THE SEA CHANGE IN SAVING UK COASTLINES

The world's only PPP/PFI sea defence contract this year celebrates its 10th anniversary of protecting East Sussex from coastal flooding. **Margo Cole** talks to some of the key players in the arrangement to find out what has made it such a success.

At first glance the beach at Pevensey Bay looks typical of many on the English Channel coast: a constantly shifting landscape of shingle interspersed with timber groynes in varying states of disrepair. But closer inspection reveals that this 9km stretch of East Sussex beach is far from typical, not least because it is the location of the world's only PFI/PPP sea defence contract.

The contract runs for a 25-year period, and this year the two sides – client the Environment Agency and the four companies that make up the PPP consortium – are celebrating their 10th anniversary in an atmosphere of mutual accord. Environment Agency team leader Ian Nunn describes the arrangement as "pretty much perfect", adding: "People just didn't believe you could run this sort of project on effectively trust, but in 10 years the dispute and compensation clauses have never been used."

The agreement was signed in 2000 as a way of bringing much needed investment to Pevensey Bay, where the only protection against flooding was a naturally formed shingle embankment. A permanent breach would result in 50km² of land being flooded at high tide – an area that includes over 17,000 properties as well as roads and railway lines.

The Environment Agency estimated in 1997 that the cost of a permanent breach at Pevensey would be £125M. Also affected would be the Pevensey Levels, an important wetland environment designated as both an SSSI and a Ramsar site.

The bay's defences have suffered scant maintenance, as well as being affected by natural erosion. By the late 1990s many of the beach's 150 groynes had reached the end of their useful life and a 1 in 20 year storm may have seen the embankment fail.

Routine maintenance alone was insufficient to prevent the situation worsening, and major investment was needed to restore the shingle bank to an effective sea defence structure. But, with money tight for the necessary capital expenditure, the Environment Agency looked at alternative funding through partnership with the private sector, and in 2000 awarded a 25-year contract to a consortium of Westminster Dredging, Dean & Dyball, Mackley Construction and Mouchel to restore and maintain the beach to the required levels.

With a value of around £30M over 25 years (at 1999 prices), the PFI is fairly small in comparison with more typical contracts for roads, schools and hospitals. As a result, the four firms were able to finance the PFI themselves, rather than borrowing money. At the time of the appointment they created a special company Pevensey Coastal Defences (PCDL) to deliver the contract.

In simple terms the

SEA DEFENCES: PEVENSEY BAY

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Ian Thomas, PCDL

consortium has been contracted to provide protection against a breach of the shingle bank for any storm with a joint return period of one in 400 years or less. As PCDL project manager Ian Thomas – based permanently at Pevensey – puts it: "We've committed to protecting Sussex from a one in 400 event. That's the contract, and it's up to us how we do that."

Nunn adds: "In a normal sea defence contract we would still own the risk of the concrete wall, or other defence structure. Here we don't. We've said: 'There's your beach – you manage it'."

