Best Practices for Environmentally Responsible Maintenance Dredging in the River Tees: An Integrated Framework for TSHD Operations

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1 The Dichotomy of the Tees: A Working River in a Protected Seascape

The River Tees represents a profound and complex challenge in modern environmental management. It is simultaneously a vital artery of commerce, essential to the economic prosperity of the Tees Valley and the wider UK, and a critically important ecological sanctuary, home to habitats and species of national and international significance. The routine activity of maintenance dredging, indispensable for the river's function as a major port, lies at the nexus of this conflict. This report provides an integrated framework for best practices in maintenance dredging, specifically focusing on the use of Trailing Suction Hopper Dredgers (TSHDs). It seeks to reconcile the statutory duty to maintain navigation with the legal and ethical imperative to protect a fragile and highly designated marine environment. The analysis establishes that best practice is not a static set of rules but a dynamic, adaptive process that requires advanced technology, procedural rigour, and a strategic shift from a waste disposal mindset to one of resource management.

1.1 The Economic Imperative: The Role of PD Ports as Statutory Harbour Authority

The operational necessity of maintenance dredging in the River Tees is absolute and legally mandated. PD Ports, as the Statutory Harbour Authority (SHA), holds a 12-mile jurisdiction along the river and is vested with the public duty and statutory power to conserve the harbour and facilitate safe navigation for all vessels. This responsibility is not discretionary; it is a fundamental requirement for the functioning of Teesport, one of the UK's largest ports by volume. The economic stakes are immense. The port and its associated industries contribute an estimated £1.4 billion to the UK economy annually and support a workforce of 22,000 jobs in the wider supply chain, making PD Ports the largest private employer in the Tees Valley region[1].

To accommodate the diverse and large-scale shipping that underpins this economic activity, the SHA must maintain prescribed channel depths. The approach channel has a charted depth of 15.4m below Lowest Astronomical Tide (LAT), which progressively reduces to 4.5m LAT further upstream near Billingham Beck[2]. These depths are maintained through a continuous programme of maintenance dredging to remove river-borne silts and marine sands that would otherwise cause shoaling and render the channel unnavigable for the large vessels that use the port, which can reach lengths of up to 305m[2]. The critical nature of this work is starkly articulated by PD Ports' Chief Executive Officer, who stated that without dredging, "all economic activity on the Tees would stop within weeks, if not days"[3].

This operational imperative is set against a backdrop of ambitious future growth. The "Future Teesport" vision aims to establish the River Tees as the UK's most successful port region by 2050, defined by high-value trade and sustainability[4]. Projections anticipate a 70% increase in container volumes and a 110% increase in dry bulk volumes by 2029, driven by the expanding UK container and renewable energy sectors. Furthermore, the creation of a new Freeport on the Tees is projected to add a further £2 billion to the economy and create up to 32,000 new jobs[4]. These growth ambitions inherently imply that the demand for maintenance dredging will not diminish but will likely intensify, making the adoption of environmentally responsible best practices more critical than ever to ensure this growth is sustainable. The SHA's own public commitments, including a mission to become the "UK's most sustainable port company" and to develop a "Green Port Strategy," create a self-imposed driver to move beyond mere regulatory compliance and towards genuine environmental leadership[1]. This establishes a complex dynamic where the entity responsible for a potentially impactful industrial activity is also a key stakeholder in, and public proponent of, the river's environmental health.

1.2 The Ecological Jewel: The Teesmouth and Cleveland Coast Designated Sites

Juxtaposed with the intense industrial and commercial activity is an ecosystem of exceptional environmental value. The Tees Estuary is not merely a site of ecological interest; it is a protected landscape formally recognized through multiple overlapping and mutually reinforcing legal designations. In 2018, Natural England confirmed the notification of the Teesmouth and Cleveland Coast Site of Special Scientific Interest (SSSI), a landscape-scale designation covering nearly 3,000 hectares (12 square miles)[5]. This single SSSI merged and expanded seven previously separate sites, including Seal Sands, Redcar Rocks, and Coatham Sands, to provide a more coherent and comprehensive conservation framework[6]. The SSSI underpins the even more stringent protections of the Teesmouth and Cleveland Coast Special Protection Area (SPA) and Ramsar site, which are designated under international conventions and UK law to protect rare habitats and bird species of European importance.[9] The SPA covers over 12,000 hectares, of which nearly 90% is marine area[7].

The special interest of these designated sites is multifaceted. They encompass a rich mosaic of coastal habitats, including intertidal sand and mudflats, saltmarsh, sand dunes, rocky shores, and saline lagoons[8]. These habitats are themselves of high conservation value; the estuary supports the largest area of saltmarsh between Lindisfarne and the Humber and the most extensive sand dune complex between Northumberland and East Yorkshire[6]. The significance of these habitats is amplified by the historical context: the Tees is one of the most heavily modified estuaries in the country, having lost approximately 90% of its intertidal habitats to land claim and industrial development[6]. The remaining semi-natural areas are therefore precious remnants, nestled amongst the infrastructure of one of the UK's busiest ports and a significant portion of its chemical industry[6].

These habitats, in turn, support a remarkable array of wildlife. The site is of national importance for its breeding population of harbour seals (*Phoca vitulina*), which recolonized the estuary in the 1980s. The intertidal mudflats of Seal Sands constitute the only regular pupping site for this species in the whole of north-east England[6]. The area is also a vital hub for birdlife. It supports nationally important breeding populations of avocet (*Recurvirostra avosetta*), common tern (*Sterna hirundo*), and little tern (*Sternula albifrons*), and is of international importance for its non-breeding waterbird populations[6]. The SPA designation specifically protects an assemblage of over 20,000 non-breeding waterbirds and qualifying populations of ten species, including knot (*Calidris canutus*), redshank (*Tringa totanus*), and Sandwich tern (*Thalasseus sandvicensis*)[7]. The sand dunes also host a nationally important assemblage of invertebrates, including at least 14 threatened species[6].

The following table provides a consolidated summary of the key ecological receptors within the designated sites and their specific vulnerabilities to dredging operations, forming a critical baseline for risk assessment and the development of targeted mitigation strategies.

