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MINISTERO DEI LAVORI PUBBLICI

MAGISTRATO ALLE ACQUE

NUOVI INTERVENTI PER LA SALVAGUARDIA DI VENEZIA

Convenzione rep. 7601 del 20 marzo 1996

INTERVENTI ALLE BOCCHE LAGUNARI PER LA REGOLAZIONE DEI FLUSSI DI MAREA

STUDIO DI IMPATTO AMBIENTALE (SIA) DEL PROGETTO DI MASSIMA

NON-TECHNICAL SUMMARY

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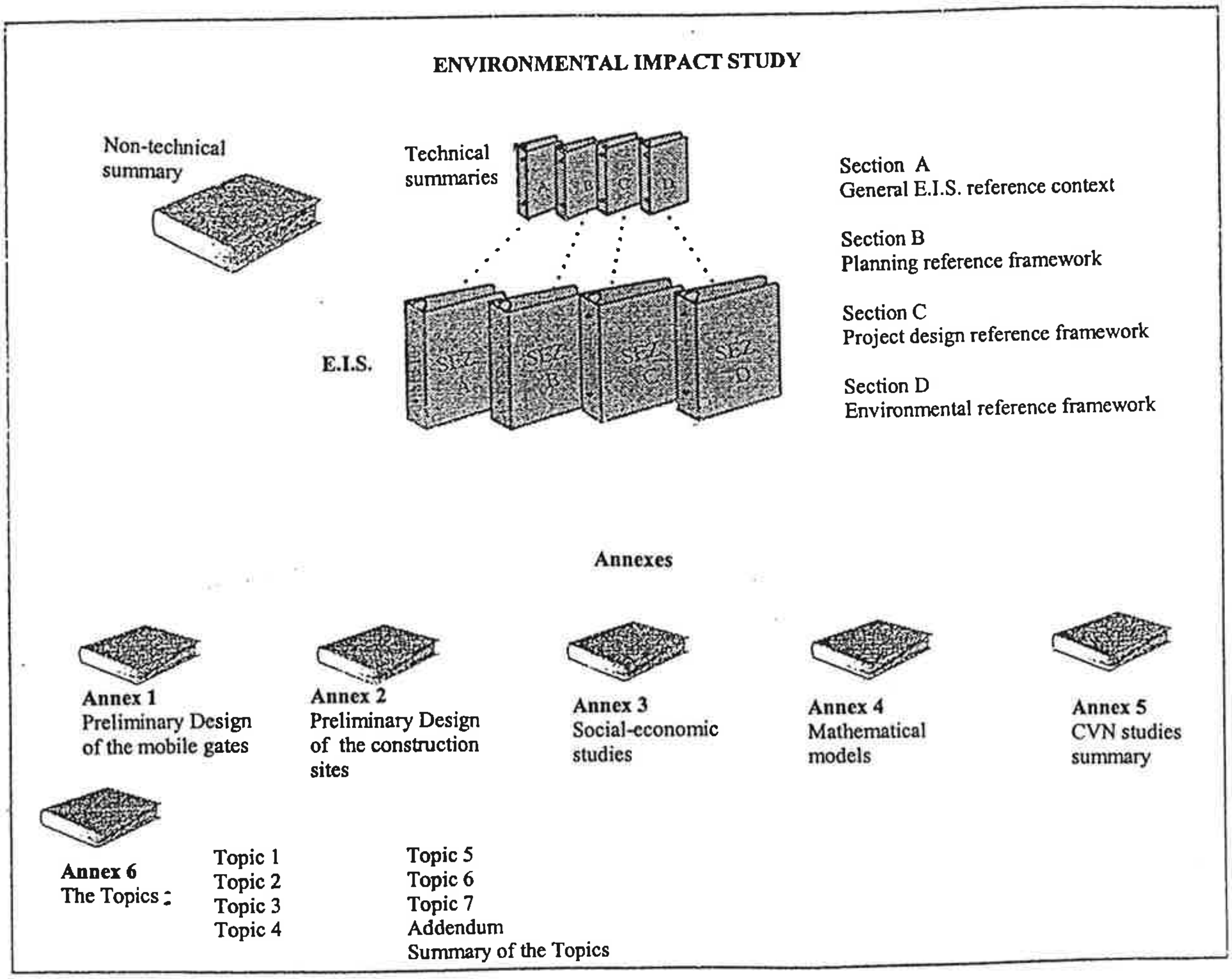
ENVIRONMENTAL IMPACT STUDY (EIS)
FOR THE PRELIMINARY DESIGN FOR THE INTERVENTIONS
AT THE LAGOON INLETS FOR TIDAL FLOW CONTROL

