To be read with the Metrotidal Thames Orbital Presentation: October 2019

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INTRODUCTION AND EXECUTIVE SUMMARY

The Metrotidal Thames Orbital is a system of integrated infrastructure including the next generation of London's flood defences that provides substantial growth across the Lower Thames Estuary into Essex, Kent and London without an associated increase in carbon audit. The new flood defences through to the 22nd century provide a more robust system for lower cost and environmental impact and for longer duration than the TE2100 proposals. The green-growth is achieved through the generation of renewable, zero-carbon energy for the conurbation of South Essex and North Kent including the 100,000 new homes already planned around the lower estuary, along with improved rail connectivity and efficient data storage.

The Metrotidal Thames Orbital integrates the following infrastructure to improve flood defences, mitigate the environmental impacts of rising sea levels, provide renewable energy and generate green-growth: -

1. TE2200 flood defences for London and the Thames Estuary
2. renewable energy generation: solar, wind, tidal
3. Thames Estuary rail orbital
4. cycle superhighway and promenade
5. Orbital Express services
6. efficient data storage and distribution
7. rail freight and utility connections across the Lower Thames Estuary
8. marine developments
9. sustainable residential and commercial development
10. sustainable leisure and tourism

GENERAL ARRANGEMENTS: THROTTLE, TUNNEL, ORBITAL AND FLOATING SOLAR

The integrated infrastructure consists of a tideway throttle across Sea Reach that in the event of a storm surge reduces the maximum water level upstream by up to a meter, thereby providing London and all areas downstream to the sea with flood defences through the 21st century, while leaving the tideway open for navigation to all existing wharves and docks. The throttle is formed from the shipping channel with moles and sea walls extending each side to the shore. The open throttle system then becomes a full barrier with gates in the 22nd century and thereafter the flood datum is raised as required to meet rising sea levels.

A tunnel formed within the Essex and Kent sea walls links the eastern limbs of Crossrail to complete a twin-track rail orbital of the Lower Thames Estuary. The link between the tunnels within the Essex and Kent sea walls is completed by two immersed-tube tunnel sections, cast within the moles and placed under the open-channel of the throttle. The rail orbital, with cycle superhighway and promenade, including wayleaves for data distribution and utilities, improves the connectivity for a million households, thereby generating substantial agglomeration benefits across the Lower Thames Estuary into Essex and Kent. An optional new station on the Essex sea wall serves a Cruise Liner Terminal, Thames Clipper Berth, Southend Marina and harbour for the Thames Cockle Fleet. Renewable energy, generated from a floating solar array, sheltered by the flood defence system, and wind turbines on the moles and sea walls, more than offsets the demands of the flood defence system, tunnel M+E systems, data storage and the new housing of local plans around the estuary. As sea levels rise there is scope for adding tidal power generation from tidal sluices and a flood storage system.

The new infrastructure orbital makes use of existing railway lines and is implemented without significant disturbance to areas in Essex and Kent where the sea walls come ashore. Construction undertaken in the tideway makes use of a rail head from concrete batching and casting facilities at an aggregates wharf nearby on the Isle of Grain. Spoil from the tunnel excavations and sea-dredged aggregates are used to form the embankments and flood bunds so that the embodied energy of construction and environmental impacts are kept to a minimum.

1 LONDON’S FLOOD DEFENCES

The throttle and sea walls form a flood defence system that protects flood risk areas from a storm surge by reducing the landward peak tide level. The existing 300m wide shipping channel along Sea Reach becomes an open throttle dredged and secured with scour protection to a uniform depth of 16m between the north and south moles. Each mole can accommodate a small cylindrical gate that when turned together reduce the open channel width to 240m, to increase the throttle effect and reduce peak landward levels as required by rising sea levels. Each mole can also accommodate large surge-tide gates in due course, like those of the Maeslantkering at Rotterdam and the St. Petersburg Flood Protection Barrier, to close the channel during a surge-tide when required by rising sea levels. Small ship navigation channels and tidal sluices each side of the moles minimise peak tidal flows and the landward range reduction for normal tides. Additional tidal sluices are provided for the Leigh Channel and Ray Gut, the creek that provides navigation to Leigh-on-Sea. The small ship channels are fitted with locks and the tidal sluices are fitted with simple lifting gates, when required by rising sea levels. The throttle effect of the open channels is designed for the minimum number of simple lifting gates to provide the required landward peak range reduction and corresponding reduction of flood risks from surge tides through the 21st century while maintaining normal tidal flows.