Table 1: Key Ecological Receptors and Sensitivities in the Teesmouth and Cleveland Coast Designated Sites

Ecological Receptor	Designation Feature	Key Sensitive Period(s)	Primary Vulnerabilities to TSHD Dredging
Harbour Seal (*Phoca vitulina*)	SSSI, SPA (supporting habitat)	**Pupping Season: June - July**; Year-round haul-out at Seal Sands	Noise and visual disturbance leading to stress, altered behaviour, and potential mother-pup separation/abandonment. Indirect impacts from changes to prey availability[6].
Little Tern (*Sternula albifrons*)	SSSI, SPA (Breeding & Passage)	**Breeding Season: May - August**	Noise and visual disturbance at foraging areas. Turbidity plumes reducing foraging success (visual hunters). Smothering of prey species in intertidal areas[6].
Common Tern (*Sterna hirundo*)	SSSI, SPA (Breeding)	**Breeding Season: May - August**	Noise and visual disturbance at foraging areas. Turbidity plumes reducing foraging success. Indirect impacts on prey availability[6].
Sandwich Tern (*Thalasseus sandvicensis*)	SSSI, SPA (Passage)	**Passage Periods: Spring (April-May) &**	Noise and visual disturbance at foraging/roosting sites. Turbidity plumes impacting foraging on small fish[6].

		Autumn (August-October)	
Non-breeding Waterbirds (e.g., Knot, Redshank, Sanderling)	SSSI, SPA (Wintering Assemblage)	**Wintering Period: November - March** (peak numbers)	Disturbance at low-tide feeding grounds. Smothering and siltation of intertidal mudflats, reducing biomass/availability of benthic invertebrate prey[6].
Migratory Fish (e.g., Atlantic Salmon)	Not a primary designation feature, but ecologically important	**Main Migration: July - August** (and other periods)	Turbidity plumes acting as a potential barrier to migration. Noise disturbance. Oxygen depletion from sediment resuspension[9].
Intertidal Mudflats & Sandflats	SSSI, SPA, Ramsar (Habitat Feature)	Year-round	Direct removal of habitat. Smothering and changes in sediment composition due to siltation from plumes. Remobilisation and deposition of contaminants[10].
Saltmarsh	SSSI, Ramsar (Habitat Feature)	Year-round	Indirect impacts from altered hydrodynamics and sediment supply. Potential for smothering at the marsh edge from excessive siltation[6].
Benthic Communities (Infauna, Epifauna)	Supporting feature for birds/fish	Year-round	Direct removal (entrainment). Smothering and mortality from siltation. Changes in community structure due to altered sediment type. Bioaccumulation of remobilised contaminants[11].

1.3 The Dredging Operation: Current Fleet and Methodology

The maintenance dredging operation in the Tees is a continuous, large-scale industrial process tailored to the specific sedimentary characteristics of the river. PD Ports employs a fleet of two primary vessels for this task: the "Heortnesse" and the "Emerald Duchess", which replaced the "Cleveland Count" in 2024.[23] Both are traditional Trailing Suction Hopper Dredgers (TSHDs) with a hopper volume of approximately 1500m^3 / 2300m^3 and active bottom door dumping systems for disposal[12]. Their roles are differentiated by the type of material they target. The "Heortnesse," the larger vessel by deadweight, is equipped with an active drag-head to assist in excavating denser material and predominantly dredges sand or sandy silts. It typically operates on a six-day-per-week schedule. Previously, the smaller "Cleveland County" concentrated on finer materials—silts and fine sands—and was also used for more precise dredging in berths and along frontages, operating on a three-day-per-week basis[12]. It is assumed that the new "Emerald Duchess" is a more flexible vessel able to take on both roles[13].

The dredging statement is based on the fact that the sediment below the top of the riverbed surface the composition of the dredged material varies systematically along the river's length. In the upper reaches of the maintained channel (designated as chart areas 1 to 5), the material is generally of an organic, silty nature. Moving downstream towards the estuary mouth (chart areas 6 to 8), the sediment transitions to sandy silt and silty sand. From chart area 9 seaward, the material is predominantly sand, becoming coarser further out into the sea reaches[12]. This variation is significant, as the finer, organic silts are more likely to be associated with historical contamination.

Dredging operations are nominally scheduled for 8-10 hours per day, primarily during daylight hours. However, the operational tempo is highly responsive to environmental conditions. Following storm events, which can cause sudden and significant deposition of sediment in the channel, the dredging intensity can be increased to 22 hours a day, seven days a week for limited periods to restore navigable depths. When both vessels worked together at maximum capacity, the disposal rate can reach approximately 1,200 metric tonnes per hour. In addition to the TSHDs, PD Ports also utilizes a plough dredger. This vessel employs a 5-metre bed-leveller to move material from isolated high spots, particularly in confined areas or near frontages, into deeper adjacent areas where it can be more efficiently removed by the TSHDs. This practice helps maintain depths without necessarily increasing the total volume of material disposed of at sea[12].

Regardless of where it is dredged, all material is transported to a single, designated offshore disposal site: Tees Bay 'A' (TY160)[14.]. This site is managed under a strict protocol. It is subdivided into 12 distinct zones, which are rotated on a monthly basis to disperse the impact of disposal over a wider area. The positioning of the dredgers for disposal is controlled using integrated navigation software and confirmed by the Port's Vessel Traffic Service (VTS), ensuring accurate placement and recording. This entire operational cycle—from dredging to transport and disposal—forms the baseline against which all environmental risks and potential best practices must be assessed.

2 The Regulatory Gauntlet: Navigating Environmental Law and Policy for Dredging

The execution of maintenance dredging in the River Tees is governed by a multi-layered and intricate regulatory framework. This system is designed to balance the port's operational needs with the stringent environmental protections afforded to the estuary. It involves a triumvirate of key governmental bodies—a licensing authority, scientific advisors, and habitat experts—working within a legal structure defined by UK and international law. Understanding this regulatory gauntlet is essential to defining best practice, as it dictates the minimum standards of environmental performance and establishes the mechanisms through which risk is assessed and managed.

