

## MAJOR PROJECT: ST PETERSBURG FLOOD BARRIER



**South to Bronka:** The final road connection on the St Petersburg flood barrier is underway as the main gates also near completion

### PART 1: OVERVIEW

# RUSSIA'S PRICELESS DEFENCE

After 30 years, a giant construction effort to protect the beautiful city of St Petersburg from catastrophic flooding is drawing close to completion.

**Jackie Whitelaw** reports on an historic civils project.



**P**erched on a rocky promontory out in the Neva Bay on a balmy autumn day it is hard to imagine how threatening this environment can become. And not least to the brightly painted stonework and golden spires of the Russian city of St Petersburg which glows pink in the afternoon sun at the head of the bay.

But the city is under threat, and from the same serene expanse of water that is lapping around the promontory on the island of Kotlin just a few kilometres out into the bay. Storms in the west create huge surge waves that funnel down the Gulf of Finland straight at the city.

At the worst projection the city would be flooded to a depth of 5.15m. Up to 3M of St Petersburg's 5M inhabitants would be directly affected and some of the world's most precious monuments would be swamped at unimaginable cost.

The gloriously, decadently grand Winter Palace completed by Catherine the Great – which was the focus for the start of the

Russian revolution and which houses the Hermitage, one of the world's greatest museums and art galleries – would be flooded up to its first floor windows. Other city landmarks like St Isaac's Cathedral and the Church of the Saviour on Spilled Blood with its ceramic and enamel decoration and priceless wall paintings would be semi-submerged in freezing, abrasive sea water.

Water and sewage treatment plants, schools, hospitals and the city's metro would also be inundated and the people left safe after the waters had receded would be facing a humanitarian crisis to rival or eclipse that of New Orleans in 2005.

But after an extraordinary effort by the Russian government, some help from European funding and an all out assault by Russian and international civil engineering experts, none of this will happen – if the weather holds good for one more winter.

In St Petersburg it is the custom to wrap al fresco diners in soft, pastel fleecy blankets »



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» as they brave the chill autumn evenings. Currently the city is wrapping itself in its own protective blanket, in the form of a curving flood barrier that embraces the shallow waters of Neva Bay.

The project is something of an epic in scale and timeframe. The 25.4km barrier consists of 11 embankment dams, six sluices and two navigation channels each with floodgates. The dimensions are massive. Each of the pair of floating steel gates that closes like a door to shut the main navigation channel measures 122m long by 23.5m high by 4.7m wide. "Effectively they are like two large submarines which are driven out into the channel, water is pumped in and they land on the sea bed," explains Oleg Panchuk, deputy general director for security and public relations for client the Ministry of Regional Development.

The second channel is closed by a steel barrier that rises from a concrete slot at cill level and is 118m long, 12m deep and 9m thick. It can punch through 600mm of ice – the most that would be expected in a St Petersburg winter.

The barrier also doubles as a motorway – the latest link in the St Petersburg ring road. It will carry a six lane highway that crosses one navigation channel via a bridge that lifts 9m to allow shipping underneath. It passes beneath the main navigation channel in a 2km long, 26m deep tunnel.

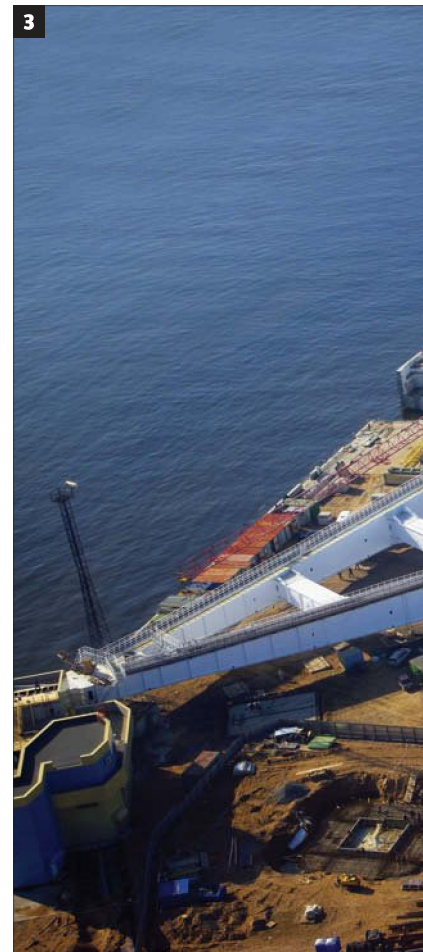
The barrier has effectively been under construction for a heroic 30 years.