The tideways of the Leigh Channel and Ray Gut are separated by the intertidal bank of the Chapmans Sands and Marsh End Sand that extends east from Canvey Point to the Essex Sea Wall of the flood defence system. The depth and number of the tidal sluices are set so that the flood tides cover Marsh End Sand and Chapman Sands uniformly without crossflow. As sea levels rise the fitting of gates to Ray Gut and the raising of a shallow ridge to form a weir across Chapman Sands and Marsh End Sand from Canvey Point to the sea wall enables the volume of the estuary to the north of the weir to be used for flood storage, thereby providing a modest reduction in peak landward levels for surge tides and a modest reduction in peak tidal flows for normal tides. The weir is raised to the intertidal height of Clock Bank beside Canvey Point at 3.5m chart datum so that the whole landward side of the estuary to the west of Sea Reach Throttle including the weir is still covered at high tide. The existing ridge from Clock Bank to the Essex Sea Wall is 4.8km long, over which the height descends by 2m, mostly over the last kilometre. Consequently, only a small volume of material is needed to form the flood storage area within a stable weir at 3.5m chart datum from Canvey Point to the Essex Sea Wall. With the Ray Gut sluices and the existing Benfleet Barrier closed at low tide ahead of a surge tide, the volume of the intertidal flood storage north of Chapman Sands and Marsh End Sand is reserved until the flood tide spills over the weir. The intertidal area north of the weir at 3.5m chart datum is some 10sq.km while the subtidal area at low tide is 1 sq.km indicating that the flood storage volume will be over 9m cubic meters or close to 4% of the total tideway volume for normal tides. This volume of flood storage held in reserve helps to reduce peak flow rates through the throttle and reduce the landward peak tide levels, thereby postponing the need to fit additional tidal gates to the tidal sluices provided by the initial construction. The scale of the peak flow and peak tide level reduction and the period for postponing the fitting of gates to the main tidal sluices are determined by hydrographic analysis. The management and control of peak flow rates during a surge and normal tides are again resolved through hydrographic analysis, with a target of reducing the peak flow rates so that they have minimal impact on navigation. A likely width and depth of tidal sluices and gates is indicated for now from which the required number and a programme for their provision, including when to implement the flood storage, will be determined by detailed hydrographic and environmental analysis. For the flood storage function, it is assumed that the entrance to Ray Gut would need to be dredged to match the depth of the Leigh Channel so that both channels would have a similar depth and number of sluices.

Later in the 21st century as sea levels rise, the fitting of the small cylindrical gates to the main channel or tidal gates to the sluices requires only modest investment. The substantial reduction in flood risk through the 21st century enables the Government’s Flood Re agreement to be renegotiated to reduce flood-risk insurance premia and release a large area of land for safe use. If sea levels rise more rapidly in the 22nd century the small sector-gates followed by the large gates of similar scale to those already built for the Maeslantkering system at

Rotterdam and for the St. Petersburg Flood Protection Barrier can be provided to extend the flood protection through the 22nd century.

The programme for the fitting of gates to the Metrotidal system requires less construction and engineering for a lower cost than the construction of the Long Reach Barrier upstream, which requires 106km of sea walls with additional gates downstream. The Metrotidal system protects almost the whole of the TE2100 programme area from tidal squeeze, including an additional 90sq.km downstream from Long Reach, so that the TE2100 remediation, requiring 876ha of new intertidal area on the Isle of Grain, can be postponed. The relatively short 8km length of the Metrotidal flood defence system between the high ground at Southend in Essex and Allhallows in Kent, compared with the 106km length of flood defences required each side of the Thames for the Long Reach Barrier, enables the Metrotidal system to provide the most viable long-term flood risk reduction through the 22nd century. This TE2200 flood defence system applies the same adaptive flood risk management strategy as the TE2100 programme, to postpone investment in the flood defence agenda until required by the risk of rising sea levels. The lower cost of the flood defence system, subsidised by the rail orbital construction, is phased, with the passive, economical open-throttle system providing protection through most of the 21st century, supplemented by the flood storage system, then the fitting of tidal gates later in the century and by raising the flood barrier datum at modest cost later in the 22nd century, as required by rising sea levels.