2.1 The Licensing Authority: The Marine Management Organisation (MMO)

The primary regulatory body for dredging-related activities in English waters is the Marine Management Organisation (MMO). The MMO's authority stems from the Marine and Coastal Access Act 2009 (MCAA), which mandates that a marine licence is required for specific activities, including the disposal of substances at sea. A crucial nuance in the regulation of the Tees is that while the MMO licenses the *disposal* of dredged material, it does not license the *dredging activity* itself. Under Section 75 of the MCAA, statutory harbour authorities like PD Teesport are granted an exemption that covers their dredging activities to maintain the port[15].

Consequently, the MMO's principal lever of control over the entire process is the disposal licence. PD Teesport currently operates under marine licence L/2015/00427, which was granted on 30 December 2015 and is set to expire on 31 December 2025. This licence permits the disposal of up to a maximum of 2,889,700 tonnes (wet weight) of dredged material per year into the designated Tees Bay 'A' (TY160) disposal site. The licence is not a static permission but a dynamic regulatory instrument. It contains specific conditions, most notably a requirement for comprehensive sediment sampling and analysis at three-yearly intervals[14].

The history of this licence demonstrates the MMO's adaptive management approach. The licence has been varied on multiple occasions in response to new evidence, primarily from sediment analysis. For example, Variation 3 (September 2019) introduced a new condition that prohibited the disposal of material from the Billingham Reach area at sea, following sampling results that showed high contaminant levels. This restriction was later lifted under Variation 4 after the applicant provided further sampling evidence that, following consultation with scientific advisors, was deemed to demonstrate the material was suitable for sea disposal[14]. This process highlights that the chemical quality of the sediment is the lynchpin of the regulatory system. While this demonstrates an evidence-based approach, it has also drawn criticism that the system is reactive and that the MMO, by allowing disposal of historically contaminated material, is not applying a sufficiently precautionary approach, particularly in an already stressed industrial estuary[9].

2.2 The Scientific Advisors: Cefas and Natural England

The MMO does not make its licensing decisions in a vacuum. It relies heavily on the expert scientific and technical advice of two key statutory bodies: the Centre for Environment, Fisheries and Aquaculture Science (Cefas) and Natural England[15].

Cefas provides the core scientific advice on the physical and chemical properties of the dredged material and the potential impacts of its disposal. As part of the licensing process, Cefas reviews sediment chemistry data submitted by applicants and advises the MMO on the material's suitability for sea disposal, assessed against international obligations such as the OSPAR Convention guidelines[15]. Cefas's role extends beyond pre-licence assessment. Under a service level agreement with the MMO, Cefas conducts its own independent, long-term monitoring of dredged material disposal sites around England, including Tees Bay 'A' (TY160) and the nearby Tees Bay 'C'

(TY150)[16]. These monitoring surveys, conducted from Cefas research vessels, analyse sediment particle size, contaminant concentrations (such as PAHs and organohalogens), and benthic fauna. The resulting reports provide a crucial, independent dataset that tracks long-term trends and informs the MMO's risk assessment and decisions on licence conditions and variations.[31]

Natural England is the government's advisor for the natural environment in England, and its role in the Tees dredging context is to advise on the potential impacts of the activity on legally protected habitats and species. Natural England was the lead body in the designation of the expanded Teesmouth and Cleveland Coast SSSI and the proposed extension of the SPA[5]. When dredging operations are planned that could affect these designated sites, Natural England acts as a statutory consultee, providing expert advice to the MMO on the requirements of the Conservation of Habitats and Species Regulations 2010 (the "Habitats Regulations"). This advice is critical in shaping the scope and conclusions of Habitats Regulations Assessments (HRAs) and in defining necessary mitigation measures to protect the integrity of the designated sites.

To streamline this complex interaction, the MMO, Natural England, and the Environment Agency have signed a Memorandum of Understanding (MoU) for the Tees Estuary. This agreement aims to provide a more efficient and consistent regulatory service by establishing a "one lead authority" principle, coordinating advice, and reducing the duplication of evidence requirements for developers and operators[17]. This partnership model, created under the auspices of the Tees Estuary Partnership, is designed to balance environmental protection with sustainable economic growth in this uniquely challenging location.

2.3 The Assessment Framework: HRAs and Sediment Analysis

The regulatory framework is put into practice through two principal assessment mechanisms: the Habitats Regulations Assessment (HRA) and routine sediment sampling and analysis.

The HRA is a legally mandated process under the Habitats Regulations for any plan or project that may have a significant effect on a European designated site (i.e., an SPA or SAC).[10] Given that dredging operations take place within and adjacent to the Teesmouth and Cleveland Coast SPA, an HRA is a critical component of the assessment process.[17] The HRA process involves a rigorous, staged assessment to determine if a project, alone or in combination with other plans, is likely to have a significant effect on the site's conservation objectives. If a likely significant effect cannot be ruled out, an "Appropriate Assessment" is required to determine whether the project will have an adverse effect on the integrity of the site.[17]

A recent HRA for a project in the Tees provides a concrete example of this framework in action. The assessment identified specific risks from dredging, including "Visual Disturbance & Noise" to protected bird species and "Smothering and siltation rate changes" impacting the intertidal mudflat habitats[18]. Because these effects could not be ruled out, an Appropriate Assessment was necessary. This process resulted in the imposition of specific mitigation measures as licence conditions to avoid an adverse effect. A key mitigation measure retained on an existing licence is a temporal restriction, prohibiting dredging activities in a specific area during the period two hours on either side of low tide between November and January, inclusive, to protect feeding birds during a critical time[18]. This demonstrates how the HRA process translates ecological risk into tangible, legally enforceable operational constraints.

The second pillar of the assessment framework is sediment analysis. The disposal licence explicitly requires PD Teesport to conduct sediment sampling and analysis at three-yearly intervals[14]. This is not a passive monitoring exercise; the results directly inform the MMO's regulatory decisions. The process is highly regulated: a sampling plan must be agreed with the MMO in consultation with Cefas, and the analysis must be conducted by an MMO-validated laboratory.[17] The results are assessed against action levels defined by Cefas and OSPAR guidelines.[29] As noted, these results have led directly to licence variations, such as the temporary restriction on disposal from Billingham Reach[14]. Long-term monitoring by Cefas has established that sediments in the Tees, particularly those disposed of at the Inner Tees site, are consistently high in contaminants like PAHs, a legacy of the region's industrial history[19]. While Cefas reports indicate that these levels have remained broadly stable over time, the very presence of this contamination places the dredging operation under intense scrutiny. The regulatory decision to allow its disposal at sea, based on a judgment that the risk is contained and monitored, lies at the heart of the debate over whether the current framework is sufficiently precautionary or is permissive of ongoing, low-level pollution in a sensitive environment[9].