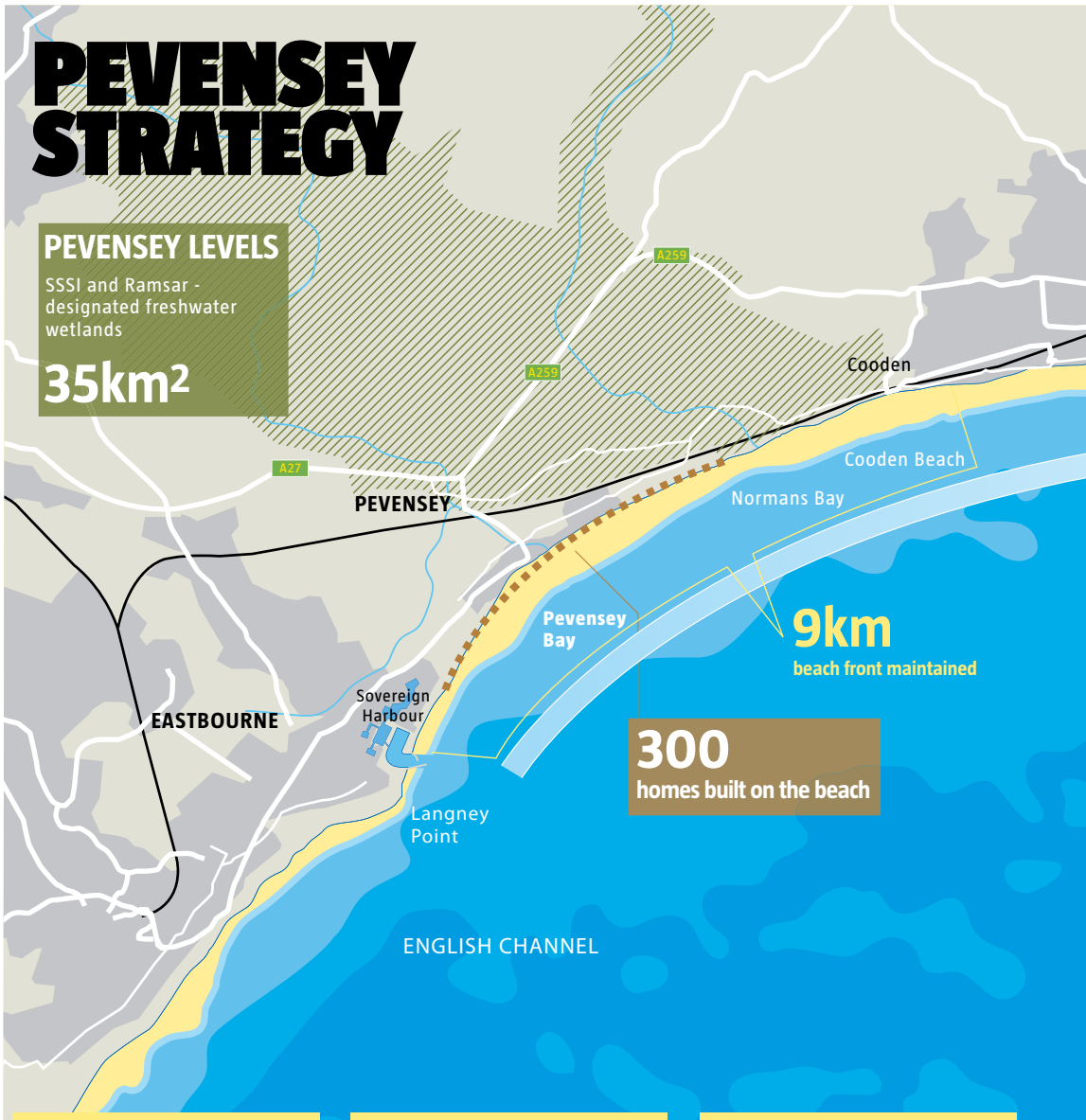
PCDL has three strategies: improve the defences to the required standard; maintain the improved defences; and respond when the shingle is disturbed by storm events.

The initial work to raise the standard of the defences required importing 200,000m³ of shingle dredged from banks at nearby Hastings and Littlehampton.

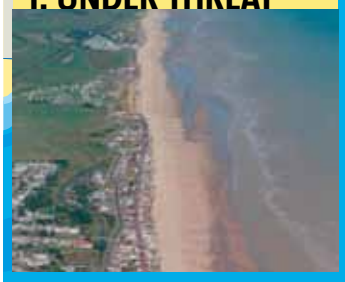
With the shingle bank restored the plan was then to gradually create a more open beach by removing most of the existing groynes as they became unsafe. It is likely only six will eventually remain, located at strategic points along the shore.

But without groynes the shingle can work its way to the north-east end of the bay and be lost. In fact, this is part of the plan as the next section of coast at Bexhill-on-Sea depends on this littoral drift for its shingle supply. So PCDL's contract includes a provision for at least 16,000m³ of shingle to move onto that frontage every year. Add to this the amount that is lost to sea, and, as Thomas says, "we have to provide a minimum of 20,000m³ of shingle every year just to stand still".

In addition to this annual replenishment, however, PCDL also recycles the shingle while it is on the beach. After a storm, shingle can be lost from particu-



1. UNDER THREAT



If the shingle bank had not been restored a breach could have flooded 50km² of land, 17,000 properties, caravan parks, roads and railway lines. Also at risk were the Pevensey Levels, an important SSSI and Ramsar-designated wetland environment

17,000
properties at risk of flooding

2. REPLENISHMENT

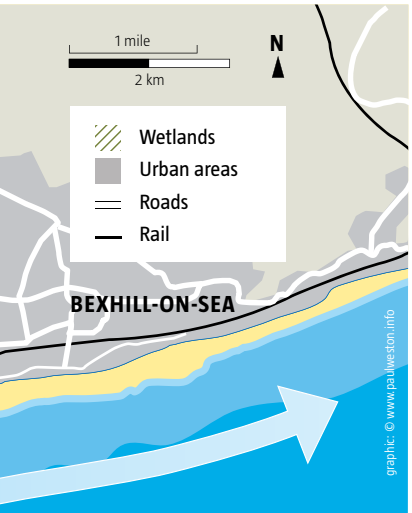
At the start of the contract 200,000m³ of shingle was brought in to build up the defences. Now every year the beach is replenished by a specially commissioned dredger taking shingle from nearby banks and depositing the material at the western end of the bay