2 RENEWABLE ENERGY GENERATION

The integrated infrastructure includes renewable energy generation to more than offset the demands of the system and the 100,000 new homes already proposed by the various local authority plans around the Lower Thames Estuary. The sub-tidal area of the estuary protected by the sea walls accommodates 400 hectares of floating solar arrays with an annual output assessed from well-established local solar farm precedents and current PV panel efficiencies. The floating solar arrays are sheltered by the Essex Sea Wall and protected by a perimeter boom. The solar power generated offsets the operations of the flood defence system, the tunnel M+E systems, the data storage and distribution and the demand from the 100,000 new homes of current local plans around the estuary. Additional renewable energy is generated by wind turbines and solar panels mounted on the moles and sea walls.

As sea levels rise and gates are fitted to Ray Gut, the use of the Ray Gut basin to the Benfleet barrier for flood storage opens the way for tidal energy to be generated from turbines located in the Ray Gut sluices. High tide would be held by the flood storage at 3.5m chart datum for release through the turbines on the ebb tide with a view to maintaining the tidal cycle with minimal change at low tide. The holding of high tide prolongs the navigation of Ray Gut to Leigh-on-Sea, Canvey Island and Benfleet while also prolonging seaside recreational activities along the shore from Southend to Benfleet. The balance of environmental benefits and impacts will be analysed, with the system designed to provide a stable environment through rising sea levels.

3 THAMES ESTUARY RAIL ORBITAL

The cost of a twin-track rail orbital under the Thames Estuary is substantially reduced by integrating the orbital construction with the sea walls and throttle of the flood defence system across Sea Reach. The twin tracks approach from the southwest on the route of the Isle of Grain Line, formerly the Hundred of Hoo Railway, where the land can already accommodate dual tracks. The route descends from the Hoo hillside to run at low-level by the Medway shore, where a seaward flood bund protects the line and screens rail operations from the sensitive habitats of Stoke Saltings. New twin-tracks diverge northeast from the Isle of Grain Line by Stoke and head directly for Southend accompanied by the seaward flood bund, here screening the rail operations from the sensitive habitats of the Stoke and Allhallows Marshes. Allhallows Station is formed within the embankment on a site served by linking Binney Road from Allhallows with Avery Way from Allhallows-on-Sea. By the Kent shore the twin tracks are joined by a landward flood bund, raised on the existing sea wall from Allhallows-on-Sea, and the tracks then run in an open cutting between the two embankments, like the approaches to the Medway and Øresund tunnels, to form the Kent Sea Wall across Yantlet Flats, before descending in a sheet-piled, cut-and-cover tunnel to the South Mole. From here two 180m lengths of immersed-tube tunnel complete the connection under the open tideway of Sea Reach to the North Mole and Essex Sea Wall, where the tracks rise in a symmetrical cut-and-cover tunnel to emerge and cross Leigh Channel and Ray Gut within an open channel with the track at 3m chart datum. The tracks at this low level across Leigh Channel and Ray Gut require a channel on the landward side of the sea wall to provide navigation from the Leigh Channel to Ray Gut, this to be fitted with a lock if Ray Gut is used for flood storage. From Ray Gut the twin tracks then cross Southend Flat in an open cutting between flood bunds like those of the Kent Sea Wall, to reach the shore by the Western Esplanade at Southend. The option of a Cruise Liner Terminal, Southend Marina, Thames Clipper Berths and Cockle Fleet Harbour is served by a station built within the Essex Sea Wall on the south side of the Leigh Channel. The immersed-tube tunnel under the main shipping channel has separate sections for the twin tracks, the cycle superhighway and a pedestrian foot tunnel. Lifts and stairs each side of the small-ship channels provide surface access to the cycle superhighway and promenades on the sea walls.