3 A Synthesis of Environmental Risks from TSHD Operations

The year-round maintenance dredging in the River Tees, while operationally necessary, presents a suite of specific and significant environmental risks. These risks are not abstract but are direct consequences of the interaction between the chosen dredging technology—the Trailing Suction Hopper Dredger (TSHD)—and the unique ecological and geochemical characteristics of the estuary. The primary impact pathways can be categorized as chemical (contaminant remobilisation), physical (turbidity and siltation), and biological (direct disturbance to fauna). A thorough understanding of these risks is the prerequisite for developing effective mitigation strategies.

3.1 The Legacy Below: Contaminant Remobilisation and Water Quality Degradation

The sediments of the River Tees are a repository of its long industrial history, containing legacy contaminants that pose a persistent environmental threat. A primary risk associated with dredging is the remobilisation of these substances. The mechanical action of the TSHD's drag head on the riverbed and the subsequent overflow of fine sediment slurry can stir up these historical deposits, releasing contaminants from the sediment matrix back into the water column. Once in the water column, these contaminants can become more bioavailable, meaning they can be taken up by marine organisms, potentially entering the food chain and causing toxic effects such as poisoning and reproductive issues[20,21].

The contaminant of greatest concern in the Tees is a group of compounds known as Polycyclic Aromatic Hydrocarbons (PAHs), which are by-products of burning fossil fuels and are associated with industrial processes[22]. Independent monitoring by Cefas at the Inner Tees disposal site (TY160) has confirmed the presence of significantly elevated PAH levels. A 2023 report documented a summed PAH concentration as high as 83,300μgkg^{-1} (dry weight) in sediments at the southern corner of the disposal site, with other high concentrations of 69,300μgkg^{-1} and 61,700μgkg^{-1} also recorded within the site. Analysis indicated that the source of this contamination was predominantly petrogenic, meaning it originated from oil-based products rather than combustion[19]. While Cefas's long-term data suggests that overall PAH concentrations have remained generally comparable to historical levels, some individual monitoring stations have shown recent increases, and the levels remain among the highest found in UK marine sediments[19].

This issue is compounded by the choice of dredging equipment. International guidance from the OSPAR Commission, which the UK follows, has assessed various dredging techniques for their suitability in handling contaminated sediments. In this assessment, the TSHD is ranked as the *least suitable* technique for contaminated sediment dredging because it causes dispersal of sediments and mixes contaminated material with clean surrounding sediments. The very nature of its operation—dragging a suction head across the seabed and overflowing fine particles—is counter-intuitive to the precise, contained removal required for contaminated sites[23]. The fact that PD Ports' primary maintenance dredging tools are TSHDs, operating in an estuary with known sediment contamination hotspots, creates a fundamental conflict. The regulatory response has been to manage this risk through monitoring and, when necessary, temporary restrictions on disposal from specific areas, as was the case with Billingham Reach[14]. However, this approach does not eliminate the inherent risk of contaminant remobilisation during the dredging and overflow process itself, which can create a diffuse pollution source within the estuary, impacting water quality and posing a risk to the sensitive ecological receptors of the SSSI and SPA.

3.2 The Spreading Plume: Turbidity, Siltation, and Benthic Smothering

Beyond the chemical risks, TSHD operations generate significant physical impacts, primarily through the creation of sediment plumes that increase water turbidity and lead to siltation. Turbidity, a measure of water cloudiness, is increased by the suspension of fine particles in the water column[24]. A TSHD generates turbidity at two main points: at the seabed, where the drag head excavates material, and in the water column, from the discharge of overflow water[25]. The overflow process is integral to the efficiency of a TSHD; as the hopper fills with a slurry of sediment and water, the excess water, laden with the finest sediment particles, is discharged overboard to maximize the volume of denser solids retained in the hopper[25]. This creates a visible plume of suspended sediment that can drift with the current.

The environmental consequences of this plume are manifold. Increased turbidity reduces light penetration into the water, which can inhibit the growth of submerged aquatic vegetation and affect the foraging ability of visual predators like fish and seabirds[23]. The suspended particles can also clog the gills of fish and filter-feeding benthic organisms[11]. As the plume disperses and the particles settle out, they cause siltation—the deposition of fine sediment on the seabed. This can smother benthic habitats, burying organisms such as worms and shellfish that form the base of the estuarine food web and are a key food source for the protected bird populations of the SPA[11]. In severe cases, this deposition can alter the composition of the seabed, turning sandy or gravelly substrates into muddy ones, thereby changing the entire benthic community structure[26]. Furthermore, the decomposition of organic matter within the resuspended sediment can consume dissolved oxygen in the water, potentially leading to localized oxygen depletion[23].

This pressure is explicitly recognized as a key risk in the Habitats Regulations Assessments for the Tees. Dredging activities are identified as having the potential to cause smothering and changes in the siltation rate, with the intertidal mudflats—a designated feature of the SPA and a critical feeding ground for birds—being a primary receptor at risk[18]. Field studies and modeling of TSHD operations indicate that these plumes are not insignificant; near-bottom plumes have been measured extending from 700 to 730 meters down-current from the dredger[27]. The continuous, year-round nature of maintenance dredging in the Tees means that the physical stress from turbidity and siltation is a chronic, rather than acute, pressure on the ecosystem, impacting all areas of the dredged river and surrounding areas.

3.3 The Zone of Disturbance: Direct Impacts on Marine Fauna

The final category of risk relates to the direct disturbance of marine fauna by the physical presence and noise of the dredging vessels. A large, self-propelled industrial vessel operating continuously within a protected wildlife area creates a "zone of disturbance" that can disrupt the essential life-cycle activities of sensitive species[11].