It started in 1979 under the Soviet regime, then juddered to a halt 65% complete under Glasnost and Perestroika and the break up of the Soviet state.

What was built was close to being demolished in the early 1990s when the local population took against it, seeing it as a threat to the environment of the Neva Bay.

But the project was then revived as environmental fears were allayed and concerns about climate change and rising sea levels grew.

With the barrier's construction, the island of Kotlin in the Neva Bay will for the first time be properly linked to the mainland. The barrier runs from Bronka in the south to Kotlin and its main city of Kronstadt and then to Gorskaya on the



northern shore of the bay.

Total cost of the project is 87bn roubles (£1.8bn). "The project is expensive," says Panchuk "But the losses that will be avoided in the city from regular flooding will compensate for the expense. And the



**"The barrier gives an impetus for the development of new ports and industry"**

Oleg Panchuk,  
Ministry of Regional  
Development

### 1. FREQUENT FLOODS

Surge tides often flood St Petersburg. A flood is a rise in water level of 1.6m

### 2. MAIN GATES THEN

The site of the main gates after the 15 year delay to the project.

### 3. MAIN NAVIGATION GATE NOW

The 130m long 65m wide connecting arm moves each floating gate into position across the channel

### 4. SLUICES

Sluices with 10 or 12, 24m wide radial steel gates control flows of water in an out of Neva Bay

### 5. SECONDARY NAVIGATION

The secondary navigation is crossed by a lift bridge and closed with a 9m thick, 117m long gate.

barrier gives an impetus for the development of new ports and industry – on Kotlin and on the mainland.

"The cost takes into account construction inflation and the cost of the motorway as well as dredging for a new, deeper sea channel to allow larger ships into St Petersburg, a new navigation system and power supplies to the barrier and the town of Kronstadt. So we are solving a huge, complex task here."

The barrier is now something of an important project for Russian prime minister Vladimir Putin who studied at St Petersburg University and who was a senior member of the city's administration.

On his visit last year Putin told the construction team that the original completion date of 2012 should be brought forward to the end of 2010.

You can understand the sense of urgency – as well as admire the ability to accelerate a major project.

In its 306 year history the city has been flooded more than 300 times. The most catastrophic was in 1824 when the water level rose by 4.21m; the second, 100

years later, was in 1924 when levels reached 3.6m. It has been 85 years since the last major flood.

"The scheme is designed for a 1000 year flood of 4.55m but is checked against failure for a 1:10,000 year flood of 5.15m. And during construction of the barrier 20% of all the flooding in the last 300 years – 59 incidents of water level rise over 1.6m – has happened.

"The frequency of flooding is increasing. So the project is not a whim, it is vital," Panchuk says.

Attracting the attention of the government hierarchy has its benefits – there are never any problems with the financing. But progress is watched critically and success raises expectations.

"When Mr Putin visited last year the speed of construction progress was clear," says Panchuk. "And it was clear that the project could be finished earlier so we were told to go for it. It was not about a voluntary decision."

Signed up to that deadline is UK consultant Halcrow which is lead designer for the flood barrier scheme.

When the European Bank





for Reconstruction & Development agreed to lend money to the scheme (*see box*) there was general agreement that after a 15 year halt in construction the designs should be reassessed and updated where possible.

Halcrow won the international design competition in 2003 in association with DHV of the Netherlands and Norplan of Norway.

“Our job was to review the existing designs and then produce technical documentation for tenderers that allowed the work to proceed. The actual design changes were done under our direction by the Russians through their design institutes,” says Halcrow project manager David Edwards.

This was not an easy job. The project had been underway for almost a decade before it was halted. Much had been done, much had still to be done.

The embankment and sluices to the north of Kotlin Island were all substantially built and in place and the box girder bridge at the secondary navigation channel was fabricated but sitting on the ground rusting away. There were gaps in the

#### FUNDING

**Funding for the £1.8bn scheme has come from three sources. International financing includes a £150M European Bank for Reconstruction & Development (EBRD) loan matched as a condition of the loan by the same funding from the Russian federal budget.**

The rest is additional funding from the federal budget. The EBRD says the international financing “gives the Russian authorities an opportunity to demonstrate that large public sector projects can be completed in time and within budget on the basis of open and transparent procurement practices”.

viaduct leading to the bridge and the sea channel was a 17m deep hole covered in scrub and home to a pack of wild dogs.