NON-TECHNICAL SUMMARY



CONTENTS

PREMISE

The tidal flow control interventions at the Venetian Lagoon inlets, as described in the Preliminary Design (*Progetto di Massima*) - also referred to herein as the mobile gate project, the mobile barrier system and simply the project - approved by the Italian High Council for Public Works (*Consiglio Superiore dei Lavori Pubblici*) with its vote No. 48 of 18 October 1994, form the basis of the solution proposed by the Consorzio Venezia Nuova (CVN), on behalf of the Water Authority of Venice (MAV) (*Magistrato alle Acque di Venezia – Ministero dei Lavori Pubblici*), for protecting the Lagoon towns and villages from flooding at typical or exceptional high water levels, established as the fundamental priority for safeguarding Venice by the Italian Laws No.171/1973, No.798/1984 and No.139/1992.

At the meeting of 4 July 1995, the Committee of Ministers as per article 4, Law No.798/1984 established that the project should be submitted for Environmental Impact Assessment, and also specified the relevant requirements. The MAV consequently entrusted the responsibility of the environmental study as ordered by the Committee to CVN.

The Environmental Impact Study (EIS) was executed in accordance with the guidelines established by the applicable Italian legislation (DPCM 27/12/88) and is divided into three frameworks which were preceded by a general description of the context for the proposed interventions and for the corresponding EIS:

- the Planning Reference Framework;
- the Project Design Reference Framework; and
- the Environmental Reference Framework;

The EIS considered the projects, studies and experiments developed by the CVN and took into account all the documentation and data available from the Information Service of the MAV. The study also referred to other studies, findings and scientific works produced by the technical departments of local authorities, scientific research establishments and institutes, universities and other authoritative sources. As the need arose, specific analyses were also implemented to integrate the information already available.

In addition to the aforementioned documentation, the study also covers:

- the Preliminary Design for the interventions at the lagoon inlets for tidal flow control (*Progetto di Massima degli "Interventi alle bocche lagunari per la regolazione dei flussi di marea*") revised according to the requirements of the voting authorities (MAV and Consiglio Superiore dei Lavori Pubblici) that gave their technical approval (Annex 1);
- the Preliminary Design for the construction sites (Annex 2);
- the socio-economic studies relating to the Project (Annex 3);
- a report describing the mathematical models used in the Project and for the EIS (Annex 4);
- an organised list of all the studies that the MAV had carried out by the Consorzio Venezia Nuova on the Venetian Lagoon and on how it can be protected, with an indication of their position in the context of the "General plan for the intervention" (Annex 5).
- considerations on questions of particular interest for Venice and the Venetian Lagoon (the Topics (*Temi*), dealing with observations frequently voiced by the Venetian community and the local authorities (Annex 6).

1. INTRODUCTION AND PRINCIPAL CONCLUSIONS OF THE STUDY

Venice was founded on water and, ever since, water has not only served as the basis for Venice's very existence, but also as a constant threat to its survival. For centuries, the technical and political abilities of the Venetians have been tested against the crucially delicate nature of the relationship between the city and villages and the Lagoon as a whole, in an attempt to monitor and regulate an extremely difficult and unstable balance between land and sea. In fact, Venice's history is replete with mammoth enterprises such as diversion of the course of major rivers and construction of imposing coastal defence works. Albeit with their ups and downs, these endeavours have enabled the city of Venice and its Lagoon to survive to the present day with the characteristics of a natural environment that is artificially protected and strongly influenced by man.

In the last few decades, however, the problem of flooding in the urban areas of the Lagoon has dramatically worsened because of the progressively shrinking difference in level (or altimetric clearance) between the elevation of inhabited dry land and sea, a phenomenon that is likely to continue in future at a rate that it will only be possible to establish precisely in years to come.

On 4 November 1966, Venice suffered the most disastrous floods in living memory. As a result, it became obvious that suitable action to preserve the city and its Lagoon, in all their physical, environmental and socio-economic complexity, could no longer be postponed. Defending the towns and villages in the Lagoon from high water flooding was consequently indicated as the main priority of a special Italian Law No.171/1973, subsequently confirmed by Laws No.798/1984 and No.139/1992.

