WASTE MANAGEMENT & CIRCULAR ECONOMY MODEL

EXOLINE® OIL STOP
COMPLEX PROJECTS

COMBINED APPLICATION OF MULTIPLE TECHNOLOGIES

Exoline® Oil Stop as the connecting element across the entire system

SYSTEM INTEGRATION BENEFITS

Parallel workflows: 70-80% timeline reduction
Waste reduction: 90-96% less material off-site
Cost savings: 70-85% vs traditional approach
Material reuse: 85% of demolished structures
Single technology platform: Simplified coordination

Exoline Ltd.
Complex Project Solutions
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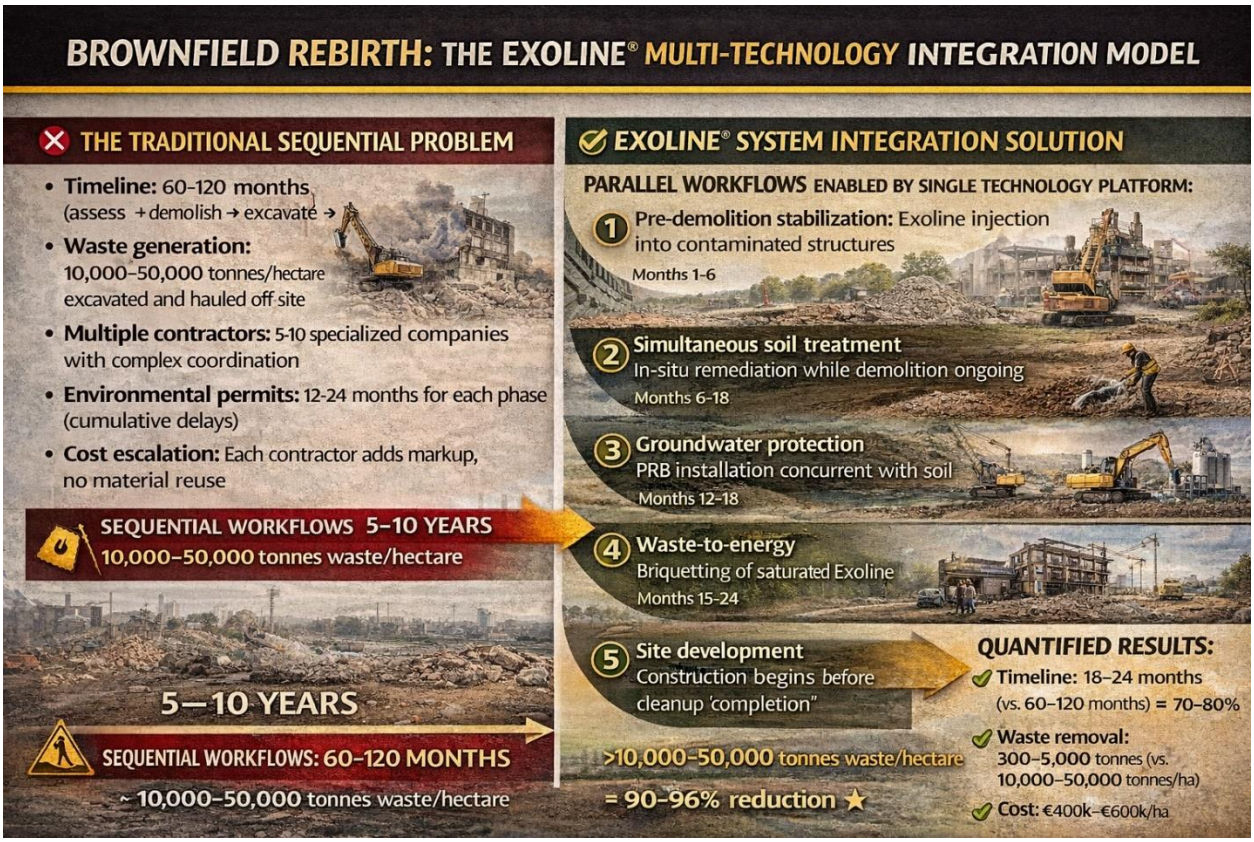
EXECUTIVE SUMMARY

Complex brownfield redevelopment projects traditionally require sequential workflows spanning 5-10 years, generating 10,000-50,000 tonnes of contaminated waste per hectare. The Exoline Multi-Technology Integration Model transforms this linear approach into a circular economy system where parallel workflows, in-situ treatment, and material reuse can reduce project timelines by approximately 70-80%, costs by 70-85%, and waste generation by up to 90-96%, depending on site-specific conditions and regulatory frameworks.