“The gate itself was in 230 fabricated sections in a yard in Gorskaya and had been sitting there since the 1990s,” says Edwards.

“South of Kotlin the embank-

**“The gate itself was in 230 fabricated sections in a yard in Gorskaya and had been sitting there since the 1990s”**  
David Edwards, Halcrow

ment was part built to a low level, about 3m above water level, with the final embankment height being 6.5m, and the two sea sluices were half complete.

“The embankment built out from Bronka on the southern mainland petered out in the water separated by almost 1km of deep water from a 25m deep cofferdam containing partially completed docking chambers for the main gates and a section of cut and cover tunnel.

“The gates were in sections in a steel yard,” he says.

“Most of the tunnel was concreted bottom, sides and top but cast in 60m section with no joints completed so there were 2m gaps between the sections.

The docking chambers – which are 13m deep when complete – were concreted up to between 6m and 7m and the training wall for the navigation channel was also at half height only. It was quite hard to make sense of all the pieces.

“We had to update the designs according to revised design codes, incorporate new materials for example for tunnel and bridge joints, react with redesigns to extra wind and wave data that had become available, all without reliable as-built documentation for the existing structures, and with many of the original designers having retired. Plus, we were working with Russian codes which are not particularly compatible with the Fidic contract to which we are operating.”

Edwards says it is a testament to the ability and goodwill of all the nationalities, companies and individuals on the scheme that work restarted swiftly in 2005 and so much has been achieved in a short space of time.

The biggest challenges, not surprisingly, have been the gates to close off the navigation channels.

# MAJOR PROJECT: ST PETERSBURG FLOOD BARRIER

## PART 2: INFOGRAPHIC

# SAVING THE SAINT

St Petersburg is under threat from the sea; its new flood barrier will protect it for centuries.

In certain weather conditions over 5km of water could surge through the Gulf of Finland, into Neva Bay, and swamp St Petersburg. Thanks to a £1.8bn major infrastructure project to construct a 25.4km barrier across Neva Bay that threat is receding day by day. By the end of next year the city should be protected for centuries to come.

The barrier consists of a 6.5m high embankment running from Bronka in the south to Gorskaya in the north. Two major navigation channels – known as S1 and S2 – are each protected by huge steel gates that can be closed quickly when a surge is threatened. Water flow between Neva Bay and the Gulf of Finland is also aided by six sluices up to 300m wide and equipped with their own steel gates that can be shut to keep out a surge wave.

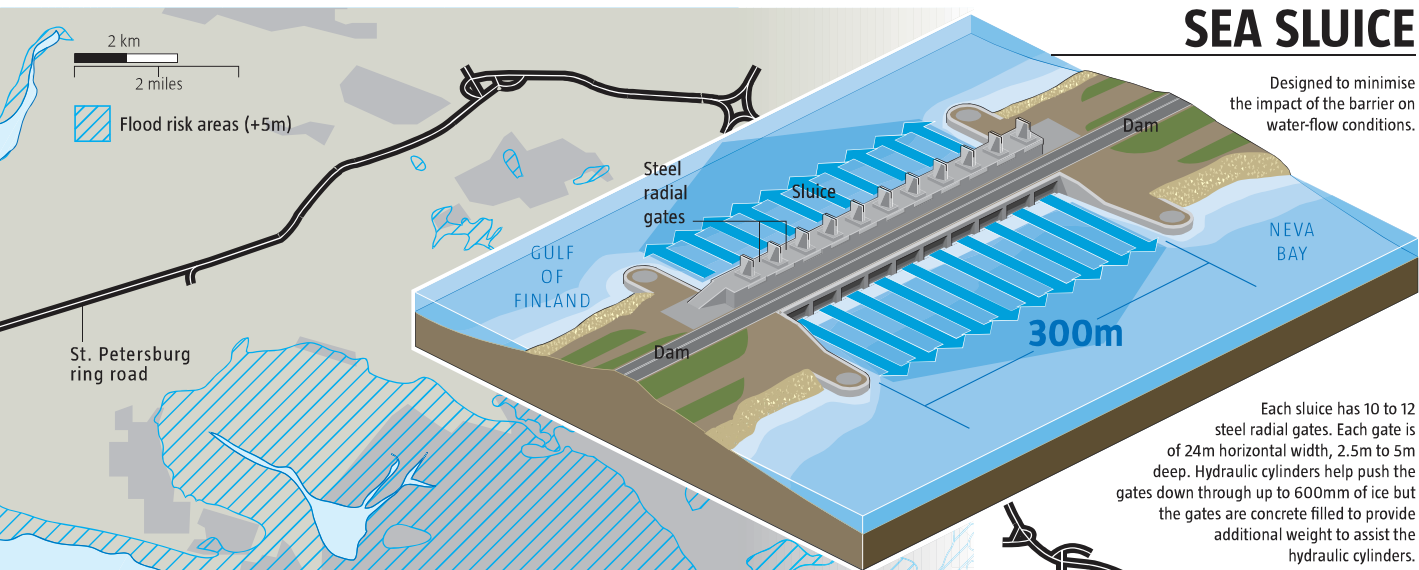
Running along the top of the barrier is a six lane motorway that is the latest link in the St Petersburg ringroad. This highway crosses the smaller navigation via a lift bridge that can be raised 9m to allow local shipping to pass beneath. At navigation S1 the road disappears into a 2km long, 26m deep tunnel under the navigation channel.