The primary vectors of disturbance are underwater noise and visual presence. TSHDs emit broadband noise, with most of the acoustic energy concentrated in the low-frequency range below 1 kHz[11]. While this level of noise is considered unlikely to cause direct physical injury to the auditory systems of marine mammals, it can cause significant behavioural impacts. The noise can mask important biological sounds, such as communication between animals or the sounds of prey, and can lead to avoidance behaviour, causing animals to move away from preferred feeding, resting, or breeding areas[11].

This risk is particularly acute in the Tees due to the proximity of dredging operations to critical wildlife sites. The Seal Sands area, which hosts the only harbour seal pupping colony in north-east England, is located directly within the industrialised estuary[6]. The pupping season, from June to July, is an exceptionally vulnerable period[18]. Disturbance from boat traffic has been shown to be extremely detrimental during this time, as it can interrupt lactation or cause the separation of a mother from her pup, which can be fatal for the pup[28]. The constant movement of dredgers in the vicinity of these haul-out and pupping sites represents a significant potential stressor.

Similarly, the SPA's designated bird populations are vulnerable to disturbance. The visual presence of the dredger and associated noise can cause birds to take flight from their feeding or roosting grounds, forcing them to expend valuable energy and reducing their foraging time. This is a particular concern for the tens of thousands of wintering waterbirds that rely on the estuary's intertidal mudflats, and for breeding species like terns that forage for fish in the river's channels. The risk of disturbance has been formally acknowledged in HRAs and has led to mitigation measures, such as the temporal restriction on dredging around low tide in winter to protect feeding birds[11]. In addition, dredging has been cited as a potential disruption to the migration of fish like Atlantic salmon, which are sensitive to noise and turbidity barriers. The cumulative effect of this year-round disturbance from dredging, combined with other shipping and industrial activity, places a chronic pressure on the wildlife of the Teesmouth and Cleveland Coast designated sites.

4 Part IV: A Framework for Best Practice: Technological and Operational Mitigation

Mitigating the environmental risks of maintenance dredging in the River Tees requires a multi-faceted approach that addresses impacts at every stage of the operation. A robust framework for best practice must integrate advanced engineering solutions on the dredgers themselves, rigorous procedural controls during operations, and strategic planning based on a deep understanding of the ecosystem's seasonal rhythms. This section outlines a hierarchical strategy of controls, moving from technological interventions at the source of impact to adaptive management procedures and, finally, to measures designed to protect the most sensitive ecological receptors.

4.1 At the Source: Advanced Dredger Technology and Configuration

The single most important piece of equipment in the dredging operation is the TSHD itself. Therefore, the adoption of best practice begins with the vessel's design and configuration. PD Ports has taken a significant step in this direction with the introduction of the "Emerald Duchess," a new-generation TSHD set to replace the 50-year-old "Cleveland County"[13]. This vessel represents a major investment in environmental technology, but its focus is primarily on reducing atmospheric emissions and decarbonizing the operation[1]. The *Emerald Duchess* is equipped with a sophisticated diesel-electric hybrid propulsion system, an intelligent power management system that utilizes a large battery pack (equivalent to ten Tesla cars), and engines that run on Hydrotreated Vegetable Oil (HVO), also known as renewable diesel. HVO can achieve up to a 90% reduction in net CO2 emissions compared to conventional diesel. The vessel is also "future-proofed," with a design that allows for the eventual replacement of its current power units with fuel cells running on methanol or ethanol. These features align directly with PD Ports' stated ESG goals of achieving carbon neutrality for its landside operations by 2027 and becoming a Net Zero business by 2040[1].

However, a critical examination reveals that these advancements, while commendable and important for climate targets, do not inherently address the most pressing, localized environmental risks of dredging in the Tees: sediment resuspension, turbidity, and contaminant mobilisation. True best practice in this specific context demands a dual focus. Alongside emissions reduction, technology must be employed to minimize the physical disturbance of the dredging process itself. Such technologies are available and include:

Advanced Drag Head Design: Specialized drag heads can be designed for greater precision, allowing for more targeted removal of sediment layers and reducing the amount of over-dredging[20,21]. Drag heads equipped with high-pressure water jets integrated into the cutting teeth can increase excavation efficiency, reducing the force and time required to dredge hard-packed soils[25].

Overflow and Turbidity Management: The overflow is a primary source of turbidity. Modern TSHDs can be fitted with technologies to mitigate this. "Green valves" or environmentally friendly overflow systems are designed to reduce the velocity and turbulence of the discharged water. Another effective method is to route the overflow through a pipe to a discharge point near the seabed, releasing the plume into a less sensitive, lower-energy part of the water column, rather than at the surface[25].

Operational Control Systems: Advanced control systems that integrate suction power, vessel speed, and drag head pressure can optimize the dredging process to create a denser slurry with less excess water, thereby reducing the need for and volume of overflow[20,21].

The current public information on the *Emerald Duchess* focuses heavily on its emissions technology[3]. A best practice approach would require PD Ports to ensure that this new vessel, and the existing "Heortnesse," are also equipped with the best available technology for turbidity reduction. The following table provides a comparative analysis of the fleet, highlighting where technological advancements have been made and where further investment may be required.

Table 2: Comparative Analysis of PD Ports' TSHD Fleet

Feature	Cleveland County (Retired)[12]	Heortnesse (Active)[12]	Emerald Duchess (New)[3,13]
Vessel Type	Trailing Suction Hopper Dredger	Trailing Suction Hopper Dredger	Trailing Suction Hopper Dredger
Hopper Capacity	~1500m^3	~1500m^3	2000m^3
Dredged Load	Not specified	Not specified	2,500 tonnes
Propulsion System	Conventional Diesel	Conventional Diesel	Diesel-Electric Hybrid with Battery Pack
Fuel Type	Conventional Diesel	Conventional Diesel	Hydrotreated Vegetable Oil (HVO); Methanol/Ethanol

			Ready
Key Emissions Control	Basic/Legacy	Basic/Legacy	State-of-the-art after-treatment systems; HVO fuel use; Battery for peak shaving and emission-free maneuvering
Key Sediment/Turbidity Control	Standard bottom-door dumping system	Active drag-head for sand dredging; Standard bottom-door dumping system	Not explicitly specified in available documentation. Assumed standard systems unless otherwise stated.