The symmetrical composition of the tunnel between the open cuttings of the Kent and Essex Sea Walls is just 3km long including the 360m immersed tube tunnel. To reduce the embodied energy and carbon audit of the construction, the Essex and Kent Sea Walls are formed from locally dredged sea-aggregates, delivered either directly by barge to the construction sites or by rail from the aggregates wharf nearby on the Isle of Grain. The embankments are built up beyond the flood datum and surcharged for eighteen months to form stable sea walls that then provide construction platforms for the piling rigs to form the cuttings and cut-and-cover tunnels for the rail orbital and the wharves for the marine developments. The embankments of sea-aggregates with suitable facings increase the resilience of the sea walls to impact and enable the flood datum to be raised simply by raising the embankments as required through the 22nd century.

The axes of Southend Pier, from Garrison Point at Sheerness (9.8km) to Pier Hill, and of the Sea Reach Throttle, from Middle Stoke on the Hoo (11.1km) to Pier Hill, meet on the pier plaza area just below Pier Hill. The Sea Reach sea walls approach on this axis to cross Ray Gut before turning north to meet the shore by the Western Esplanade where a bored tunnel completes the rail link to tracks approaching the Southend Victoria Terminus. To retain the current, flood-risk level of the Western Esplanade (5m OS and 8m Chart Datum) the rail line approaching on the Essex sea wall descends to pass under the esplanade in twin cut-and-cover tunnels above which hinged steel gates complete the 11m chart flood datum across the carriageway.

Three route options are considered for the Southend Tunnel that links the twin tracks of the Sea Reach sea walls to those approaching the Southend Victoria Terminus: -

- (A) High Street Route
- (B) Nelson Street/Capel Terrace/Devereux Road Route
- (C) Prittlewell Square Route

Each of the three routes follows the same northeast axis of the Sea Reach sea walls from Middle Stoke towards the Park Inn by Radisson Palace Hotel at Southend until crossing the Ray Gut navigation where (A) continues to Adventure Island just west of the Pier while (B) and (C) turn north earlier to meet the Western Esplanade further west, opposite the funicular Southend Cliff Railway and the foot of the cliff below Prittlewell Square respectively. All three routes pass in a cut-and-cover tunnel under the Western Esplanade and enter bored tunnels through the sloping cliff to provide an underground station and connection to C2C Southend Central and change from bored to cut-and-cover tunnel just east of the Focal Point Gallery and Southend Central Library before emerging from a portal amongst the existing 5No. tracks nearby Carnarvon Road north of Southend Victoria Terminus.

(A) HIGH STREET ROUTE

Passes under the High Street with an underground station just north of the railway bridge where the 19m width of the High Street suggests the two platform tunnels would be one above another as at Chancery Lane in London, an arrangement of relative track levels that would then have to be carried through to Prittlewell Station to resolve the track gradients. The new station concourse and escalator connection to Southend Central can be formed in the lower parts of Central House, the offices on the corner of Clifftown Road, or through redevelopment of the building north of the C2C line beside Station Approach. The north entrance to the station is on the southwest side of Victoria Plaza.

(B) NELSON STREET/CAPEL TERRACE/DEVEREUX ROAD ROUTE

Two bored tunnels 40m apart provide access to underground platforms between Clifton Terrace and Scratton Road with almost level access to the platforms from the north pavement of the Western Esplanade and escalator access from the C2C Southend Central Station north of Scratton Road. Separate bored tunnels then pass north under the central part of Southend Central Station to run between the South Essex College and Sunningdale Court and between Sunningdale Court and Napier Court West before merging north of the London Road. Station entrances are provided at Southend Central and by the foot of the Southend Cliff Lift on the north side of the Western Esplanade.

(C) PRITTLEWELL SQUARE ROUTE

Two bored tunnels 40m apart run to underground platforms between Prittlewell Square and Scratton Road again with almost level access to the platforms from the north pavement of the Western Esplanade and escalator access from the C2C Southend Central Station north of Scratton Road. Separate bored tunnels then pass north under the western ends of the Southend Central platforms to run west of the Napier Court West apartments before merging north of the London Road. Station entrances are provided at Southend Central and on the axis of Prittlewell Square on the north side of the Western Esplanade.