Completion of the scheme, which started in 1979 but was halted for 15 years by the end of the Soviet era, is scheduled for the end of 2010.

**Running along the top of the barrier is a six lane motorway that is the latest link in the St Petersburg ring road**







## SEA SLUICE

Designed to minimise the impact of the barrier on water-flow conditions.

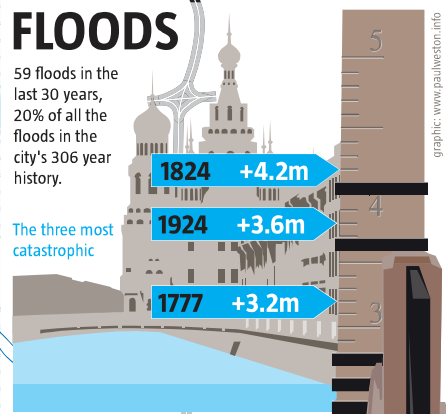
Each sluice has 10 to 12 steel radial gates. Each gate is of 24m horizontal width, 2.5m to 5m deep. Hydraulic cylinders help push the gates down through up to 600mm of ice but the gates are concrete filled to provide additional weight to assist the hydraulic cylinders.



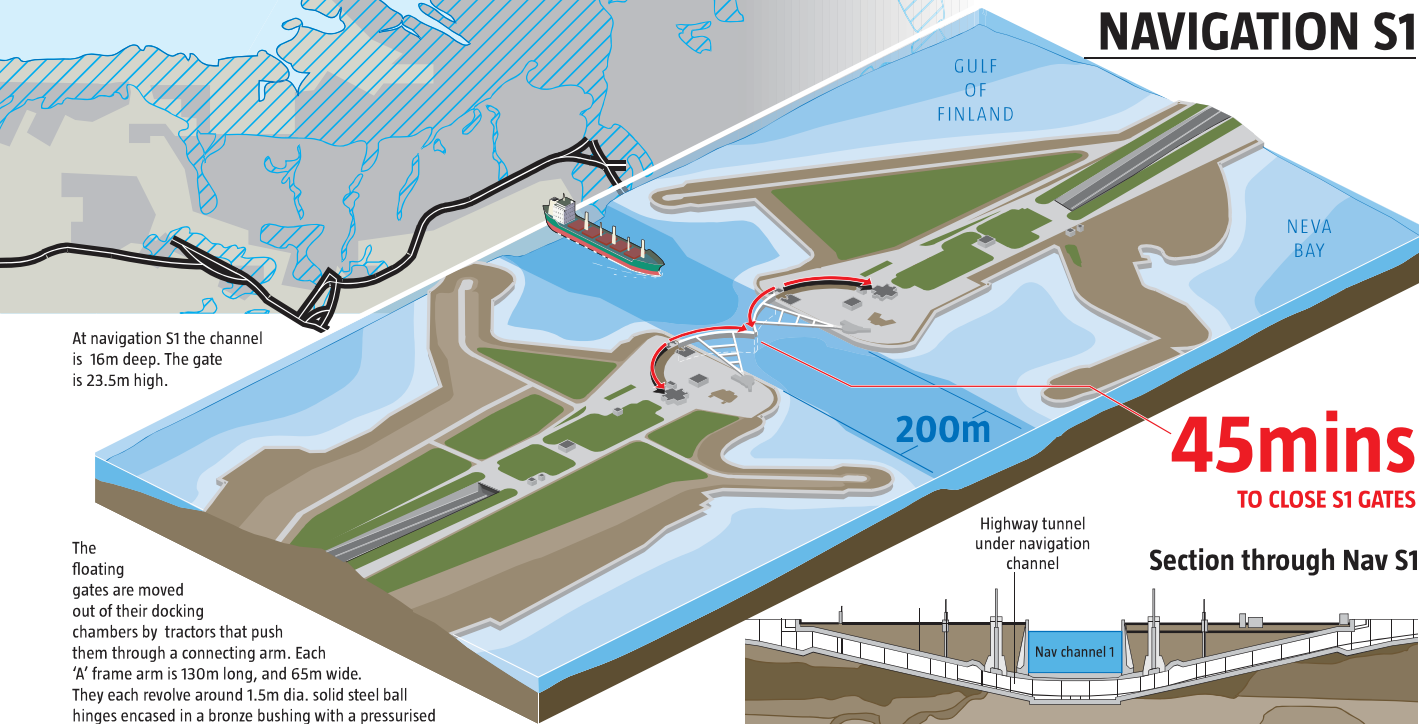
## FLOODS

59 floods in the last 30 years, 20% of all the floods in the city's 306 year history.

The three most catastrophic



## NAVIGATION S1

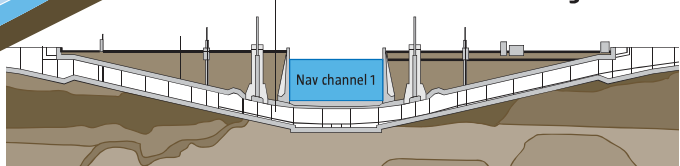


At navigation S1 the channel is 16m deep. The gate is 23.5m high.

The floating gates are moved out of their docking chambers by tractors that push them through a connecting arm. Each 'A' frame arm is 130m long, and 65m wide. They each revolve around 1.5m dia. solid steel ball hinges encased in a bronze bushing with a pressurised lubrication system.

**45mins**  
TO CLOSE S1 GATES

Section through Nav S1



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### PART 3: FLOODGATES & SLUICES

# SWING THROUGH THE SEA

The huge curved floating gates that will close off the deep water navigation channel through the St Petersburg flood barrier are soon to be closed for the first time. **Jackie Whitelaw** reports.

**S**t Petersburg's main floodgates give the impression of straining at their seams, desperate to get to sea. But though they will float on water they do not have the look of ships.

The slender curve of their prows with ballast tanks above are more akin to submarines and their conning towers.

"That shouldn't be a surprise," says lead designer Halcrow's project manager for the flood barrier David Edwards. "Because the gates were designed by submarine designers."

And when they do set off to do their duty protecting St Petersburg they have to behave

like submarines. The 122m long, 23.5m high and 4.7m thick steel structures will be floated in their dry docks and will then set sail to meet in the middle of the 200m wide, 16m deep navigation channel.

Chambers within the gates will then be flooded with sea water helping the structures to gently sink to the sea bed where they can use the weight of their steel and the weight of the sea water to hold back threatening surge waves heading ashore from the Gulf of Finland.