200,000m³
initial shingle replenishment

3. RECYCLING

After a storm PDCL collects shingle that has been moved by the waves and returns it to the section of beach it came from. If this is done quickly enough the shingle does not dissipate over a wide area, and can be easily collected, returned and placed by bulldozer

2M.m³
volume of shingle on beach



LITTORAL DRIFT
pushes shingle west to east along the coast eroding the natural beach defence

4. REPROFILING

One bulldozer stays on site throughout autumn and winter to carry out day-to-day reprofiling. But if the shingle profile changes after a bad storm the contractor has to mobilise whatever plant necessary to start restoring the original shape within one tidal cycle

12 hours
maximum mobilisation time

KEEPING THE NEIGHBOURS HAPPY

"I think this is a partnership not just between us and the client but between us and the local community," says PCDL project manager Ian Thomas, who is based permanently at a small office behind the beach.

"We thought at the outset that, as we were being paid for something not to happen, we needed to be more proactive in terms of liaising with people and how we were presenting ourselves."

Unlike many coastal zones, the beach at Pevensey Bay is not owned by a single landowner or authority. Instead, there are 300 properties built directly on top of the shingle bank, each with ownership of their beach frontage as far as the mean high water line.

Despite being able to undertake the work under the Environment Agency's permissive powers, the PFI consortium is aware of the need to be as sensitive as possible to these landowners and other local residents, especially as the shingle replenishment and recycling involves the use of heavy plant. "Reprofiling has to happen at low tide, so we often tend to be working at 6am, meaning residents could be woken up by a bulldozer," explains Thomas.

From the start, the team has encouraged local residents to visit Thomas in his beachside office. This "open door" policy has worked, as residents have told Thomas they no longer need specific stakeholder meetings that used to be held on a regular basis, because they already know what is going on, from their day to day contact with Thomas.

larly volatile areas, but the company has discovered that it does not initially move very far. If this shingle is collected soon after it moves, it can be returned quite quickly and easily (and cheaply) using dumptrucks.

Unlike traditional PFI contracts, the Pevensey arrangement could be seen as "paying for something not to happen". Over any 25-year period – the length of the PFI agreement – it is highly unlikely that defences capable of withstanding a one in 400 year flood will ever be fully tested, making it difficult to measure whether PCDL has done what it was contracted to do. But the two parties have agreed a set of "key physical features" that define the required defences, with monthly payment based on the beach meeting these criteria.

The two core requirements are that there should be 2M.m³ of shingle distributed over the 9km long bay, and that the shingle bank should have a minimum width of 22m at its crest.

To ensure the beach has a roughly even spread of shingle, it has been subdivided into 53 sections, and the required volume and acceptable recession rate stipulated for each section. "We compare the volumes on a monthly basis to the contract volumes and tolerances," explains Thomas, who uses a GPS system mounted on a quad bike to survey the entire beach once a month on the Spring tide.

Individual readings are vertically accurate to within ±30mm, which means 2M.m³ of shingle can be measured to an accuracy of ±10,000m³.

This monitoring also gives the company vital information about how the beach behaves, and how the shingle moves tide by tide and after storm events.

Both sides believe the PPP contract encourages innovation, with the 25-year timescale allowing PCDL to try new techniques and refine its methods. Evidence of this can be seen in the way the company now carries out the annual replenishment in which 20,000m³ of new shingle is deposited on the beach.

In the first year PCDL used a 5,000t dredger to offload into two barges that bottom dumped it at the base of the beach at high tide. The shingle was recovered at low tide and placed with an excavator and bulldozer.

A year later the efficiency of the process had been improved, because Westminster Dredging had commissioned a new dredger, *Sospan Dau*, so that the shingle could be "rainbowed" directly from the vessel onto the beach on the high water line. This not only meant the shingle was closer to where it was required, but also avoided the need to wait for the tide to go fully out – and the risk of losing some of the shingle by tidal action. It also eliminated the need for dump trucks.

This method also had the advantage of almost eliminating "cliffing" – the tendency for the shingle bank to form steep "cliffs" once it is attacked by waves. The phenomenon occurs because sea-dredged aggregate introduces more sand into the beach crest than occurs naturally. When subject to wave action, the higher sand content allows the material to stand much steeper than naturally sorted sediment. The resulting cliffs not only make it difficult to walk on the beach, but can also collapse.

But during the rainbowing process the sand tends to migrate to the fringes of the mound, making it possible to recover just the coarse elements to the widened crest and leave the sand lower down on the beach.

