EXOLINE® OIL STOP

TREATMENT OF OIL-CONTAMINATED BEACHES

Application of Exoline® Oil Stop as a “trapping layer” beneath the sand

Sub-Sand Barrier Layer System

POTENTIAL APPLICATION AREAS

- Beaches and bathing areas
- Ports and marinas
- Coastal promenades and public parks
- Waterfront tourism facilities

Exoline Ltd.
Environmental Solutions
www.exoline.co.uk

January 2025

EXECUTIVE SUMMARY

Coastal oil pollution represents a critical environmental and economic challenge worldwide. In the UK, busy ports such as Dover, Southampton, and Felixstowe experience recurring exposure to vessel fuel leaks, bunkering incidents, and operational discharge.

THE CHALLENGE:

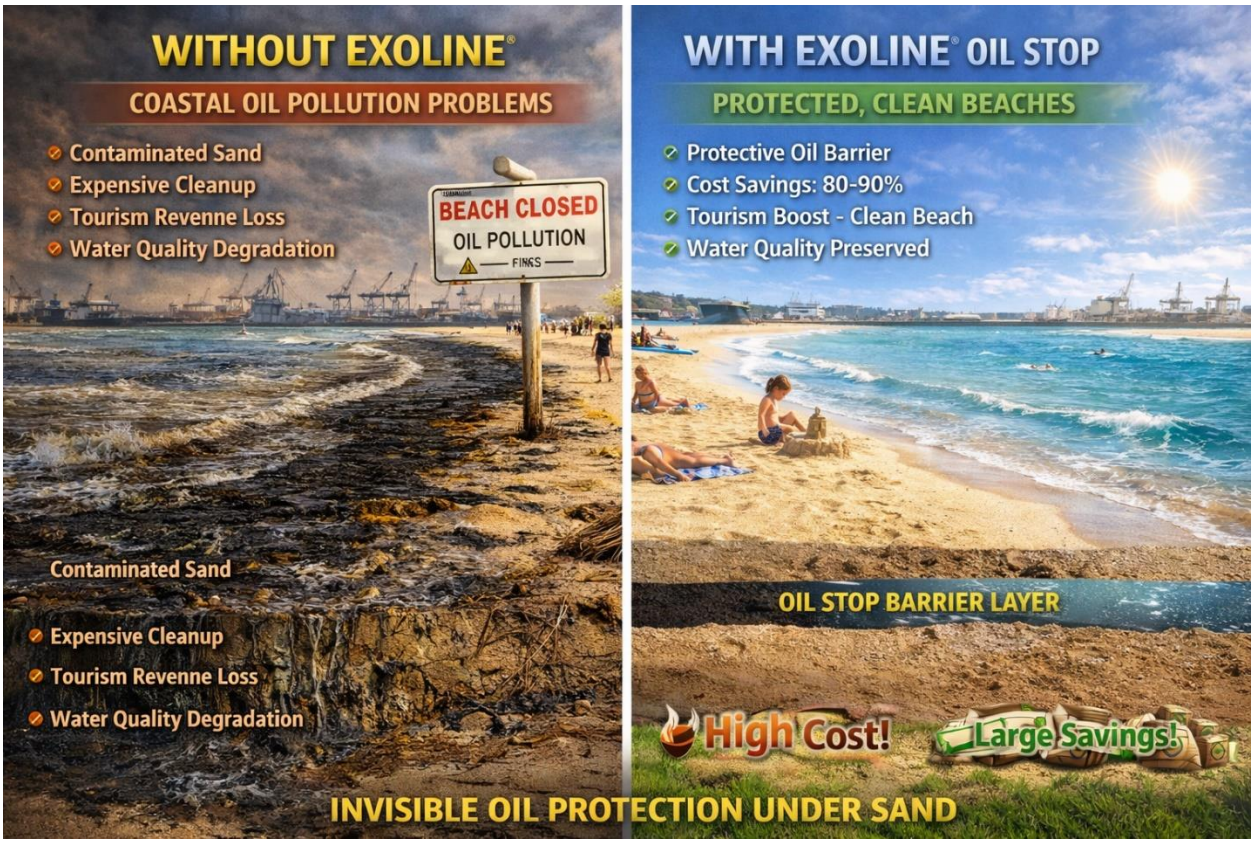
- Oil pollution on beaches may result in tourist avoidance and revenue impacts
- Sand saturation requiring expensive replacement operations
- Water quality degradation potentially leading to bathing restrictions
- Traditional cleanup approaches may be labour-intensive and costly