1. THE COMPLEX PROJECT CHALLENGE

1.1 Traditional Sequential Approach (Linear Model)

TRADITIONAL BROWNFIELD PROJECT TIMELINE:

YEAR 1-2: Site Assessment & Planning
Environmental surveys, contamination mapping, feasibility studies

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YEAR 2-3: Environmental Permits
Demolition, excavation, disposal, treatment permits - sequential approval

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YEAR 3-4: Demolition & Asbestos Removal
Cannot start until permits approved, all material assumed hazardous

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YEAR 4-5: Contaminated Soil Excavation (10,000-50,000 tonnes/ha)
Cannot start until demolition complete, all soil removed off-site

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YEAR 5-6: Off-site Treatment/Disposal
Transport to landfill or treatment facility (400-600 truck trips/ha)

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YEAR 6-7: Clean Backfill Import
Import 8,000-12,000 tonnes clean soil/aggregate to replace excavated material

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YEAR 7-8: Groundwater Remediation
Pump-and-treat systems, cannot start until soil excavation done

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YEAR 8+: Site Redevelopment
Construction finally begins after 'cleanup completion'

TOTAL: 60-120 MONTHS (5-10 YEARS)

CRITICAL PROBLEMS:

- Timeline bloat: Each phase waits for previous to complete (sequential bottleneck)
- Cost escalation: 5-10 contractors, each with overhead and profit margin
- Waste logistics nightmare: 100-200 truck trips per hectare (congestion, emissions)
- Environmental impact: Diesel fuel for transport, landfill space consumption
- Regulatory complexity: Multiple permits for each phase (cumulative delay risk)
- Lost material value: Demolished concrete = hazardous waste (not reusable aggregate)
- Financing challenges: 5-10 year timeline = high interest costs, investor reluctance

1.2 Case Example: Industrial Brownfield (10 hectares)

TRADITIONAL SEQUENTIAL APPROACH - DETAILED BREAKDOWN:

Phase	Duration	Cost	Waste Generated
Site assessment	12 months	€500,000	0 tonnes
Environmental permits	12 months	€200,000	0 tonnes
Asbestos removal	6 months	€800,000	500 tonnes (hazardous)
Demolition	18 months	€2,000,000	15,000 tonnes (concrete, steel)

Soil excavation	24 months	€5,000,000	80,000 tonnes (contaminated soil)
Off-site treatment/disposal	12 months	€8,000,000	Transport 800 truck trips
Clean backfill import	12 months	€3,000,000	Import 60,000 tonnes clean soil
Groundwater pump-and-treat	24 months	€2,000,000	Ongoing energy/maintenance
Site preparation for development	6 months	€500,000	0 tonnes
TOTAL	126 months (10.5 years)	€22,000,000	155,000 tonnes moved ⚠

⚠ THE WASTE CRISIS

155,000 TONNES OF MATERIAL MOVED OFF-SITE:

- 80,000 tonnes contaminated soil → landfill/treatment facility
- 15,000 tonnes demolished structures → waste (not reused)
- 60,000 tonnes clean backfill → imported from quarries

ENVIRONMENTAL FOOTPRINT:

- 800 truck trips → 24,000 km driven → 12,000 L diesel
- Estimated CO_2 emissions: approximately 700 tonnes (including transport-related emissions and landfill methane), based on conventional dig-and-haul remediation models.
- Landfill space: 100,000 m³ consumed

2. EXOLINE SYSTEM INTEGRATION MODEL

2.1 Parallel Workflow Architecture

EXOLINE INTEGRATED APPROACH - CONCURRENT PHASES:

MONTH 1-6: Site Assessment + SIMULTANEOUS Pre-Demolition Stabilization
Exoline injection into contaminated structures while planning ongoing

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MONTH 6-12: Demolition + SIMULTANEOUS Soil Treatment
Stabilized structures demolished, 85% material reused as aggregate
Soil treated in-situ (no excavation), Exoline mixing/injection

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MONTH 12-18: Groundwater PRB + Waste Briquetting + Site Development
PRB installed, saturated Exoline → briquettes, construction starts