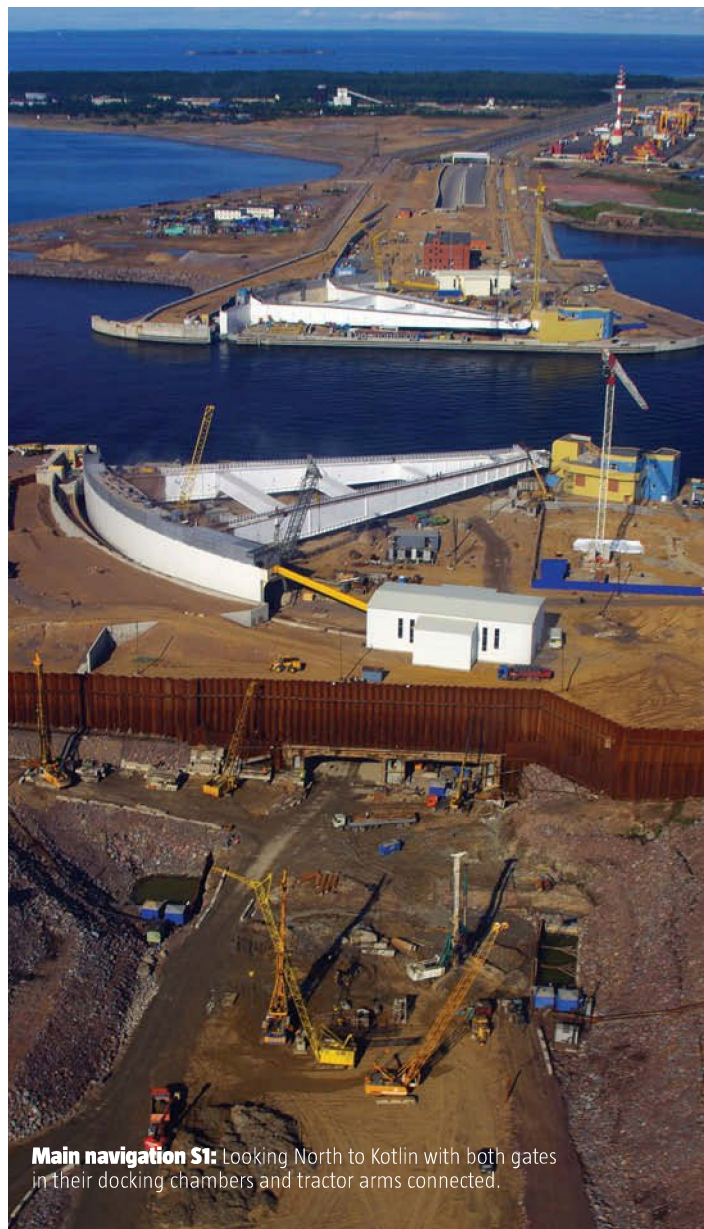
"The gates will take 45 minutes to close the navigation channel and will only take 25 minutes to land on the cill," says main contractor Atomstroyexport contracts manager for the gates, civil engineer Ivan Seryogin.

"And we should get eight hours notice of a flood risk."

Last month they were each individually successfully launched and sunk.

"They weigh 3,000t each but they glided out so silently and powerfully, it was awesome," Edwards says. Their biggest test will be when they are required to do their dance together for the first time – a date for which has yet to be fixed.

The gates and their method of propulsion are marvellous examples of really muscular engineering – good, solid design with nothing overcomplicated and the result undoubtedly of the design being originally conceived in the mid 1980s. They are the embodiment of the



