrollsystem

1111 – CPR – 0733


bsi. Certificate of Entitlement to use the Kitemark

BS EN 206 & BS 8500

in respect of Ready-Mixed Concrete supplied conforming to BS EN 206 and BS 8500-2 under a Quality Management System complying with ISO 9001.

The BSI Kitemark Scheme for Ready-Mixed Concrete is Accredited by UKAS, the UK Accreditation Service.

KITEMARK CERTIFICATE No. KM 97722

The Kitemark Scheme Certification Technical Manager, BSI, hereby confirms that

Wiltshire Heavy Building Materials Ltd
Hopton Park Industrial Estate
Hopton Road
Devizes
SN10 2EY
United Kingdom

is entitled to use the Kitemark in accordance with the Conditions governing the use of the Kitemark.

Paul Newby, 1st January 2019

Certificate of Entitlement valid to: 31st December 2019


CE

VELDE

YTELSESERKLÆRINGEN
NR. 311
CPR 2018.01.01

PUSHING THE BOUNDARIES

What’s next?

HOW DO WE DO BETTER?

- Environmental regulations are tightening
- Urban redevelopment, land reclamation
- Sustainable construction

Ongoing R&D and future developments:

- Goal: 100% material recovery
- Mobile solutions

Q&A

THANK YOU FOR YOUR ATTENTION! DON'T HESITATE TO GET IN TOUCH.

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T. +44 (0)7714 270 372