Flood barriers

Saving Venice
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Scientists now largely agree that flood gates are necessary to protect Venice from high water

ANYONE considering a trip to Venice in the next few months would be wise to pack wellington boots. Between now and April the lowest parts of the city will be regularly inundated.

High water is an increasingly frequent problem (see chart). Besides the inconvenience this brings to Venetians and tourists, salty water lapping above Venice's foundations is eating away at the fabric and treasures of this unique and historic city. But for decades there has been an acrimonious debate about what exactly should be done and little routine maintenance work on the structure of the city. So researchers met at Cambridge University this month to survey what is known about the flood risk and the best ways of tackling it.

To grasp the problem, the popular tourist destination of St Mark's Square is an excellent place to start. One of the lowest, and oldest, points in the city, it is home to treasures such as St Mark's Basilica and the Doges' Palace. In the first decade of the 20th century, the square flooded less than ten times a year. By the 1980s it was flooding 40 times a
year, and today it floods some 60 times a year. Severe inundations, when more than 90% of the city’s surface is under water, are becoming more frequent. Another disastrous flood, such as the one the city suffered in 1966, may only be a matter of time.

**Bouncing back**

The problem is not simply that Venice is sinking into the mud. It is true that groundwater extraction during the last century may have caused the city to sink by as much as 10cm, but, thankfully, this has since stopped. Roberto Frassetto, an oceanographer at the Marine Sciences Institute in Venice, says that small rebounds might even be possible if hydrostatic pressure in the aquifer can be re-established. The other reason for the subsidence, which continues unabated, is a natural geological decline of around 0.5 to 1mm per year due to movement of the continental plate and compression of the soil.

The real root of Venice’s problems with high water appears to be that sea levels are rising fast. The city’s total movement with regard to sea level is about 2.3mm a year (plus or minus about 0.7mm to account for the possible error in scientific calculations), according to Dr Frassetto. Compounding the effects of this problem, changes have been made to the structure of the lagoon which have reduced its natural protection against high water.

One suggested solution is a barrier that will prevent the high tides from entering Venice’s lagoon in the first place. The idea is by no means unique. Flood and storm barriers against the sea are now common in various places around the world. London and St Petersburg have such barriers. The Maeslant barrier in the Netherlands is another example.

Nor is the idea of a barrier for Venice new. Dr Frassetto first proposed it in the 1970s. But it took more than a decade for the idea to be accepted, and another two decades before work on a breakwater started this May. Construction will take a decade to complete, and that is only if scientific wranglings and Italy’s complicated politics do not cause further delays.

The gates are often referred to as MOSE, or the Moses gates, a name that comes from an experimental prototype called the *modulo sperimentale elettromeccanico*. The nearly €3 billion ($3.4 billion) scheme will comprise about 80 hollow gates embedded in the seabed at the three inlets to Venice’s lagoon. When not needed, the gates will rest on the seabed, full of water. But when high tides threaten the city, compressed air will force water out of the gates. This will cause them to rise and act as a barrier to water trying to enter the lagoon.

Will the gates justify their large cost? That question has been fiercely debated by Venetians themselves. Bedevilling that debate is the fact that there are no agreed estimates of the cost of flooding and the savings the gates will bring. And not everyone is convinced the gates are a good idea. For one thing, once they are installed, they will require an estimated €9m each year to operate—money that might be spent on other flood protection measures. For another, since the 1966 flood, many changes have been made that have reduced the damage from high water. Electrical junction boxes have been moved out of the reach of even the highest tides, and the ground floors of many buildings have been abandoned.

Also, much routine maintenance work is now under way to raise, where possible, pavements to act
as a barrier to high water (a long-employed strategy to beat the rising water). And the damaged foundations of Venice’s 45km (30 miles) of canals, and the buildings that line them, are being repaired and waterproofed.

These are costly and unexciting tasks. Many people, though, believe they are more fundamental to the future of the city than the gates. There are also some, such as Albert Ammerman, an archaeologist from Colgate University in New York, who say that the gates should not be built at all because the designers have underestimated the amount the sea may rise. Debate continues on medium-term forecasts and, when it comes to what will happen to sea levels beyond 2050, nobody can even guess with much confidence.