**Main navigation S1:** Looking North to Kotlin with both gates in their docking chambers and tractor arms connected.



**"It was a big challenge. Our ideas were constrained by the fact that the docking chambers were already built"**

David Edwards, Halcrow

old joke about the Americans spending millions of dollars inventing a ballpoint pen that will write in space, while the Russians took a pencil.

Each gate is controlled by two enormous 130m long horizontal A-shaped steel arms which are connected at their apex to a rather beautiful 1.5m diameter solid steel ball hinge encased in a bronze bushing with a pressurised lubrication system.

This is the pivot that the 1,500t arm and thus its gate swings around. Each gate is propelled by a chunky tractor that pushes it out from the rear via a steel cattle-prod type connecting arm.

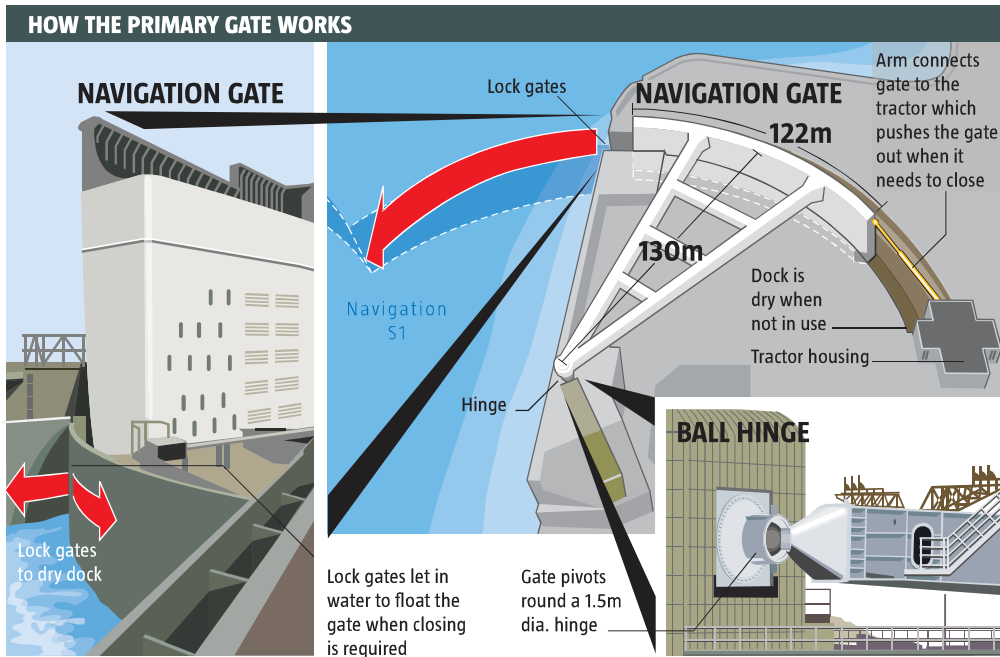
The tractors run along cog and wheel tracks – designed, perhaps not surprisingly by a former army tank commander. At the moment each tractor is