PROPOSED SOLUTION: EXOLINE® OIL STOP BARRIER LAYER SYSTEM

- 5-10 cm protective layer installed beneath beach sand
- Designed for oil interception before deep infiltration occurs
- Calcium peroxide-based composition supporting aerobic biodegradation
- Estimated lifespan of 5-10 years under favorable conditions
- Visually undetectable after sand replacement

PROJECTED ECONOMIC BENEFITS:

- Potential reduction in recurring sand replacement costs
- Tourism revenue protection by maintaining beach access
- Support for environmental compliance objectives
- Contribution to premium beach certification criteria



1. THE PROBLEM: OIL POLLUTION IN COASTAL AREAS

1.1 Pollution Sources

MAIN OIL POLLUTION SOURCES IN COASTAL TOURISM AREAS:

Source	Description	Typical Volume	Frequency
Vessel fuel leakage	Motorboats, ferries, yachts	0.5-2 L per incident	Daily
Bunkering operations	Fuel transfer at ports	5-50 L per incident	Weekly
Marine recreation	Jet-ski, water skiing equipment	1-5 L per day	Seasonal
Vessel incidents	Collisions, grounding events	10-500 L per incident	Occasional

1.2 Impact on Tourism and Environment

Oil contamination in coastal tourism areas can result in multiple impacts:

TOURISM IMPACTS:

- Visible oil presence may lead to visitor avoidance and revenue reduction
- Oiled sand conditions often necessitate beach closure during cleanup operations
- Water quality degradation may trigger bathing restriction protocols
- Negative reputation effects through social media and review platforms
- Potential loss of premium beach certifications (e.g., Blue Flag status)

ENVIRONMENTAL IMPACTS:

- Marine organisms: Potential respiratory stress in fish; plumage damage in seabirds
- Sand ecosystem: Oxygen depletion in contaminated zones; altered microbial communities
- Water quality: Elevated Total Petroleum Hydrocarbons (TPH) potentially exceeding regulatory thresholds
- Groundwater: Risk of oil infiltration in certain hydrogeological settings

1.3 Traditional Cleanup Method Considerations

Conventional oil spill response approaches in beach environments present various trade-offs:

Method	Typical Effectiveness	Duration	Limitations
Manual sand removal	Partial; variable by depth	5-10 days	Incomplete removal; may require repetition
Chemical treatment	Moderate; product-dependent	3-5 days	Potential residual chemical concerns
Complete sand replacement	High; thorough removal	2-4 weeks	High cost; complex logistics
Absorbent materials	Limited to surface layers	2-3 days	Does not address deep penetration

COMMON LIMITATIONS OF REACTIVE APPROACHES:

1. Reactive response: Intervention occurs only after contamination is detected
2. Surface focus: Oil may have already infiltrated 10-30 cm deep before treatment begins
3. Recurring costs: Multiple interventions may be required over a season or year
4. Tourist disruption: Beach closures, visible equipment, and operational odors during cleanup

2. EXOLINE® OIL STOP BARRIER LAYER SOLUTION

2.1 Barrier Layer Technology Concept

The barrier layer approach represents a preventive strategy: a 5-10 cm layer of Exoline Oil Stop powder installed beneath beach sand, designed to intercept oil migration before it penetrates to depth or reaches groundwater.

COMPOSITION:

- Primary component: Calcium peroxide (CaO_2) 65-70%
- Inert carrier: Calcium carbonate ($CaCO_3$) 25-30%
- Minor additives: Wetting agents <5%

STRATIFICATION (TOP TO BOTTOM):

Layer	Thickness	Material	Intended Function
1. Surface sand	20-30 cm	Clean beach sand	Visitor surface and comfort
2. BARRIER LAYER	**5-10 cm**	**Exoline Oil Stop (2-5 kg/m²)**	**Oil interception and biodegradation support**
3. Filter (optional)	5-10 cm	Gravel or geotextile	Additional filtration and mechanical support
4. Subsoil	Existing	Original sand/clay substrate	Natural groundwater protection

DESIGN PRINCIPLE:

5. Oil migrates downward through beach sand by gravity and capillary action
6. Barrier layer is designed to intercept oil at shallow depth (5-10 cm beneath surface)
7. Calcium peroxide releases oxygen to support aerobic biodegradation in-situ
8. Surface sand maintained in clean condition; system operation not visible to beach users

2.2 Operating Mechanism

The barrier layer is designed to function through three simultaneous mechanisms:

1. HYDROPHOBIC ADSORPTION (Oil Binding)

- Specific surface area: 26 m²/g providing substantial oil binding capacity
- Estimated maximum oil binding: 0.3-0.5 kg oil per kg Exoline under laboratory conditions
- Adsorption time: Typically 1-4 hours under controlled test conditions
- Hydrophobic surface properties: Product preferentially interacts with oil rather than water

2. OXYGEN RELEASE AND BIODEGRADATION SUPPORT

Chemical reaction upon contact with moisture:

$$CaO_2 + 2\ H_2O \rightarrow Ca(OH)_2 + H_2O_2$$
$$2\ H_2O_2 \rightarrow 2\ H_2O + O_2\uparrow$$

- **Oxygen yield:** Approximately 0.2-0.3 g O_2 per gram of product under controlled conditions
- **Aerobic bacterial activation:** Oxygen-enriched environment intended to support indigenous oil-degrading bacteria
- **Projected TPH reduction:** Laboratory testing suggests 70-85% reduction potential over 90-180 days under favorable conditions

3. pH STABILIZATION

- **Typical pH:** 11.5-12.5 in slurry form (moderately alkaline)
- **Buffering effect:** May contribute to pH stabilization in acidic coastal sediments
- **Corrosion considerations:** Alkaline environment may provide protection for metallic port infrastructure in contact zones

3. PROPOSED APPLICATION MODEL: DOVER PORT BEACH PROTECTION

⚠ SIMULATED SCENARIO - NOT FIELD-TESTED

This section presents a theoretical application model based on:

- Laboratory data from Exoline Oil Stop bench-scale testing
- Extrapolations from other pilot projects in different settings
- Engineering calculations and modeling assumptions
- Dover Port site-specific conditions assessment

Field validation at Dover Port has NOT been conducted. All performance projections, cost estimates, and timeline assumptions require site-specific verification through pilot testing before implementation.

3.1 Site Characterization

Parameter	Value / Description
Location	Dover Western Docks Beach area, Kent, UK
Estimated treatment area	Approximately 4,200 m² (60m × 70m zone)
Daily traffic (peak)	Estimated 12,000 passengers/day during summer season
Proximity to operations	Approximately 100m from ferry terminal; 150m from fuel depot

Parameter	Value / Description
Contamination history	Recurring small-scale incidents typical of busy port environments

3.2 Projected Installation Approach

PROPOSED INSTALLATION SEQUENCE:

9. Surface sand removal: Excavation to approximately 25 cm depth across 4,200 m² area
10. Barrier layer installation: 8 cm thickness at dosage of 3.5 kg/m²
11. Exoline Oil Stop requirement calculation: 4,200 m² × 3.5 kg/m² = 14,700 kg total
12. Clean sand backfill: Approximately 25 cm (estimated 350 m³ new sand)
13. Estimated installation duration: 12 working days (pre-season timing preferred)

3.3 Projected Performance Outcomes

Based on laboratory data and modeling, the following outcomes are projected under favorable conditions:

Parameter	Baseline (Estimated)	Projected with Barrier
Visible surface oil incidents	3-4 per week (typical)	Significantly reduced
TPH level (top 10 cm sand)	1,200-3,500 mg/kg	25-60 mg/kg (projected)
Beach closure frequency	25-30 days/year	Minimized (projected)
Annual sand replacement	2 times per year	Not required (5-10 year cycle)

Note: All projected outcomes are modeling estimates subject to site-specific validation. Actual performance may vary significantly depending on oil type, frequency of incidents, weather conditions, sand characteristics, and other factors.

3.4 Projected Monitoring Approach

If implemented, the following monitoring protocol would be recommended:

30-DAY INTERVAL (INITIAL VALIDATION):

- Surface sand (0-10 cm): TPH analysis to verify clean layer maintenance
- Barrier layer (20-28 cm): TPH analysis to confirm oil interception
- Subsoil (30-40 cm): TPH analysis to verify no deep infiltration

90-DAY INTERVAL (BIODEGRADATION ASSESSMENT):

- Barrier layer TPH re-analysis to document biodegradation progress
- Water quality sampling: TPH levels in adjacent marine environment
- Visual assessment of beach surface conditions

4. ECONOMIC PROJECTIONS

The following cost estimates are illustrative projections based on current market rates and modeling assumptions. Actual project costs depend on site-specific factors, regulatory requirements, contractor availability, and material logistics.