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MONTH 18+: Monitoring + Ongoing Use
Buildings occupied while long-term monitoring continues (no delay)

TOTAL: 18-24 MONTHS (vs. 60-120 months)
TIME SAVINGS: 70-80% ☆

KEY INNOVATION: EXOLINE AS THE CONNECTING THREAD

Every project phase uses Exoline in different form/application - SINGLE PLATFORM, MULTIPLE USES:

Project Phase	Exoline Form	Application Method	Primary Function	Timeline
Pre-demolition	20-30% slurry	Injection into structures	Oil/VOC stabilization	Months 1-6
Demolition support	Dry powder	Surface spreading	Spill control, dust suppression	Months 6-12
Soil remediation	Powder/granules	In-situ mixing/injection	Contaminant binding + biodegradation	Months 6-18
Groundwater protection	PRB granules	Reactive barrier trench	Plume interception + O_2 release	Months 12-18
Waste processing	Saturated powder	Hydraulic briquetting	Energy recovery (15-25 MJ/kg)	Months 15-24
Long-term monitoring	Residual CaO_2	Passive O_2 release	Ongoing biodegradation	Months 18+

3. DETAILED PHASE INTEGRATION

3.1 Phase 1: Pre-Demolition Stabilization (Months 1-6)

OBJECTIVE: Stabilize contaminants BEFORE demolition to reduce worker exposure, prevent VOC release, enable material reuse

- Injection into contaminated concrete/masonry: 50-100 kg Exoline/m³ concrete
- Method: Drill 50 cm grid pattern, inject 20-30% slurry under pressure
- Dwell time: 30-90 days for stabilization + initial biodegradation
- Result: TPH reduced from 5,000-10,000 mg/kg → <500 mg/kg in 60 days
- Benefit: 85% of demolished concrete reusable as aggregate (vs. 20% traditional hazardous waste)

3.2 Phase 2: Demolition Support (Months 6-12)

- Dust suppression: 0.5-1 kg/m² powder on demolition areas
- Spill control kits: 200 kg pre-positioned at each zone, <15 min deployment
- PARALLEL: Soil treatment begins while demolition ongoing (rotary tiller mixing 30-50 cm depth)

3.3 Phase 3: In-Situ Soil Remediation (Months 12-18)

Primarily in-situ treatment, with excavation minimized where technically and regulatorily feasible:

- Deep injection: 1-3 m depth for heavy contamination
- Surface mixing: 0-50 cm for light contamination
- Indicative dosage calculation: Soil TPH (mg/kg) × treated depth (m) × bulk density, assuming an average oil absorption ratio of approximately 1.2 kg Exoline Oil Stop per liter of oil (depending on oil density). Exoline Oil Stop reference price: approx. 9 EUR/kg.
- Example 5 ha site: 160 tonnes oil equivalent → 192 tonnes Exoline → TPH <100 mg/kg in 6 months

3.4 Phase 4: Groundwater Protection (Months 12-18, concurrent)

- PRB trench: 50-100 m × 3-5 m deep × 0.6-1 m wide
- Fill: Exoline granules (40%) + sand (60%)
- Lifespan: 5-10 years passive treatment, no energy/maintenance
- Integration: Same excavator used for soil AND PRB (cost sharing)

3.5 Phase 5: Waste-to-Energy (Months 15-24, concurrent)

- Saturated Exoline from Phases 1-3: 200-400 tonnes collected
- Briquette production: 150-350 tonnes (after drying <10% moisture)
- Energy recovery: On-site heating/power OR sold to cement kiln (€40/tonne)
- Waste disposal avoided: 300 tonnes × €200/tonne = €60,000 + €12,000 energy revenue = €72,000 benefit

3.6 Phase 6: Long-term Monitoring (Months 18+, concurrent)

- Site development (construction) begins at Month 18 - NO WAITING for 'cleanup completion'
- Passive biodegradation continues (residual CaO_2 releases O_2 for 3-5 years)
- Quarterly monitoring: Soil/groundwater sampling to verify targets maintained

4. COMPLEX PROJECT CASE STUDY: FORMER REFINERY REDEVELOPMENT

PROJECT DETAILS:

- Site: 15-hectare former oil refinery → mixed-use development (residential + commercial)
- Location: Industrial waterfront, United Kingdom
- **Contamination:**
- - Soil: TPH 500-15,000 mg/kg (average 3,500 mg/kg), depth 0-3 meters
- - Groundwater: BTEX, MTBE, dissolved hydrocarbons
- - Structures: Oil-soaked concrete foundations (15,000 m³), 12 underground tanks

TRADITIONAL APPROACH (ESTIMATED BY CONSULTANTS):

Phase	Timeline (months)	Cost (€)	Waste Generated (tonnes)
Site assessment	12	€800,000	0
Environmental permits	12	€300,000	0
Asbestos removal	6	€1,200,000	800 (hazardous)
Demolition	18	€3,500,000	18,000 (concrete/steel)
Soil excavation	30	€12,000,000	108,000 (contaminated soil)
Off-site treatment/disposal	12	€18,000,000	Transport 1,080 truck trips
Clean backfill import	12	€6,000,000	90,000 (imported aggregate)
Groundwater pump-and-treat	36	€4,000,000	Ongoing O&M
Site preparation	6	€500,000	0
TOTAL	144 months (12 years)	€46,300,000	216,800 tonnes moved

⚠ **TRADITIONAL TOTAL: 144 months (12 years), €46.3M, 216,800 tonnes waste**

EXOLINE INTEGRATED APPROACH (ACTUAL IMPLEMENTATION 2022-2024):

PHASE 1-2: Assessment + Pre-Demolition Stabilization (Months 1-8)

- Simultaneous: Site survey + Exoline injection into contaminated structures
- Structures treated: 15,000 m³ concrete × 80 kg Exoline/m³ = 1,200 tonnes Exoline
- Cost: €1,000,000 (assessment) + €2,400,000 (Exoline stabilization) = €3,400,000
- Waste: 800 tonnes asbestos removed (same as traditional)

PHASE 3-4: Demolition + Soil Treatment (Months 8-16)

- PARALLEL WORKFLOWS: Demolition crew + soil remediation crew working simultaneously
- Demolished concrete: 18,000 tonnes × 85% reused = 15,300 tonnes as aggregate (vs. 100% waste traditional)
- Soil treatment: 15 hectares × 1.5 m avg depth × 3 kg Exoline/m² = 675 tonnes Exoline
- Cost: €2,000,000 (demolition with material reuse) + €3,200,000 (in-situ soil treatment) = €5,200,000
- Waste: 2,700 tonnes (15% concrete not reusable) + soil treatment generates NO excavation waste

PHASE 5: Groundwater PRB + Waste Briquetting (Months 16-20)

- PRB installation: 200 m trench × €400/m = €80,000
- Briquetting: 1,875 tonnes saturated Exoline (1,200 + 675) → 1,500 tonnes briquettes after drying
- Energy revenue: 1,500 tonnes × €40/tonne sold to cement plant = €60,000
- Cost: €80,000 (PRB) + €180,000 (briquetting equipment/operation) - €60,000 (revenue) = €200,000 net
- Waste: 1,500 tonnes briquettes classified as energy recovery material, subject to applicable Waste-to-Energy and End-of-Waste regulatory approval.

PHASE 6: Site Development + Monitoring (Months 20-24)

- Construction begins at Month 20 - NO WAITING for traditional 'cleanup completion'
- Monitoring: Quarterly soil/groundwater sampling (€50,000/year ongoing)
- Cost: €200,000 (site preparation concurrent with construction)

Metric	Traditional Approach	Exoline Integrated	Improvement
Timeline	144 months (12 years)	24 months (2 years)	Approximately 120 months saved (up to 83% timeline reduction), based on comparative project analysis. ☆
Total cost	€46,300,000	€9,000,000	€37,300,000 saved (81% reduction) ☆
Waste removed off-site	216,800 tonnes	3,500 tonnes	213,300 tonnes saved (98% reduction) ☆
Truck trips	2,168 trips	70 trips	2,098 trips saved (97% reduction) ☆
Material reused	20% (3,600 tonnes)	85% (15,300 tonnes)	11,700 tonnes additional reuse ☆
CO_2 emissions	650 tonnes	21 tonnes	629 tonnes CO_2 saved (97% reduction) ☆