**In high water**

However, the most serious objections to the gates have always been environmental. The population of Venice and its accompanying urban sprawl on the mainland pour their sewage directly into the lagoon—relying on twice-daily tides to flush this into the Adriatic. This flushing, says Job Baretta, a consultant on coastal system dynamics, was rapid enough to avoid overfertilisation of the lagoon until the 1980s, when massive and persistent blooms of algae broke out. Steps were then taken to reduce nutrient run-off into the lagoon from industry, agriculture and sewage, and the blooms stopped. But some worry that if the gates are now closed, even briefly, the balance will be upset again and the lagoon will stagnate.

As a result, the group of engineering and construction companies that are building the gates—Consortio Venezia Nuova (CVN)—have been told that the gates must reduce water exchange between the lagoon and the Adriatic by only 5%. Many, including Dr Baretta, believe that the gates are unlikely to cause stagnation anyway. They will be closed only for short periods of time and only during the winter when the water temperature and light are too low for algal blooms. But Dr Baretta warns that the jetties proposed along with the gates will be a problem—reducing flushing of the lagoon, and thus its water quality.

Nevertheless, Donald Harleman, a hydrologist at the Massachusetts Institute of Technology, argues that it is possible to use selective operation of the gates, when there is no flood risk, to actually increase flushing. There are three gates, and circulation could be aided by keeping some open at some times, and closed at others. He adds, rather pointedly, that there is rarely a mention of the real solution to this problem: collect and treat Venice’s sewage. Treatment plants for the most densely populated mainland areas of the lagoon have recently been approved and should be built by 2006.

If there is one thing that researchers do agree on, it is that the gates are not the sole solution. Many think something must be done to halt and reverse changes to the structure of the lagoon that have reduced the flood protection it provides for the city. Pierpaolo Campostrini, director of CORILA—a consortium for co-ordinating research concerning the Venice lagoon system—says that the lagoon is being transformed from a marsh into a completely marine environment. Sediment-carrying rivers have been diverted, sea level has risen (increasing the volume of water in the lagoon), a deep-water channel has been dredged for shipping, and turbid waters are killing the eel grass that stabilises mud flats.

Giovanni Cecconi, the head of engineering at CVN, explains that way back in 1810, protective salt marshes occupied more than 150 square km of the lagoon, but by 1998 these had declined to only 33.5 square km. What should be a shallow, marshy environment, complete with a complex set of channels, islands and sand bars is becoming a flat, scoured bay subject to the full force of the Adriatic. And the deeper the water gets, the greater the wave energy that can build up. This results in a further deepening of the lagoon. Dr Cecconi says that between 1950 and 1960, the

rate of erosion in the lagoon increased by 20 times.

Restoration work, such as reconstructing salt marshes near the island of Burano and sand dunes at Cavallino, and planting eel grass all over the place, is part of the solution. But sediment is being lost at a rate of 700,000 cubic metres a year. This is so serious that the authorities have twice considered redverting a river into the lagoon.

Another solution is to use sediment dredged from navigation channels in one part of the lagoon to build beaches and new islands or to reinforce old ones in another part. But in some areas, sediments are so polluted with toxic chemicals, such as mercury, that the mud must be stored in a dump. Instead, Alberto Scotti, president of Technital, an engineering consultancy, that works for the Venice Water Authority, says that the CVN is evaluating a plan to import mud from where it is accumulating behind a hydroelectric dam.

Despite lingering doubts over the gates, construction has begun with a breakwater at the Malamocco inlet into the lagoon. The gates will certainly buy the city time, while more controversial long-term solutions—such as closing off the lagoon permanently—can be considered.

**Gate expectations**

The root of much of the acrimony over the gates has been suspicion about the body responsible for building them, CVN. This state-backed consortium includes most of Italy's biggest building and engineering firms, and they alone have been charged with defining the nature of Venice's flooding problems and designing and implementing a solution. Many Venetians are quite naturally suspicious that an expensive structure has been proposed by the companies that are being paid to build it.

Looking ahead, Anna Somers Cocks, chairman of the Venice in Peril Fund, warns that the way work on the project is being implemented is guaranteed to lead to further problems. The Venice Water Authority, she warns, does not have independence and influence over CVN, and so cannot monitor its work in any credible way.

She also hopes that the gates will go some way toward addressing Venice's other basic problem—its loss of residents. Venetians have been leaving the city in droves—its population of 60,000 is now half of what it was only a few decades ago. If the gates stop the continual flooding of the city, it will make a big psychological change to the city, she suggests. Venice might then become a city where more people will want to live, invest and do business, rather than just visit. Although the future holds much promise, it is too early to say whether Venetians will ever be high and dry again.