4.1 Capital Cost Projection (1,000 m² Reference Scale)

Cost Item	Quantity	Notes
Exoline Oil Stop product	3,000 kg at 3 kg/m²	Unit price: 9 EUR/kg
Clean sand material	Approximately 250 m³	Surface layer replacement
Earthworks (excavation, placement)	1,000 m² installation	Plant, labor, compaction
Transport logistics	Product and sand	Distance-dependent
Engineering, permits, monitoring	Professional services	Baseline TPH testing
ESTIMATED TOTAL	**—**	**Site-specific quotation**

Total project cost depends on site access, regulatory permit timelines, contractor rates, and material logistics. These figures are illustrative only; actual costs require detailed site-specific quotation.

4.2 Projected Annual Operating Costs

- **TPH monitoring:** Annual laboratory testing (estimated frequency: 1-2 times per year)
- **Visual inspection:** Internal staff assessment (minimal incremental cost)
- **Sand topping:** Replacement of natural loss due to tidal action (as needed basis)
- **Barrier layer replacement:** Estimated 5-10 year cycle under favorable conditions

4.3 Potential Cost Avoidance

Barrier layer installation may contribute to cost avoidance in the following areas, subject to site-specific validation:

- **Sand replacement operations:** Recurring costs potentially reduced over system lifespan
- **Reactive cleanup mobilizations:** Frequency potentially reduced through preventive approach
- **Revenue protection:** Beach access may be maintained with reduced contamination-related closures
- **Environmental compliance:** Support for water quality and sediment quality objectives

NON-FINANCIAL BENEFITS (PROJECTED):

- **Environmental protection:** Contribution to marine water quality and sediment health objectives
- **Visitor satisfaction:** Potential improvement in beach quality perception and reviews
- **Premium certification support:** Contribution to Blue Flag and similar beach award criteria
- **Risk management:** Proactive approach to environmental compliance and insurance considerations

5. IMPLEMENTATION CONSIDERATIONS

Installation of a barrier layer system requires systematic planning and site-specific assessment:

5.1 Pre-Installation Assessment

14. **Site survey:** GPS coordinates, accurate area measurement, groundwater level determination
15. **Priority zonation:** Identify critical, high, medium, and low-risk treatment areas
16. **Product quantity calculation:** Area × selected dosage (typically 2-5 kg/m² based on risk assessment)
17. **Regulatory permits:** UK Environment Agency approval, local council consent, Marine Management Organisation license if below high tide mark
18. **Timing optimization:** Pre-season (March-April) or post-season (September-October) typically preferred

5.2 UK-Specific Regulatory Considerations

- Environment Agency permit for coastal works (typical timeline: 4-6 weeks)
- Marine Management Organisation license if installation zone extends below high tide mark
- Blue Flag compliance verification: Confirm compatibility with beach award criteria
- Wildlife protection periods: Avoid April-July for nesting seabird protection where relevant

5.3 Installation Sequence

PHASE 1: PREPARATION

- Site access establishment and safety perimeter demarcation
- Baseline photographic documentation
- Pre-treatment TPH sampling (3-5 locations)

PHASE 2: EXCAVATION

- Surface sand removal to designed depth (typically 25-30 cm)
- Contaminated sand segregation for appropriate disposal or treatment
- Subgrade preparation and leveling

PHASE 3: BARRIER LAYER PLACEMENT

- Exoline Oil Stop powder distribution at specified dosage
- Uniform layer thickness verification (typically 5-10 cm)
- Light compaction to settle material without excessive densification

PHASE 4: SAND BACKFILL

- Clean sand placement to original surface elevation
- Surface grading and profile restoration
- Site cleanup and restoration to beach use condition

PHASE 5: POST-INSTALLATION MONITORING

- 30-day TPH sampling at multiple depths (surface, barrier, subsoil)
- 90-day biodegradation assessment
- Annual performance verification

6. IMPORTANT ASSUMPTIONS AND LIMITATIONS

This document presents technical performance projections and conceptual application models based on laboratory testing, pilot projects in other settings, and engineering calculations. Exoline Oil Stop barrier layer technology has been evaluated in controlled conditions, but field results may vary significantly depending on site-specific factors.