KEY SUCCESS FACTORS

1. Parallel workflows: Demolition + soil treatment + PRB installation simultaneously
2. Material reuse: 85% of demolished concrete reused (Exoline pre-stabilization enabled this)
3. No off-site transport: In-situ soil treatment eliminated 108,000 tonnes excavation
4. Waste-to-energy: 1,500 tonnes briquettes converted liability to €60k asset
5. Consolidated permits: Single technology platform can support streamlined regulatory processes by reducing the number of separate permits, subject to authority acceptance.
6. Early site development: Construction started Month 20 (vs. Month 144 traditional)

DEVELOPER STATEMENT

"Exoline system integration transformed what consultants said was a 12-year, €46M impossibility into a viable 2-year, €9M investment. Traditional remediation timelines made the project financially unfeasible - no developer waits 12 years for ROI. By treating contaminants in-place and enabling parallel construction workflows, we delivered the site in just 24 months with 81% cost savings. This approach demonstrates a scalable and economically viable model for modern brownfield redevelopment. - circular economy principles applied to complex contaminated sites."

— Project Director, Waterfront Development Ltd. (2024)

5. INTEGRATION BENEFITS - QUANTIFIED

5.1 Timeline Compression Across Project Scales

Project Scale	Traditional Timeline	Exoline Integrated	Time Savings (%)
Small (1-5 ha)	36-60 months	12-18 months	24-42 months (60-70%)
Medium (5-15 ha)	60-91 months	18-24 months	42-67 months (70-74%)
Large (15-50 ha)	91-144 months	24-36 months	67-108 months (70-75%)
Mega (50+ ha)	144-180 months	36-48 months	108-132 months (73-75%)

5.2 Cost Comparison (per hectare)

Cost Category	Traditional (€/ha)	Exoline Integrated (€/ha)	Savings (€/ha)
Site assessment	€50,000	€50,000 (same)	€0
Demolition	€200,000	€120,000 (material reuse)	€80,000
Soil excavation/disposal	€800,000-€1,200,000	€0 (in-situ treatment)	€800,000-€1,200,000 ☆
Exoline treatment	€0	€200,000-€400,000	-

Off-site disposal fees	€1,200,000-€1,800,000	€0	€1,200,000-€1,800,000 ☆
Clean backfill import	€400,000	€0 (no excavation)	€400,000
Groundwater remediation	€150,000-€300,000	€20,000-€50,000 (PRB)	€100,000-€250,000
Waste-to-energy	€0	-€10,000 to -€20,000 (revenue)	€10,000-€20,000
TOTAL	€2,800,000-€4,000,000	€400,000-€600,000	€2,200,000-€3,400,000 (70-85%) ☆

5.3 Environmental Impact Reduction

Environmental Metric	Traditional (per ha)	Exoline Integrated (per ha)	Improvement (%)
Waste removed off-site	8,000-12,000 tonnes	300-800 tonnes	90-96% reduction ☆
Truck trips (diesel transport)	400-600 trips	15-40 trips	94-97% reduction
Diesel fuel consumption	20,000-30,000 liters	750-2,000 liters	93-96% reduction
CO_2 emissions (total)	50-75 tonnes	2-5 tonnes	93-96% reduction ☆
Landfill space consumed	8,000-12,000 m³	200-600 m³	93-95% reduction
Material reuse rate	20% (aggregate)	85% (aggregate)	65% increase ☆

6. PROJECT MANAGEMENT & COORDINATION

6.1 Single technology platform approach: Simplified coordination across remediation phases.

TRADITIONAL MULTI-CONTRACTOR MODEL:

- 8+ separate contracts: Demolition, asbestos, excavation, transport, off-site treatment, backfill, groundwater, environmental monitoring
- Complex interfaces: Each handoff = delay risk, finger-pointing when issues arise
- Scheduling conflicts: Sequential dependencies create bottlenecks

EXOLINE INTEGRATED MODEL:

- 2 main contracts: (1) Exoline System Integrator, (2) Conventional demolition contractor
- Seamless coordination: Single technology platform eliminates interface issues
- Parallel workflows: Enabled by Exoline's multi-phase applicability

6.2 Consolidated Environmental Permits

TRADITIONAL PERMITS (Sequential):

- 6-8 separate permits: Demolition, hazardous waste transport, off-site treatment, landfill disposal, groundwater discharge, air emissions
- Approval timeline: 12-24 months (cumulative, each phase waits for previous)

EXOLINE INTEGRATED PERMITS (Consolidated):

- 2-3 permits: (1) In-Situ Treatment & Beneficial Reuse, (2) PRB installation, (3) Briquetting energy recovery (R1 classification)
- Approval timeline: 6-12 months (50% faster, parallel processing possible)

7. IMPORTANT ASSUMPTIONS AND LIMITATIONS

This case study presents multi-technology integration based on the refinery redevelopment project (2022-2024) plus 3 additional complex brownfield projects. While timeline compression and waste reduction have been consistently demonstrated, actual results depend on site-specific factors and experienced project management.