Based on these established legal requirements, a Project was developed for tidal flow control interventions at the Lagoon inlets, the purpose of which is to protect the inhabitants of the Lagoon from all high water events (even the most exceptional). This Project has undergone a lengthy period of revision, both from a technical and an environmental standpoint. The Preliminary Design for these interventions at the Lagoon inlets, already approved by the Higher Council of Public Works in 1994, has now been submitted for Environmental Impact Assessment (EIA). For this purpose, an EIS has been performed and the document presented heretofore provides the non-technical synthesis of said study, as specified by the DPCM 27.12.88.

The EIS has thoroughly analysed the relationship of the interventions contemplated in the Project with the surrounding environment, verifying their effects in every detail. The main conclusions of the Study can be summarised as follows:

- regarding the planning arrangements specifically considered in the Planning Reference Framework:
  - the Project has been developed in compliance with the specifications of the Special Laws for Venice and with the planning tools organised by the responsible Italian governmental bodies;
  - during the course of its development, the Project has been adapted to comply with indications emerging from the various territorial planning schemes. The Project is consistent with the guidelines of said planning schemes, both in general and in detail, and a considerable design effort has gone into complying with said criteria;

- regarding the benefits for the towns and villages in the Lagoon, in their current conditions:
  - the Project is capable of overcoming the difficulties, and resulting costs, that flooding causes the local population;
  - the Project is capable of significantly reducing the causes of damage to Venetian buildings and Lagoon infrastructures, also reducing the related risks; it would consequently alleviate the urgency of maintenance work and the corresponding costs;
  - the prevention of flooding appears to be the necessary, though not sufficient, condition on which to base any socio-economic development of Venice;
- as far as the environmental aspects are concerned, those specifically considered in the Environmental Reference Framework are:

  the effects of the interventions on the environment are relatively small and localised. They are clearly marginal by comparison with the benefits to the Lagoon's inhabited area due to the prevention of flooding; benefits which become all the more important, the greater the rise in mean sea level over the coming decades due to the combined effects of natural subsidence and eustatism. It is also worth adding that, if the most pessimistic forecasts of eustatic change were to be realised, the situation would become critical to the very survival of Venice if nothing were to be done to protect the city from high water phenomena.

The conclusions of the EIS can also be summarised by means of a comparison between the various options as illustrated in the following table:

- the "zero option", i.e. no action is taken to provide protection against flooding;
- "wide area measures" are taken with a view to reducing high water levels by altering the physical structure of the Lagoon;
- the "mobile gates" of the project are built to protect the Lagoon from high water episodes by temporarily separating it from the sea during significant flood tidal events.

OPTION	Technical feasibility	Protective effect	Environmental impact	Cost in Italian Lire	Economic damage ***
"Zero" option	–	–	Low/High**	–	Extensive
Wide area measures *	Fair	Low	Low/High**	4095 billion *	Extensive
Mobile gates *	Fair	High	Low**	4175 billion *	Marginal

* including the so-called *insulae* intervention
** assuming a future rise in mean sea level
*** in terms of the effects of high water flooding of the inhabited areas of the Lagoon

2. PROTECTION AGAINST HIGH WATER FLOODING FOR THE INHABITED AREAS OF THE LAGOON

2.1. Venice and the Venetian Lagoon

Situated between the mouths of the River Piave to the north-east and the River Brenta to the south-west, and extending over an area about 50 km long and an average 11 km wide, the Venetian Lagoon is the largest wetland area on the Mediterranean and includes island settlements of considerable historical, artistic and cultural interest (Fig. 2.1.1).

This brackish water area is composed of patches of land that are periodically submerged by high tides and areas of shallow water traversed by natural and artificial canals and dotted with inhabited islands.

The main island settlements, apart from the city of Venice, are Murano and Burano to the north of the city, and Chioggia at the southern end of the Lagoon.

The Lagoon is separated from the sea by a slender natural strip of sandy shores (the Cavallino coast, the islands of the Lido and Pellestrina, and the Sottomarina coast), artificially reinforced in several places by historical coastal dams and other defence works, and with three inlets giving access to the Lagoon, the Lido to the north, Malamocco in the middle and Chioggia to the south.