a flat bed affair with 28 sets of wheels. "But we are going to add a futuristic housing on top to make them look exciting," says Seryogin.

Although the main gates can be moved out and closed quickly they will take longer to drain, refloat and return to the docking chambers.

It is critical that the main gates (and their sister gate at Navigation S1 further north) are opened within 48 hours "because that is the amount of time it would take the waters of the River Neva pouring down from Lake Ladoga only 74km upstream to back up and start causing their own flooding problems in the city", explains Ministry of Regional Development head of environment and flood warning Rosa Mikhailenko.





Anyone in the flood protection world who feels they have seen a similar type of flood protection gate at Meislantkering near Rotterdam would be right, but the Russians feel they came up with the original concept, just took a little longer to build it.

"The Dutch barrier does have practically the same gate design," says the Ministry's deputy general director of security and PR Oleg Panchuk. "Our Dutch colleagues started later but opened earlier! But we are not arguing about copyright of the idea, just co-operating."

The St Petersburg team takes trips to see Maeslantkering in operation but Edwards believes that the Russian gate will be the more impressive.

When the team started on site in 2006 it had to unravel the jigsaw puzzle of the 40t to

80t pieces of steel that had been fabricated for each gate over 15 years before and start putting them together.

"Many of the 68 sections needed for each gate had been fabricated at the end of the 1980s," explains Seryogin.

"We had to repair them and manufacture the new ones that were needed.

"We did have the drawings and the sections were in the hands of experienced assembly workers and welders."

Seryogin's company Atomstroyexport is well known for its nuclear power station construction work and the quality of welding work carried out by its workforce.

The biggest challenge it encountered was appending some new bits of steel when it was discovered the gates needed

some redesign work.

Edwards explains: "Part of my job was to go back to basics and we retested the hydraulics of the gates. We discovered that, when you started to get a difference in head as the gates closed, and the water level on the inside was lower than that on the outside, the gates became unstable.

"The problems started at

**"The gates take 45 minutes to close the navigation channel and 25 minutes to land on the sill"**

Ivan Seryogin,  
Atomstroyexport

about 500mm. When the gates are shut in the design flood there is a 3.5m difference and with instability, lowering would be fraught with problems.

"It was a big technical challenge because our ideas were constrained by the fact that the docking chambers were already built and the most of the gate sections were already cast.

"The solution was to add a hydrofoil section to the lower edge of the gate."

The contractor opted to weld this on insitu within the docking chambers once the gates were finished, allowing it to keep working while the detail for the hydrofoil was refined.

"It was a tight space but not a problem for experienced workers," Seryogin says.

Over the last year the huge hole that was the legacy of the first stage of construction of the barrier has disappeared. The tunnel section beneath the main navigation channel was jointed up and had its original steel plate waterproofing removed and a double skinned PVC waterproofing membrane added.

In summer last year the water was allowed to flood in, separating the two gates by sea and stranding the one to the south on its own island, only accessible by the tunnel. This new navigation channel was formally opened last October.

Since then a 1km long, 26m deep cofferdam has joined the southern gate to the embankment on the south blocking off the original navigation channel.

Within the cofferdam the final 700m of tunnel and ramp works are underway to allow completion of the barrier and its motorway. Workers on the project can look up to see huge tankers sailing above them.

Boskalis carried out dredging and earthworks and Hochtief is creating the 39m by 7m high concrete box for the tunnel.

"The idea is to finish the concrete works by mid 2010 and in parallel the tunnel will be backfilled and the utilities will go in," says Halcrow project engineer Alexey Kislenko.