The total distance from Burrows Lane, Middle Stoke to East Street, Prittlewell, the length of the Southend Tunnel and the distance of the landing of the Sea Reach sea wall on the Western Esplanade west of the Pier are compared for the three route options as follows: -

Route	Distance(km)	Southend Tunnel(m)	West of Pier(m)
(A) **High Street**	12.93	1,520	80
(B) **Nelson/Capel/Devereux**	12.84	1,400	300
(C) **Prittlewell Square**	12.78	1,420	500

Route A with the new underground station located north of C2C Southend Central provides the best local connectivity to the High Street, the central municipal area along Victoria Avenue to the north and to development sites east of the High Street where significant new development is anticipated. Routes B and C present fewer impediments to the tunnelling operations, provide best local connectivity to development sites southwest of the High Street and provide direct level access to the Western Esplanade but at the cost of bypassing the High Street. Accordingly, Route A is put forward as a solution where the subsequent benefits for the High Street will more than compensate for the impacts during construction.

The 14.5km single-track Isle of Grain Line from Hoo Junction to Stoke is dualled on the north side, where the Southern Railway land and road bridges already allow for the second track. Excavated material from the Sea Reach and Southend Tunnels and sea-dredged aggregates are used to screen the line where the rail operations would otherwise disturb the lowland habitats. The twin-track Sea Reach and Southend Tunnels with the dualled Isle of Grain Line complete an orbital connection between Ebbsfleet in Kent and Shenfield in Essex with the option of new stations at Hoo Junction, Cliffe, Sharnal Street, Allhallows and Sea Reach along with the underground connection at Southend Central to the C2C services. Whether the orbital link opens with overhead or battery power depends on the programme for related developments such as the C2E extension to Ebbsfleet making use of the safeguarded sidings at Ho Junction or the extension of the Medway Valley Line north from Strood to serve the Hoo Rural Town, along with options for upgrading existing rolling stock for dual power or third rail and battery operation. The orbital link can open by extending the existing Shenfield to Southend Victoria services with overhead power through to Hoo Junction, Gravesend or Ebbsfleet, allowing the terminus and sidings at Southend to be closed for redevelopment, or the Medway Valley Line third-rail service can lead the development with an extension from

Strood on a new chord east from Hoo Junction to Sharnal Street for interchange to the orbital services in due course. Another new chord heading northeast at Shenfield in Essex opens the way for an Essex-Kent Orbital route with interchange from overhead power to third rail at Sharnal Street, to extend agglomeration benefits across the South East Local Enterprise Partnership (SELEP) region.

The dualling of the Isle of Grain Line with the 12.5km of new line across the Lower Thames Estuary to Southend Victoria completes a 132km Crossrail orbital of the Thames Estuary Region from the eastern limbs diverging at Whitechapel, with Southend Central at the midpoint, 66km north and 66km south from Whitechapel around the orbital. The Essex-Kent Orbital including the Medway Valley Line opens a 108km outer orbital route between Tonbridge in Kent and Shenfield in Essex, with the option of opening of a new chord at Shenfield to the Great Eastern Mainline for the Essex-Kent Orbital to provide a 120km service between Tonbridge and Chelmsford, with sidings at Tonbridge West Yard near to the River Medway and Brook Street beside the River Chelmer.

4 CYCLE SUPERHIGHWAY AND PROMENADE

Route 1 of the Sustrans National Cycle Network (1,695 miles) includes EuroVelo Route 12 and follows the North Sea Coast from Dover to the Shetland Islands. Route 1 diverts inland to cross the Thames Estuary through London, first running west on the south bank from Rochester, Gravesend, Dartford and Woolwich to pass through the Greenwich foot tunnel and then heads north up the Lee Valley before returning east through Harlow and Chelmsford to Maldon on the Blackwater Estuary.

The rail orbital under Sea Reach is accompanied by a cycle superhighway on the sea walls that completes a direct link between the Medway Towns and the Southend conurbation. A new 20.4km cycle superhighway connects Route 1 at Chattenden by the Medway Towns to Route 16 on the Western Esplanade at Southend. The new route combines the existing Sustrans route 179 and the recent traffic-free cycleway extensions to the London Medway Commercial

Park with a new cycle superhighway accompanying the rail orbital from the Amazon warehouse at Stoke to the Western Esplanade in Southend. Routes 16 and 13 from Southend, already being developed by Sustrans, can complete a connection west then north to Route 1 at Chelmsford. However, the connection from Route 1 at Chattenden to the Western Esplanade at Southend enables a more direct North Sea Coastal Route to be extended north from Southend to Maldon (25.4km) that avoids the detour inland. The resulting 46km new Route 1 connection across the Lower Thames Estuary from Chattenden in Kent to Maldon in Essex follows the coast, providing an alternative to the 162km diversion inland through London. Renewable energy charging points along the new Lower Thames Estuary cycle superhighway support convenient and reliable train, bike and micromobility commuter journeys between the Medway Towns and the Southend conurbation.