The Venetian Lagoon environment is characterised by typical morphological elements, such as the vast, flat salt marshes (*barene)* that are covered with halophilic vegetation and are periodically submerged by high tides. The part of the Lagoon lying closest to the inlets forms an area of transition between the sandy coasts and the sandbanks, its depth varying from a few dozen centimetres in the shallows (*bassifondi*) to several meters in the deeper parts (*fondoni*) and in the numerous natural channels and man-made canals; it is called the "living Lagoon" and is always covered with water, even at the lowest tides.

The shallows that may emerge in the event of very low tides are called, mudflats (*velme*); they generally occur close to the salt marshes and help to reduce the impact of wave motion in the Lagoon or along the banks of the canals. The vast pools of very shallow water surrounded by salt marshes, typical of the innermost parts of the Lagoon, are called swamps (*paludi*) and receive a rather limited flow of water. The belt of Lagoon lying up against the mainland is characterised by the presence of the so-called fish farms (*valli*), areas of Lagoon contained behind embankments and dedicated to extensive fish farming activities.

The outer perimeter of the Lagoon is established by a contermination line (the "*linea di conterminazione lagunare*"), the first record of which dates back to 1609. It was completed in 1791 under the Venetian Republic and subsequently modified several times (the last by decree of the Minister of Public Works in 1990). This line still defines the range of responsibilities and extent of an area coming under special legislation as regards its usage and protection.

The Lagoon area thus identified has a surface area of 550 km², 420 km² of which are occupied by bodies of water and sandbanks, 90 km² by fish farm enclosures and 40 km² by dry land (coasts, reclaimed areas and islands) including the 117 islands on which the city of Venice is built. Beside this brackish water area lies the region forming the Lagoon's Drainage Basin, i.e. the area of land where the water flowing into the Lagoon is collected and conveyed from the mainland towards the sea. Over the centuries, this watershed has been the object of a careful conservation policy. It covers an area of about 1,800 km², including the provinces of Venice, Padua and Treviso, and a total of 98 municipalities.

In its present state, the Venetian Lagoon is the outcome of evolutionary processes related to the interaction between the mouths of the river and the sea, changes that are still underway and that will continue to model its future.

In addition to its natural evolution, the life of the Lagoon has been increasingly affected by the presence and activity of human beings ever since the fifth century. Between the years 1000 and 1800, the inhabitants' efforts were dedicated mainly towards defending and protecting their settlements by diverting the course of the Piave, Brenta and Sile rivers away from the Lagoon towards the sea and installing coastal dams to withstand the stormy sea. Care was taken nonetheless to ensure access to the port in order to guarantee not only physical and military safety, but also the opportunity to continue the seafaring trading activities responsible for the economic fortune of the Venetian Republic.

Since the last century, human intervention on the Lagoon has been aimed more towards the development of economic activities. Breakwaters were constructed at the three Lagoon inlets to facilitate the passage of increasingly larger shipping vessels. Certain areas close to the mainland were reclaimed for new industrial uses, to expand the urban settlements and to build new infrastructures. New canals were dug in the Lagoon to facilitate access to the industrial areas and the port. Vast areas were reclaimed for agricultural purposes and numerous fish farms were created.

More recently, extensive industrial estates have sprung up on the areas of reclaimed land, followed by the exploitation of the fresh water acquifers for industrial purposes, the extensive use of fertilisers and pesticides in agriculture, the expansion of zootechnical activities in the Drainage Basin area, the creation of uncontrolled landfills for waste products of various kinds, and the release of urban sewage into the Lagoon, all of which has had a considerable impact on the features of the environment and on the quality of the water and Lagoon floor.

All these factors have combined with the natural phenomena of subsidence and eustatism and the natural ageing of the urban fabric to contribute towards a process of deterioration affecting the Lagoon's morphological structures, the quality of its inhabited centres and of their historical, cultural and artistic heritage, the weakening of its natural and artificial defences (beaches, coastal dams and breakwaters), and the flooding of its islands, which together constitute the "problem of Venice".

2.2. The flooding problem

2.2.1 The causes of flooding

Sea level and high waters

The phenomenon of the so-called "high waters" (*acque alte*) is due mainly to two factors affecting the sea level on very different time scales (Fig. 2.2.1):

1. a temporary rise in sea level due to the combined effects of the astronomical tide and the weather, the latter due to atmospheric pressure differences and the effects of wind on the Adriatic;
2. a relative decrease in the difference between the elevation of dry land and the mean sea level due to two long-term factors, i.e. subsidence and eustatism. Subsidence is a slow but progressive lowering of the land surface due to the natural consolidation of the sediment and is typical of deltaic areas such as the Venetian Lagoon; whereas eustatism is a world-wide change in mean sea level induced by changes in the Earth's climate.