4.2 4.2 Along the Path: Procedural Controls and Adaptive Management

Beyond the dredger's hardware, best practice is heavily dependent on the software of operational procedures. A static dredging plan is insufficient for a dynamic environment like the Tees. An adaptive management approach, where operations are continuously adjusted in response to real-time environmental feedback, is essential[29].

The cornerstone of this approach is a comprehensive turbidity monitoring program. This involves deploying sensors to measure turbidity (in Nephelometric Turbidity Units, NTU) and Total Suspended Solids (TSS, in mg/L) both upstream and downstream of the dredging operation. This dual-location monitoring is crucial as it allows the operator to differentiate the turbidity generated by the dredger from the background levels caused by tides, river flow, or other vessel traffic[24].

This monitoring data is only useful if it is tied to a pre-defined system of trigger levels. Best practice, as implemented in other sensitive dredging projects, involves establishing a tiered system of alerts[30]:

Level 1 (Observation/Alert): A minor, sustained increase in turbidity above background levels. This triggers heightened observation and a check of all equipment and procedures.

Level 2 (Action Level): A more significant increase in turbidity (e.g., a sustained difference of >50 NTU between upstream and downstream monitors) that approaches a threshold of potential harm to sensitive receptors. This would trigger an operational response, such as slowing the dredging speed, reducing suction power, or altering the dredging path[24].

Level 3 (Impact/Stop-Work Level): A major increase in turbidity that exceeds the known tolerance of critical local habitats or species. This would trigger the immediate cessation of dredging activities until turbidity levels return below the action level. In some cases, it could also trigger the deployment of physical containment measures, such as silt curtains, although their effectiveness is limited in strong currents[24].

The specific values for these trigger levels must be site-specific, based on a scientific understanding of the tolerance of the Tees' key ecological receptors (e.g., benthic communities, fish, bird foraging areas) to elevated TSS[27]. This adaptive management system moves the operator from a passive to an active role in environmental protection, making real-time decisions to minimize impact. It represents a practical application of the precautionary principle during day-to-day operations.

4.3 4.3 Protecting the Receptor: A Calendar of Ecological Mitigation

The final layer of mitigation focuses on strategic, long-term planning to avoid conflicts between dredging activities and the most sensitive periods in the life cycles of protected wildlife. While some temporal restrictions are already in place for the Tees—such as avoiding dredging in July and August to protect migrating salmon[9] and restricting operations around low tide in winter to protect feeding birds[18] —these appear to be piecemeal. A best practice approach would consolidate all known ecological sensitivities into a single, comprehensive planning tool.

An **Annual Calendar of Ecological Sensitivity** would provide a month-by-month, colour-coded risk assessment for the estuary. This allows the operator (PD Ports) and the regulators (MMO, Natural England) to strategically plan the annual dredging campaign, scheduling the most intensive or disruptive work (e.g., dredging in particularly sensitive areas or after major storms) for periods of lowest overall ecological risk. Conversely, it identifies periods of highest sensitivity where operations should be minimized, restricted, or subject to heightened monitoring.

This approach moves beyond simple "no-dredge" windows to a more nuanced, risk-based system. It acknowledges that year-round dredging is a necessity but seeks to manage that necessity in the most intelligent and least impactful way possible. The following table synthesizes the available data on species sensitivities into such a calendar, providing a clear, visual tool for operational planning.

Table 3: Proposed Annual Calendar of Ecological Sensitivity for the River Tees

Month	Harbour Seal (Pupping/ Moulting)	Migratory Fish (Salmonids)	Breeding Terns (Little/Common)	Passage Terns (Sandwich)	Wintering Waterbirds (Feeding/ Roosting)	Overall Sensitivity
Jan	LOW	LOW	LOW	LOW	**HIGH**	**HIGH**
Feb	LOW	LOW	LOW	LOW	**HIGH**	**HIGH**
Mar	LOW	LOW	LOW	LOW	**HIGH**	**HIGH**

Apr	LOW	**MEDIUM** (Smolt run)	**MEDIUM** (Arrival)	**HIGH** (Passage)	MEDIUM	**HIGH**
May	LOW	**MEDIUM** (Smolt run)	**HIGH** (Nesting)	**HIGH** (Passage)	LOW	**HIGH**
Jun	**CRITICAL** (Pupping)	**MEDIUM** (Adult run)	**HIGH**	MEDIUM	LOW	**CRITICAL**
Jul	**CRITICAL** (Pupping)	**HIGH** (Main adult run)	**HIGH**	MEDIUM	LOW	**CRITICAL**
Aug	**HIGH** (Moulting)	**HIGH** (Main adult run)	**MEDIUM** (Fledging)	**HIGH**	LOW	**HIGH**
Sep	**HIGH** (Moulting)	**MEDIUM**	LOW	**HIGH**	LOW	**HIGH**
Oct	MEDIUM	**MEDIUM**	LOW	**MEDIUM**	**MEDIUM** (Arrival)	**MEDIUM**
Nov	LOW	LOW	LOW	LOW	**HIGH**	**HIGH**
Dec	LOW	LOW	LOW	LOW	**HIGH**	**HIGH**

Key:

CRITICAL: Highest sensitivity. Operations should be avoided in key areas or subject to the most stringent restrictions and monitoring.

HIGH: High sensitivity. Operations require significant mitigation, heightened monitoring, and should be minimized where possible.

MEDIUM: Moderate sensitivity. Standard best practice mitigation and monitoring should be applied.

LOW: Lowest relative sensitivity. The preferred window for more intensive or disruptive dredging activities.

Note: This calendar is a strategic planning tool based on available data[6,31]. Specific operational decisions would still require fine-scale assessment and regulatory agreement.

5 Part V: Beyond Disposal: The Untapped Potential of Beneficial Use for Tees Sediment

The ultimate evolution of best practice in dredging involves a fundamental paradigm shift: moving away from a linear model of "dredge and dispose" to a circular model where dredged material is recognized and utilized as a valuable resource. This concept, known as the Beneficial Use of Dredged Material (BUDM), is gaining traction globally as a more sustainable and economically advantageous approach to sediment management. For the River Tees, with its continuous dredging requirement and complex environmental setting, BUDM offers a transformative opportunity to reduce the pressure on offshore disposal sites, create ecological and economic value, and align the port's operations with the principles of a circular economy.