The Essex and Kent Sea Walls also complete a new promenade between Southend and Allhallows with fine views over the estuary and marshes.

5 ORBITAL EXPRESS SERVICES

The initial extension of existing Southend Victoria services through to Hoo Junction, Gravesend and Ebbsfleet can provide an express service around the orbital from Ebbsfleet stopping at Gravesend, Sharnal Street, Southend Central, Southend Airport, Wickford and Shenfield before taking the fast route through to Liverpool Street. Once the Thames Orbital is formed the Crossrail services have the option to stop at Wickford, Southend Airport, Southend Central, Sharnal Street, Gravesend and Ebbsfleet to provide a Crossrail Orbital Express for the Lower Thames Estuary. Furthermore, the existing connection to HS1 at Ebbsfleet opens the way for a high-speed Javelin service between St. Pancras International and Southend Airport, with stops at Stratford, Ebbsfleet and Southend Central resulting in an overall journey time between West London and Southend Airport of 34 minutes, the trains continuing to Shenfield before returning. For higher frequency services 4-platforms are provided at Southend Airport and Prittlewell along with those at Sharnal Street, Allhallows and Sea Reach stations to allow fast trains to pass slow trains on the orbital. The combination of these express services with the all-stops Medway Valley Line extension to form an Essex-Kent Orbital provides additional agglomeration benefits across the Lower Thames Estuary, embracing an area with a larger population than Greater Manchester.

6 EFFICIENT DATA STORAGE AND DISTRIBUTION

The cut-and-cover construction of the tunnel descending in the sea walls creates two spaces above, each enough for a resilient and energy-efficient Tier 4 data storage facility of some 40,000 – 70,000sq.m with a clear height of 3.6m: -

- the energy from the floating solar array, along with the wind turbines and additional PV panels on the Sea Reach sea walls, provides a resilient and diverse stream of local, zero-carbon energy backed up by the National Grid
- the uniformly cool temperature of the sea water passing through the tidal sluices provides efficient datacentre cooling loads throughout the year
- the wayleaves of the new rail connectivity, data storage and distribution centres extend across the Lower Thames Estuary into Essex, Kent and Central London to serve a region with a million households and associated businesses.

7 RAIL FREIGHT AND UTILITY CONNECTIONS

The new chord by Stoke Marshes to the construction site of the Sea Reach sea walls subsequently becomes a freight connection north from Thamesport on the Isle of Grain into Essex. Together with the new rail chord to the Great Eastern Mainline at Shenfield they open a 150km freight route along the eastern seaboard of England for night services between the ports of Felixstowe, Harwich and Thamesport that bypass congested routes into Central London.

The rail tunnel provides new utility wayleaves between Essex and Kent that improve the management, resilience and distribution of electricity, gas, mains water, data and communications.

8 MARINE DEVELOPMENTS: A CRUISE LINER TERMINAL, THAMES CLIPPER BERTH, SOUTHEND MARINA, HARBOUR FOR THE THAMES COCKLE FLEET, SEAWEED FARM AND HYDROGEN ELECTROLYSIS

Sea Reach Station and the associated marine developments form an independent package with a separate appraisal of their cost and programme to the main infrastructure integration. Sea Reach Station on the Essex Sea Wall, just two stops from Southend Airport, serves a deep-water, cruise liner terminal, Southend Marina and Thames Clipper berth on a new seaward channel beside the Essex Sea Wall dredged between the Leigh Channel and the main shipping channel, providing starboard circulation for international arrivals and departures. The shorter voyage on the Lower Estuary and frequent rail services from the terminal enable more cruise lines to include London on their itineraries. The Thames Clipper berth provides a convenient terminal for the extension of existing river services from Central London and Canary Wharf and opens an Outer Estuary service from Tilbury to Sheerness.