Since the beginning of this century, the historical city centre of Venice has suffered an altimetric loss of about 12 cm as a result of subsidence (its natural subsidence having been intensified by the exploitation of underground water resources for industrial purposes between the thirties and the seventies), whereas eustatic changes have generated an increase in sea level of about 11 cm in this century. All in all, therefore, since the turn of the century, Venice has lost at least 23 cm of its elevation above sea level.

Sea level measurements in Venice are based on the marigraphic zero chart datum at Punta della Salute, which is an altimetric reference point solidly integrated with the ground upon which the historical city centre is founded that corresponds to the mean sea level in Venice in 1897. The present mean sea level refers to an elevation of -23 cm with respect to the Punta della Salute datum. This altimetric loss is the main reason that the problem of flooding at high water has become so severe; tidal levels that were exceptional at the turn of the century have since become a phenomenon that recurs several times a year. (All further indications of water level herein refer to the Punta della Salute datum unless otherwise indicated.)

Already with water levels at an elevation of +80 cm with respect to the datum at Punta della Salute, there is flooding in certain central parts of the city (such as St. Mark's Square) while at elevations of +100 cm, about 5% of the historical city centre is flooded. Water levels of +110 cm coincide with a general alarm for the population in order to contain the damage due to higher water levels. A high water episode is considered as an exceptional event if it exceeds +130 cm to +140 cm, in which case about 60% of the historical city centre would be under water creating such havoc as to paralyse the city and cause considerable economic damage.

Frequency and duration of flooding events

Figure 2.2.2a (Servizio Idrografico e Mareografico, 1993) illustrates the annual distribution of high water events above +110 cm recorded at the Punta della Salute marigraph between 1860 and 1996 clearly showing the increased frequency of high water events in the last thirty years. High water phenomena occur mainly in the winter months (about 80% between October and February), when cyclonic perturbations and low pressures are most likely, and they tend to last about three hours. Estimates of the time it takes for these tides to return, i.e. how often it is statistically feasible to expect a high water event to exceed or equal a given level, are given in Table 2.2.1 for four different reference levels.

Level	Frequency
+100 cm	Seven times per year
+120 cm	Once per year
+140 cm	Once every 6 years
+195 cm	Once every 180 years

Table 2.2.1: *Estimated frequency of high water events*

November 1996 was an exceptional case, when the elevation of +100 cm was exceeded eleven times (Fig. 2.2.2b). For an evaluation of the future trend of the frequency of flooding phenomena, it is essential first of all to identify the scenarios of any future evolution in subsidence and eustatism (Fig. 2.2.3) in relation to the estimated working life of the mobile gates (100 years):

- one scenario, which could be considered optimistic, is based on the trend of the last twenty years, during which time there has been little or no eustatic rise in sea level. If this trend were to continue, we could expect just natural subsidence in the future, which would amount to about 4 cm over the next century (Scenario A);
- another possible scenario, which could be considered as more realistic, assumes that the tendency recorded in the course of the twentieth century will continue; removing the effects on the data of subsidence due to ground water pumping, this would mean an overall rise in mean sea level of 16 cm to 20 cm (Scenario B) (Fig. 2.2.3);
- a third, more pessimistic scenario, is based on the forecast of the Intergovernmental Panel for Climate Change (IPCC) that estimates the potential rise in sea level by the end of the next century at about 50 cm (Scenario C). The consequences of such a situation would be dramatic, not only for Venice (which would suffer virtually daily flooding episodes unless adequately protected), but also for other coastal areas all over the world. Well before such a scenario can become a reality, appropriate and timely decisions would have to be made by the political powers of the future.

2.2.2 The flooding episodes

All dry land in the Lagoon can be flooded during high water episodes, albeit with different frequencies and water depths. The lowest point in the city is St. Mark's Square, the highest elevation of which is +67 cm; about 12% of the historical city centre is below an elevation of +110 cm and 57% of the city is lower than +140 cm. The problem does not only affect the historical city centre of Venice, however, since the Lagoon inhabited centres of Burano, Murano, Torcello, Sant'Erasmo, Treporti, Lido and Pellestrina, the territory along the Cavallino coast and a fair proportion of the territories of Chioggia and Sottomarina are also subjected to flooding. At a sea level of +140 cm, the extent of flooding likely to occur in the historical centres of Venice and Chioggia is illustrated in Figure 2.2.4. At an elevation of +195 cm, practically all the Lagoon towns and villages would suffer flooding in 70% to 80% of their territory.