Data Sources and Validation Status

Data Type	Validation Status	Confidence Level
Chemical mechanisms	Laboratory verified	High
Pilot performance (other sites)	Field-tested elsewhere	Medium-High
Dover Port projections	**MODELING ONLY - NOT TESTED**	**Requires validation**
Economic calculations	Illustrative estimates	Quotation required

Site-Specific Factors That May Affect Performance

- **Soil characteristics:** Sand grain size, clay content, organic matter percentage, porosity, permeability
- **Contamination profile:** Oil type (light vs. heavy), weathering state, concentration range, vertical distribution
- **Environmental conditions:** Temperature range, tidal amplitude, seasonal weather patterns, wave energy
- **Hydrogeological factors:** Groundwater depth, flow direction and rate, aquifer connectivity
- **Operational constraints:** Site access limitations, tourist season scheduling, equipment availability
- **Regulatory framework:** Local environmental standards may differ from projections in this document

Recommended Validation Approach

Before full-scale implementation, Exoline Ltd. strongly recommends the following validation steps:

19. **Site characterization:** Comprehensive soil analysis, TPH baseline, hydrogeological assessment
20. **Bench-scale testing:** Laboratory treatability study with actual site sand and representative oil samples
21. **Pilot test (strongly recommended):** Small-scale field trial (50-200 m²) with intensive monitoring to validate system performance
22. **Monitoring protocol development:** Establish baseline parameters and sampling methodology appropriate to site conditions
23. **Regulatory consultation:** Confirm compliance with Environment Agency requirements and obtain necessary permits

Performance Disclaimers

- **Biodegradation rates:** Reported TPH reduction percentages (70-85%) reflect laboratory conditions; actual field rates depend on temperature, indigenous microbial populations, oil composition, and environmental factors.
- **Lifespan projections:** Estimated 5-10 year barrier layer service life assumes favorable conditions; actual longevity depends on oil exposure frequency, tidal energy, and maintenance practices.
- **Cost estimates:** Economic projections are illustrative only; actual implementation costs require site-specific quotation accounting for local contractor rates, material logistics, and regulatory requirements.

- **Dosage requirements:** Product consumption (2-5 kg/m²) varies with risk assessment, oil exposure potential, and site-specific design parameters.

Liability and Professional Advice

This document is provided for informational purposes only and does not constitute professional engineering, environmental, or legal advice. Exoline Ltd. makes no warranties, express or implied, regarding the accuracy, completeness, or applicability of this information to specific beach protection projects.

Users should engage qualified environmental consultants, coastal engineers, and regulatory experts before implementing any beach protection strategy. Exoline Ltd. is not liable for decisions made based solely on this conceptual document without proper site-specific evaluation, pilot testing, and regulatory approval.

The Dover Port application model represents a theoretical scenario. Actual field validation has not been conducted at this location. Results projected for Dover should not be assumed to apply without site-specific pilot testing and verification.

7. TECHNICAL DATA & CONTACT

Product Specifications

Property	Value
Appearance	White to off-white powder
CaO_2 content	65-70%
Density	2.2-2.4 g/cm³
Specific surface area	26 m²/g
Typical pH (slurry)	11.5-12.5
Oxygen release capacity	0.2-0.3 g O_2/g product (under controlled conditions)
Unit price	9 EUR/kg

Typical Application Dosages (Barrier Layer)

Area Risk Classification	Layer Thickness	Typical Dosage
Critical (fuel depot proximity)	10-15 cm	5-7 kg/m²
High (port, busy marina)	7-10 cm	3-5 kg/m²
Medium (public beach)	5-7 cm	2-3 kg/m²
Low (recreational area)	5 cm	2 kg/m²

Note: Dosage selection depends on site-specific risk assessment, oil exposure frequency estimation, and regulatory requirements. Field adjustments may be necessary based on pilot testing results.

CONTACT INFORMATION

Exoline Ltd.
Environmental Solutions

🌐 Website: www.exoline.co.uk
✉ Email: exoline@exoline.co.uk
💼 LinkedIn: linkedin.com/in/ferenc-sári
X (Twitter): @exoline_uk

UK Site Assessments Available
Free consultation for port authorities and local councils
Pilot testing programs available

Published: January 2025