5.1 The Current Paradigm: Disposal at Sea

The current, long-standing practice for all maintenance dredged material from the Tees and Hartlepool is disposal at sea[12]. Under its MMO licence, PD Ports is authorized to deposit up to 2,889,700 tonnes of sediment annually into the designated offshore site, Tees Bay 'A' (TY160)[14]. This approach is not unique to the Tees; it is the conventional method for managing dredged material at many major UK ports, which collectively dispose of millions of tonnes at sea each year.

The rationale for this practice is often pragmatic. In many situations, marine disposal is considered the Best Practicable Environmental Option (BPEO), primarily because it is the most economically realistic and logistically straightforward solution[32]. The costs and complexities associated with transporting, dewatering, and finding land-based uses for vast quantities of wet sediment can be prohibitive. The cessation of marine disposal for dredged material, unlike for substances like sewage sludge, is not seen as a practical or economic possibility in the short term[32]. However, this perspective is increasingly being challenged. Critics point out that other countries make far greater use of their dredged material for constructive purposes, and that treating sediment as a "waste" for disposal overlooks its potential value and represents a missed opportunity for environmental enhancement[9]. The reliance on sea disposal, especially in a region with known contamination issues, perpetuates a system that simply relocates potentially problematic material from the river channel to the offshore marine environment.

5.2 A New Paradigm: Dredged Material as a Resource

Beneficial Use of Dredged Material (BUDM) reframes the entire issue. It defines dredged sediment not as a waste product to be discarded, but as a resource with potential applications in environmental restoration, construction, and land development[33]. The range of recognized beneficial uses is broad and well-documented, including:

Habitat Creation and Restoration: Using sediment to build or restore wetlands, mudflats, bird islands, and oyster reefs, or to create shallow water habitat for fish and submerged aquatic vegetation[33].

Beach Nourishment: Placing clean, sandy dredged material onto eroding beaches to provide coastal protection and enhance recreational amenities[34].

Construction and Industrial Use: Using treated or suitable dredged material as fill for land reclamation projects, port development, or as a component in construction materials like concrete or bricks[35].

Land Remediation: Using dredged material as capping material for contaminated brownfield sites or landfills, providing a safe cover for development[33].

This approach is not theoretical; it is being actively promoted and implemented by leading bodies like the US Army Corps of Engineers (USACE), which has a national goal to increase the beneficial use of its dredged material from the historical average of 30-40% to 70% by 2030. The USACE has established a pilot program to carry out projects and has documented numerous success stories, demonstrating the feasibility of BUDM across a wide range of environmental and economic contexts[33]. International maritime and environmental bodies, including the London Convention/Protocol and OSPAR, also prioritize the consideration of beneficial use opportunities over disposal at sea[36]. Adopting a BUDM strategy is therefore a clear hallmark of international best practice.

5.3 Applying BUDM to the Tees: Opportunities and Barriers

The diverse sedimentary profile of the River Tees makes it an ideal candidate for a targeted BUDM program. The current "one-size-fits-all" disposal strategy fails to capitalize on the distinct characteristics of the material dredged from different parts of the river. A sophisticated BUDM strategy would segregate the dredged material based on its physical properties and level of contamination, creating a portfolio of management options instead of a single waste stream.

Opportunities:

Clean Sand from Outer Reaches: The maintenance dredging in the seaward reaches of the channel (chart areas 9 and beyond) yields material that is predominantly sand, becoming coarser further out to sea[12]. This clean, sandy material is a high-value resource. It is potentially suitable for direct use in local beach nourishment schemes to combat coastal erosion along the Redcar and Cleveland coastline, an established BUDM application[37]. It could also be processed and used as a replacement for quarried sand in the construction industry, reducing pressure on terrestrial aggregate resources[38].

Silts and Clays for Habitat Creation: The finer silts and clays dredged from the upper and middle reaches of the estuary could, if sufficiently clean, be used for habitat restoration projects. Given that the Tees has lost 90% of its intertidal habitat[6], using this material to restore or create new areas of saltmarsh or mudflat would be a powerful way to enhance the SSSI/SPA. This aligns with the concept of "working with nature" and could directly contribute to PD Ports' stated goal of improving biodiversity[1].

Barriers:

Contamination: The single greatest barrier to BUDM in the Tees is the legacy contamination, particularly the high levels of PAHs found in the finer, silty sediments of the inner estuary[19]. This material would likely be unsuitable for uncontained habitat creation or agricultural use without pre-treatment. This is a significant hurdle that requires a dedicated strategy.

Logistics and Cost: Implementing a BUDM program requires investment in new logistics. This could include designated areas for dewatering and processing the sediment, as well as the transportation infrastructure to move the material to its end-use site. These activities add complexity and cost compared to the relatively simple process of direct offshore disposal[33].

Regulatory and Market Framework: A successful BUDM program requires a supportive regulatory framework that facilitates the transition of dredged material from a "waste" to a "product." It also requires the development of a local or regional market for the material, connecting the supplier (the port) with potential end-users (local authorities, construction companies, conservation bodies)[36].

A pragmatic pathway to implementing BUDM in the Tees would be a phased approach. The initial focus should be on the "low-hanging fruit": developing a program for the beneficial use of the clean sand from the outer channel, which presents the fewest contamination-related barriers. This would immediately reduce the volume of material going to the offshore disposal site. In parallel, a long-term strategy should be developed for the more contaminated silts. This could involve investigating the feasibility and cost of treatment technologies, or identifying contained BUDM applications, such as the capping of local brownfield sites, where the contamination can be safely managed.[48] This strategic segregation and management of the sediment profile represents a significant advancement over the current monolithic disposal approach and is the cornerstone of a truly sustainable, long-term dredging strategy.

6 Integrated Recommendations for Environmentally Responsible Dredging in the Tees

This report has established that achieving environmentally responsible maintenance dredging in the River Tees is a complex but attainable goal. It requires a holistic and integrated approach that combines technological advancement, procedural discipline, strategic planning, and a fundamental shift in how dredged material is perceived and managed. The following recommendations are structured in a hierarchical, time-bound framework to provide a clear and actionable pathway for PD Ports, as the Statutory Harbour Authority, and its regulatory partners (MMO, Natural England, Cefas) to elevate dredging practices from a state of managed risk to one of genuine environmental stewardship.