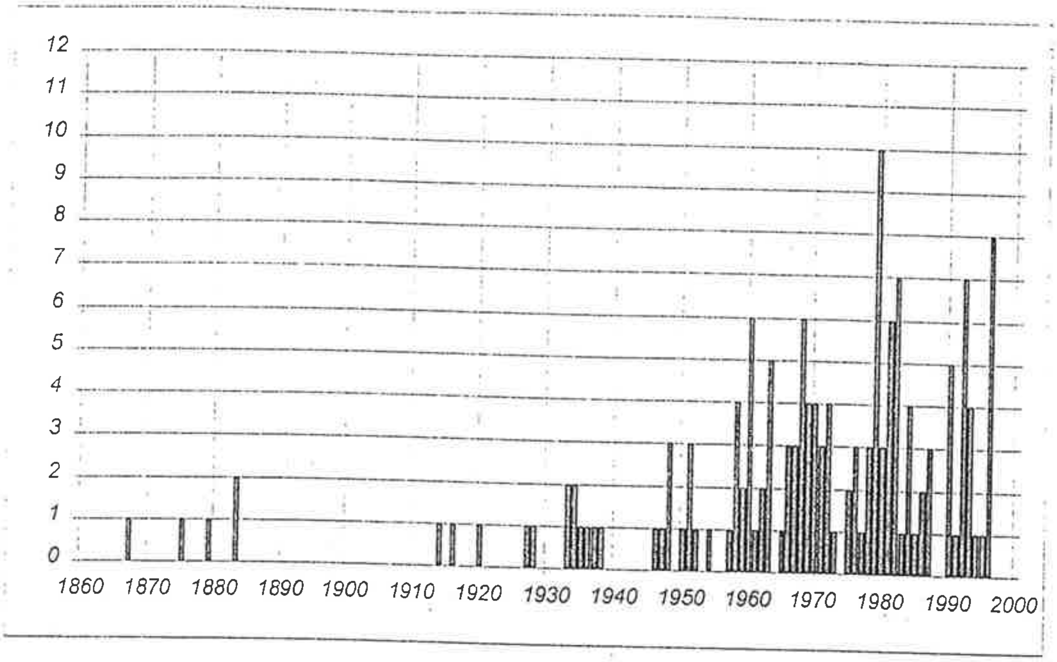


Fig. 2.2.2a - Distribuzione annuale degli eventi mareali superiori a quota +110 cm, registrati dal mareografo di Punta Salute dal 1860 al 1992 (Servizio Idrografico e Mareografico Nazionale, 1993) integrata al 1996.

Annual distribution of tides higher than +110 cm, recorded at tide-gauge of Punta Salute from 1860 to 1996.