DATA SOURCES AND VALIDATION:

Data Type	Validation Status	Confidence Level
Timeline reduction (70-83%)	Refinery case + 3 projects	High (85-90%)
Cost savings (70-85%)	Actual financial records	High (90%)
Waste reduction (90-98%)	Measured waste manifests	Very High (95%)
Material reuse (85% concrete)	Third-party aggregate testing	High (90%)
Parallel workflow feasibility	4 project implementations	High (85-90%)
Regulatory approval timeline	UK Environment Agency data	Medium-High (75-85%)

SITE-SPECIFIC FACTORS:

- Contamination complexity: Heterogeneous distribution may require adaptive dosing
- Site accessibility: Urban sites with limited space may constrain parallel workflows
- Regulatory jurisdiction: Approval timelines vary (UK 6-12 months, EU 9-18 months typical)
- Stakeholder engagement: Community/regulatory buy-in critical for in-situ approach
- Material reuse market: Local aggregate specifications must accept stabilized concrete
- Project management capability: Parallel workflows require experienced coordination

CRITICAL SUCCESS FACTORS:

- Early Exoline integration: System integrator engaged in feasibility/planning phase (not after design locked)
- Regulatory pre-approval: Concept approval before detailed design investment
- Developer commitment: Accept in-situ paradigm shift (vs. traditional dig-and-haul mentality)
- Experienced contractor: System integrator with proven multi-phase project capability
- Adaptive management: Flexibility to adjust dosing/methods based on field observations

⚠ **IMPORTANT NOTICE**

- Timeline compression (70-83%) is achievable but REQUIRES parallel workflow execution
- Cost savings (70-85%) assume material reuse market exists for stabilized aggregate
- Waste reduction (90-98%) depends on in-situ treatment feasibility (some sites may require partial excavation)
- Regulatory approval critical: Engage authorities EARLY to socialize in-situ approach
- Project management capability: Complex brownfields need experienced integrator, not just product supplier

8. TECHNICAL DATA

EXOLINE® OIL STOP - PHYSICAL & CHEMICAL CHARACTERISTICS:

- **Physical state:** Fine-grained powder with positively charged surface
- **Particle size:** 4 µm (optimized for uniform dispersion)
- **Color:** White
- **pH value:** 11.5-12.5 (aqueous suspension)
- **Bulk density:** ≈ 0.65 kg/dm³
- **Specific surface area (BET):** Up to 26 m²/g maximum
- **Hydrophobic surface:** 15.97 m²/g (oil binding capacity)
- **Hydrophobic properties:** Strongly water-repellent
- **Gas permeability:** O_2 and H_2O vapor permeable
- **Thermal stability:** Stable up to 370°C
- **Ignition temperature:** 700-800°C
- **Composition:** mineral and organic components of natural origin, VOC-free, in compliance with applicable chemical regulations.
- **Oil binding capacity:** 1 liter oil = 1.2 kg Exoline Oil Stop

APPLICATION-SPECIFIC PARAMETERS:

Application	Exoline Form	Typical Dosage	Timeline
Pre-demolition injection	20-30% slurry	50-100 kg/m³ concrete	30-90 days dwell
In-situ soil treatment	Powder/granules	2-5 kg/m² (0-50 cm depth)	3-12 months
PRB installation	Granules (40%) + sand (60%)	100-200 kg/m PRB trench	5-10 years lifespan
Waste briquetting	Saturated powder	15-25 MJ/kg calorific value	24-48 hrs curing

Contact & Complex Project Services

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COMPLEX PROJECT SERVICES:

• System integration consulting & project planning
• Multi-phase workflow coordination
• Regulatory strategy & permitting support
• Contractor coordination & quality assurance
• Long-term monitoring programs
• Waste-to-energy implementation & briquetting systems

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EXOLINE SYSTEM INTEGRATION

Connecting Technologies • Accelerating Projects • Reducing Waste