By 2004 PCDL had determined that minimal amounts of sediment were lost offshore, and so refined the process allowing it to dispense with surveys for measurement purposes.

Completion of the Sovereign Harbour development at the west end of the bay meant the company had to deposit shingle in front of a rock revetment, and since 2008 has used this as a chance to experiment with simply using the dredger and one bulldozer to place the material. It soon became clear that the annual beach replenishment could be carried out at this one location alone, and that wave action would naturally disperse material further east.

"This is the dominant transfer direction, and very quickly it starts to move along and up the beach, without any cliffing,"

"We compare the volumes [of shingle] on a monthly basis to the contract volumes and tolerances"
Ian Thomas, PCDL

SEA DEFENCES: PEVENSEY BAY

explains Mouchel technical manager Zoe Hutchison.

What started as an annual operation involving three seagoing vessels, a bulldozer, an excavator and a surveyor has since 2009 been achieved with just a dredger. The company has one bulldozer permanently on site throughout autumn and winter to carry out day-to-day reprofiling work, but if there is a bad storm Mackley – the consortium member responsible for maintenance and emergency response – mobilises enough plant to restore the beach profile within one tidal cycle. "If we failed we would get penalised by PCDL," says Mackley managing director Tony Camilleri.

"If we failed [to respond to storm damage] we would get penalised by PCDL"
Tony Camilleri, Mackley

Innovation has not been limited to the use of plant on the job. The team has also trialled lesser known hardwoods for new groynes and experimented with groyne components made of recycled plastics. "They are abrading less than the wood," says Thomas. "I would certainly use them on the part of the groyne that's not seen."

PCDL has also replaced a section of the underlying shingle with tyre bales. "You can use them to displace some good shingle that's underneath the active beach and re-use it elsewhere," says Thomas. "And during a storm, linked bales would act as a structure and not be breached."

At the moment the tyre bales are more of a research project and are being monitored to see how they perform in this saline environment. "They're most effective where you can bring them close to the site and fabricate them here, so at the moment they're not being used in earnest," explains Camilleri.

But that could change, says Thomas: "It has to be cost effective for us to use it, but if shingle goes up in price maybe we will use them more."

The nature of the PFI gives PCDL and its member companies an incentive to innovate, because it may result in financial savings. At the same time, the 25-year contract also gives the entire sea defence industry a real chance to learn how this beach works. "You don't usually get the luxury of managing a stretch of beach for a long period," says Camilleri. "But it's meant we've learnt how to deal with all of the natural processes of the beach."

Both PCDL and the Environment Agency believe that Pevensey has helped evolve best practice in the provision of shingle sea defence management. The team describes its methodology as "little and often", where the key elements are guaranteed funding, regular monitoring, physical trigger levels that define when intervention is necessary, and flexibility to adjust working practices as coastal processes change.

ICE AGE COMPLICATIONS

The shingle that forms the beach at Pevensey Bay originally came from the seabed.

As water levels rose since the end of the last ice age, and the English Channel formed and expanded, wave action gradually moved glacial and other debris towards the land. This process continued unabated for thousands of years, depositing large amounts of aggregate on the foreshore.

But once water depths went beyond a critical point, waves were no longer able to continue delivering sufficient sediment, and littoral drift became the dominant force, as wind and waves combined to move shingle along the coast faster than it arrived.

Initially a feed of material was maintained, with the shingle coming from the large beaches formed during times of excess supply. But these gradually eroded, and once they had gone many beaches faced destruction.

So for much of the last 500 years the Sussex coast has been fed by littoral drift alone, and there is no longer enough sediment in the system for them to survive without intervention.

Pevensey is typical of the area, losing 20,000m^3 every year. Without intervention the defences would not have lasted long before they would be breached, and the annual provision of new marine aggregate is critical for the beach's survival.

THE PPP/PFI

While other sectors may be questioning whether PFI has ended up costing more than conventionally procured alternatives, the Environment Agency is convinced it has got a good deal at Pevensey.

"It's difficult to clearly define what value for money the project offers, but over a 25-year period it will demonstrate its value, says Environment Agency team leader Ian Nunn. "I would challenge anyone to find anywhere in the country where less than £40M has been spent on 9km of managed defences over 25 years.

"The big benefit is having guaranteed funding," he adds. "This is the only project where we know that in 15 years time it will still be operating. It's genuine asset management."

Nunn believes the decision to identify the "key physical features" of the beach as the basis for payment is vital to the success of the beach management strategy.

"We're understanding more and more about the way the beach reacts to what we do and the operations we carry out,

"One of the big benefits of this contract is that it gives the contractor time to evolve best practice. It avoids short-termism," he says.