The cockle fleet currently operates from Leigh-on-Sea and their main cockle beds are in the shallows of the outer estuary off Foulness Island and the Dengie Peninsula. The silting of Leigh Creek and use of larger vessels is inhibiting the operations of the fleet, with access to Leigh-on-Sea along Ray Gut. The Essex Sea Wall provides deep moorings for the Thames Cockle Fleet where the vessels will be served by the Sea Reach Station and are closer to their main cockle beds on the Essex Coast to the north. In due course the gates on Ray Gut can be used to generate tidal power from the flood storage and manage navigation on Ray Gut to Leigh-on-Sea through the tidal cycle.

The Sea Reach Barrier and floating solar array create a large new marine habitat suitable for farming seaweeds such as Ascophyllum Nodosum, used in the manufacture of alginates and fertilisers. The growth of seaweed would also contribute to the carbon sequestration of the integrated infrastructure.

A pilot plant for producing hydrogen by the electrolysis of seawater can be located within the Essex Sea Wall. The hydrogen contributes to the storage and uniform distribution of the renewable energy generated by the system.

9 SUSTAINABLE RESIDENTIAL AND COMMERCIAL DEVELOPMENT

The integrated infrastructure of the Metrotidal Thames Orbital, including the extension to the Sustrans network, supports the sustainable development of the 100,000 new homes and associated businesses of the current Local Plans by providing: -

- an additional 172.5sq.km area of land protected from surge-tide and wave-overtopping flood risk
- the reduced insurance premia for use of this land
- the improved connectivity of the rail orbital services, micromobility, cycle superhighway and promenade
- the zero-carbon energy, data storage, distribution and utilities required for the new homes and businesses
- an orbital network of 45No. existing and proposed railway stations in the Lower Thames Estuary region of Essex and Kent beyond the M25
- the carbon sequestration from the planting of woodland on the Hoo Peninsula and the development of marine habitats on the Sea Reach Barrier and floating solar array.

The new rail orbital with micromobility and cycle superhighway also serves significant commercial growth zones at Southend Airport, Southend Victoria, the Isle of Grain, the London Medway Commercial Park, Hoo Junction and Ebbsfleet with a combined commercial development area of 6.0 sq.km. The radically improved connectivity of the rail orbital with micromobility and cycle superhighway allows the 100,000 new homes of the existing Local Plans to be distributed widely across the Lower Thames Estuary with only a modest proportion developed on the Hoo Peninsula.

10 SUSTAINABLE LEISURE AND TOURISM

In addition to the demand from housing, employment and counter-cyclical commuting, the rail orbital will also serve the growing demand for sustainable leisure and tourism around the Lower Thames Estuary. The Sea Reach sea walls, with a station, ferry berth and cruise terminal, have the potential to become a major tourist attraction with convenient access from Central London.

Many sites of historic interest and extensive new nature reserves have been formed along the Thames Estuary over the last two decades, to accompany well-established tourist destinations such as Southend-on-Sea and Rochester, yet access to these by road is poor and inappropriate. The rail orbital supported by the solar array provides sustainable access with a low environmental impact. The Hoo Peninsula is described by the English Heritage Hoo Historic Landscape Project (No.21 2013) and forms a prime part of the Thames Estuary National Park mooted by Sir Terry Farrell. The emphasis of development here is on conserving and enhancing the natural and historic environment. The ancient woodlands that once covered much of the Thames Estuary region can still be found at Northward Hill, descending undisturbed from the hillside to the flood plain. There is space on this hillside, which extends for five kilometres east to Allhallows-on-Sea, for planting five square kilometres of new oak, alder, lime and hazel to restore the woodland lost since the Bronze Age and create a major new landmark for the Thames Estuary National Park: Hoo Wood overlooking Sea Reach.

The five square kilometres of new woodlands can sequester over 3,000 tonnes of carbon per annum, helping to offset the carbon audit arising from the 100,000 homes already planned across the Lower Thames Estuary.

The new stations at Cliffe, Sharnal Street and Allhallows provide rail and micromobility access for walks to the restored woodlands, the historic landscape of the Hoo Peninsula and to other attractions including the Allhallows Leisure Park and Allhallows Yacht Club.

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