6.1 Immediate Actions (0-2 Years): Optimising Current Operations

These recommendations focus on leveraging existing knowledge and technology to achieve immediate improvements in environmental performance within the current operational framework.

Formal Adoption of a Dynamic Planning Calendar: PD Ports should formally adopt and integrate the **Annual Calendar of Ecological Sensitivity** (as detailed in Table 3) into its core operational planning for all maintenance dredging. This should replace any existing piecemeal restrictions with a comprehensive, risk-based traffic-light system (Critical/High/Medium/Low sensitivity). This will enable proactive scheduling of dredging campaigns to minimize conflict with critical wildlife periods, such as the harbour seal pupping season (June-July) and peak waterbird feeding times (winter low tides). This plan should be a public document, agreed upon with Natural England and the MMO.

Implementation of an Adaptive Turbidity Monitoring Program: An adaptive management program for turbidity must be implemented immediately. This requires the deployment of real-time turbidity and Total Suspended Solids (TSS) sensors both upstream and downstream of active dredging operations. Crucially, this data must be linked to a pre-agreed, three-tiered system of operational trigger levels (Alert, Action, and Stop-Work), developed in consultation with Cefas and Natural England based on the known tolerances of local sensitive receptors. This will empower dredger operators to make real-time adjustments—such as slowing down or pausing work—to keep turbidity plumes within acceptable environmental limits[24].

Technological Audit and Upgrade for Sediment Control: A full engineering audit of the new *Emerald Duchess* and the existing *Heortnesse* should be conducted with the specific goal of identifying and retrofitting the best available technology and operational practices for **sediment and turbidity control**. While the emissions-reduction technology on the *Emerald Duchess* is a positive step, it does not address the primary local impacts. Investment and training should be prioritized for technologies such as environmentally friendly overflow systems (e.g., near-bed discharge pipes) and advanced, precision drag heads to minimize sediment resuspension at the source[23].

6.2 Medium-Term Strategy (2-5 Years): Shifting Technology and Policy

These recommendations involve more significant strategic shifts in policy, technology, and inter-agency collaboration, laying the groundwork for a truly sustainable long-term system.

Commission a Comprehensive Beneficial Use Feasibility Study: PD Ports, in partnership with the Tees Valley Combined Authority and relevant agencies, should commission a full-scale feasibility study for a **Beneficial Use of Dredged Material (BUDM) Program**. This study should initially focus on the most viable option: segregating and utilizing the clean sand dredged from the outer channel (seaward of chart area 9) for local beach nourishment or as a commercial construction aggregate. The study must address logistics, dewatering requirements, costs, potential markets, and the necessary regulatory pathways to reclassify this material as a product rather than a waste.

Re-evaluate Dredging Technology for Contaminated "Hotspots": A formal review, led by PD Ports and advised by Cefas, should be undertaken to assess the suitability of continuing to use TSHDs in the historically contaminated, silty upper reaches of the estuary (e.g., near Billingham Reach). Given the OSPAR assessment that TSHDs are the least suitable technology for contaminated sediment[23], this review should explore the operational and economic viability of using more precise, lower-dispersal dredging methods (e.g., environmental clamshell dredgers, auger dredgers) for targeted "hotspot" management. This would represent a move to a "right tool for the right job" approach.

Develop and Publish a Formal Dredging Environmental Management Plan (DEMP): To enhance transparency and formalize commitment to best practice, PD Ports should develop and publish a comprehensive DEMP, following examples from other leading port authorities[39]. This public document should codify all environmental management procedures, including the Ecological Calendar, the adaptive turbidity monitoring protocol, trigger levels, mitigation measures for all designated species, contaminant management protocols, and the phased strategy for BUDM. This would serve as a single, accountable framework for all dredging-related activities[1].

6.3 Long-Term Vision (5+ Years): Towards a Circular Sediment Economy

These recommendations outline a long-term vision that fully integrates dredging into a sustainable, circular economy for the Tees region.

Establish a Tees Estuary Partnership for Sediment Management: Building on the BUDM feasibility study, a formal partnership should be established to create a functioning regional market and logistical chain for beneficially used dredged material. This partnership should include PD Ports (the supplier), local authorities, coastal protection agencies, the construction industry (the end-users), and regulators (MMO, Environment Agency) to overcome logistical and administrative barriers and create a self-sustaining circular sediment economy.

Invest in a Pilot Project for Silt Treatment and Habitat Creation: To address the challenge of contaminated silts, the partnership should seek funding for and invest in a pilot project to test and validate technologies for treating the material to render it safe for habitat creation. A successful pilot could unlock the potential to use the vast quantities of silt dredged annually to actively restore the saltmarsh and mudflat habitats lost to historical development, directly contributing to the enhancement of the SSSI/SPA and helping PD Ports meet its biodiversity and sustainability goals[1].

Integrate Sustainable Dredging into Core Port Strategy: The principles and practices outlined in the DEMP and the BUDM strategy must be fully integrated into the highest levels of the port's strategic planning. This includes embedding them within the next iterations of the Port's Master Plan, Marine Safety Plan[40], and corporate Environmental, Social, and Governance (ESG) strategy[1]. This final step ensures that environmentally responsible dredging is not treated as an ancillary compliance issue, but as a core, non-negotiable component of the vision for the River Tees as the UK's most successful and sustainable port region.

7 North East Marine Research Group

The North-East Marine Research Group (NEMRG) is an informal group of fishers from the North East Fishing Collective, academics from Durham, Newcastle, and Hull Universities, and interested individuals including representatives of community organisations including Climate Action Stokesley & Villages and Reclaim Our Sea and the Fishmongers' Company's Fisheries Charitable Trust.

Together the group works:

- *to understand the cause of the Tees Estuary ecocide event of September 2021*
- *to understand persistent issues occurring in the marine ecosystem*
- *to provide information relevant to sound environmental governance to properly safeguard the Tees environment, wider marine ecosystem, and the industries that rely on it.*

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