The desired, politically accelerated completion date of the end of next year is looking achievable.

#### Navigation S1

The secondary 110m wide navigation channel through the barrier is designed to allow the

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**“Our Dutch colleagues started later but opened earlier! But we are not arguing about copyright”**

Oleg Panchuk,  
Regional Development  
Ministry

passage of river-sea vessels.

The bridge over the channel can lift from its normal 16m height above the channel to 25m in three to four minutes.

The huge steel gate that will close off the channel in the event of a flood sits in a concrete slot below cill level and is lifted by four hydraulic cylinders. When work on site restarted the 2,500t of steelwork that had been fabricated in the 1990s was sitting in a yard in Gorskaya in 230 sections.

Finished measurements of the gate put it at 117m by 12m deep and 9m thick. The 11.3m stroke hydraulic cylinders will help the gate punch through a predicted 600mm of ice in the channel in the winter.

### Sluices

The six sluice gates that are spaced along the length of the barrier allow water into and out of Neva Bay and also double as flood defences. Each of the sluices has 10 or 12, 24m wide, steel radial gates and there are 64 sluice gates in total.

When they have to be closed they are pushed down into up to 5m of water in as little as a minute by pairs of hydraulic pistons. Concrete infill in the gates gives them some extra clout when it comes to forcing their way through the up to 600mm of ice they are designed to penetrate.

Even when partially built the embankment and sluices have been providing some protection to St Petersburg in flood scares over the last few years. Recent floods would have been much worse without them, according to Mikhailenko.

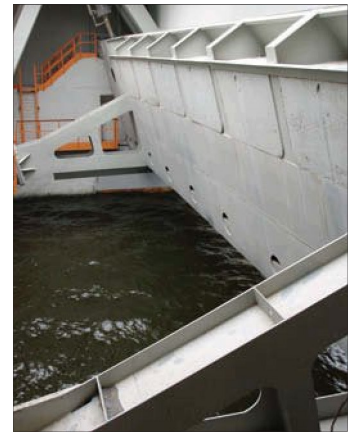
She keeps a wary eye out throughout autumn and winter as these are the critical seasons, when 85% of the city's floods have occurred and water has been known to rise by 1m an hour.



**Cut off:** The barrier gate in position at navigation S1. It is lifted by four hydraulic cylinders



**Sluices:** Pistons in stainless steel housings push the sluice gates down



**60 seconds:** Time to close sluices

“Since 1998 we have had a sophisticated flood warning system based on GIS that gives us good early warning and from that we have developed a useful flood modelling programme,” she adds.

“It is used by many agencies in the city – civil protection, planning, city development – to forward plan evacuation in the case of civil protection and how and where to develop the city in the case of the others.”

The sluices have also been proving their worth by improving water quality and environment in Neva Bay, she says. By closing some gates and keeping others open during normal weather it has been possible to change currents in the bay to help increase aeration and natural cleaning. “And we can use the flows to dissipate pollution – from oil spills from shipping for instance,” Mikhailenko says.

As St Petersburg and the Leningrad region develop in

the coming years the amount of shipping is expected to increase dramatically so the sluices' cleaning facility will be particularly useful. The new, deep navigation channel that has been created as part of the barrier works will allow much bigger ships to ply into and out of the bay. There is good reason for this.

“St Petersburg is still the northern capital of Russia and still the country's window to Europe,” says Panchuk. “And the significance of the city as a transport node is growing because new ports are being constructed nearby for liquefied gas export and for container cargos.

“Previously we had ports in Latvia, Lithuania and Estonia. Now we can only count on our own resources, so for several years we have been building in the Leningrad region and St Petersburg”

St Petersburg's flood barrier is significant for more than just the city's protection, it seems.

### WHO'S WHO

**Client** Ministry of Regional Development, Director, Department of Capital Investments – Vladimir Kogan; General Director, North West Directorate of Rosstroy – Vladimir Shchekachikhin.

**Lead designer** Halcrow with DHV and Norplan

**Designers:** Lenhydroproject, LenMornilproject, Transmost, VNIIG, Rubin, Constructor, LenHydrostahl, LenMetroGyroTrans, SPbGyproShacht, VAMI Automatics, Techno SPb

**Project implementation** FISP

**Project management** Geningconsult, Royal Haskoning, Stroyproject

**Contractors** Morteknika/Boskalis/Hochtief; Metrostroy; Atomstroyexport; Transtroy