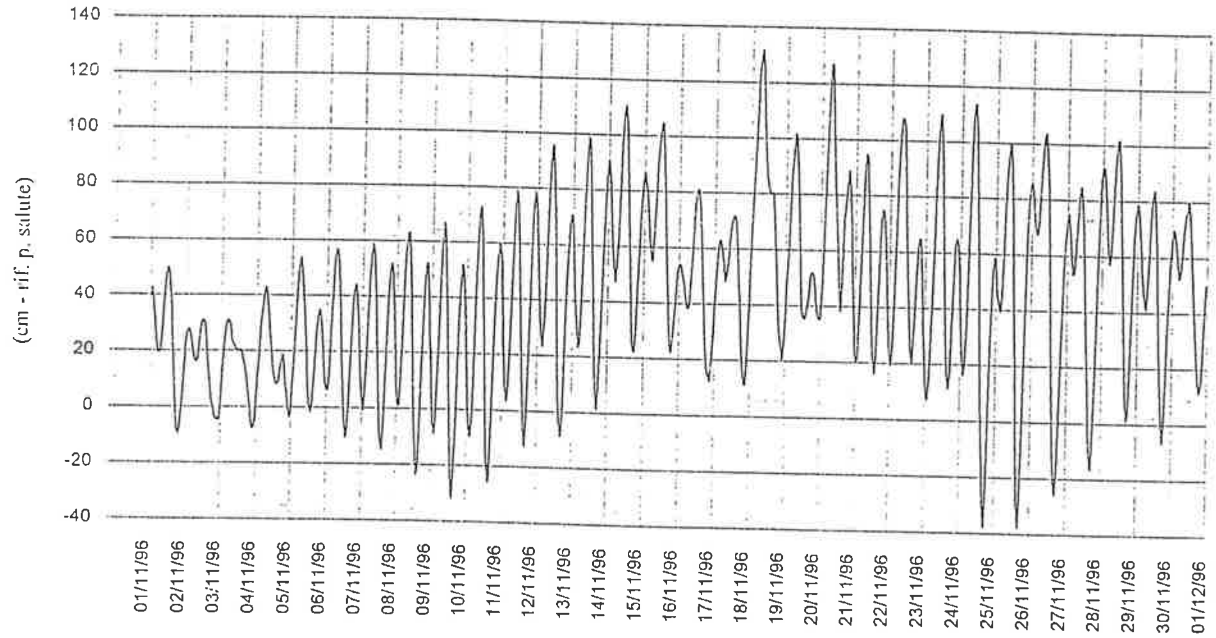


Fig. 2.2.2b - Registarzioni mareali a Punta Salute durante il mese di Novembre 1996.

Punta Salute tidal records during November 1996.

2.3 The purpose of the Project

After the event of November 4th, 1966, the Italian Law No.171 of 16 April 1973 established that safeguarding Venice was a matter of pre-eminent national interest and committed the State to achieving this aim, identifying the protection of the Lagoon's urban centres from flooding as the top priority of this program. Law No.798 of 29 November 1984 subsequently established that the physical, environmental and socio-economic safeguarding of Venice and the Venetian Lagoon should be ensured by means of an integrated and coordinated series of actions designed to achieve "the restoration of the Lagoon's hydrogeological balance, the arrest and reversal of the process of deterioration of the Lagoon basin and the elimination of its causes, the attenuation of high water levels in the Lagoon, the protection, by means of locally focused intervention, of the *insulae* of the historical centres to defend the urban settlements in the Lagoon from exceptional high water phenomena", arresting the deterioration in the sanitary and structural conditions of the urban fabric and safeguarding the socio-economic features of the Lagoon area.

These objectives were confirmed by Law No. 139 of February 5th, 1992. The goals identified by this set of Special Laws for Venice define the general framework for the effort to safeguard the Venetian Lagoon. The Special Laws delegate responsibilities of the activities to various public bodies, but the State remains responsible for taking steps to control tidal levels. In undertaking their different tasks, the various public authorities have prepared plans of action defining guidelines for the steps they intend to take to achieve the objectives established in the Special Laws. The integration and coordination of these various programs is the purpose of the "Project for Venice", which summarises the coordinated framework of the safeguarding measures, quantifies the financial commitments and indicates the works involved.

The tidal flow control interventions at the Lagoon inlets, the purpose of which is to "protect the inhabited areas in the Lagoon from exceptional high water episodes", consequently form part of a more far-reaching framework of measures to safeguard Venice and the Venetian Lagoon.

2.4 Intervention alternatives and their consequences

2.4.1 The "zero option"

The "zero option" describes the consequences to the Lagoon inhabited areas - in terms of discomfort, costs, damage and risks - of the decision to take no action to protect them from high water events.

The effects of flooding in the inhabited areas

Periodic floods have the following effects:

- physical damage to the components of the Lagoon territory, often giving rise to irreversible consequences on the ecosystem and the loss of features peculiar to the Lagoon environment;
- inconvenience to the population and interference with normal socio-economic activities, which means not only a direct cost for the community, and for the productive activities in particular, but also a reduced usability of the towns and villages;
- a series of physical damages to the wealth of monumental and historical-artistic buildings in the inhabited areas, which not only gives rise to further costs for maintenance and restoration, but may also represent a genuine hazard in some cases for the safety of the citizens and the very survival of the urban settlements.

The short-term economic costs of flooding

This section considers the inconvenience and damage incurred to the industrial and socio-economic activities due to flooding in the towns and villages, which generates a direct cost for the community. This can include the longer time it takes to get from one place to another, the temporary suspension of certain industrial activities, damage to goods, the need to supply supplementary public services, the reduced usability of private residential spaces, the trading network and the cultural opportunities.

The mean annual cost of flooding, at today's mean sea levels and with the present-day frequency of the episodes, varies between 28 and 40 billion lire per year for the historical city centre of Venice (85% of which stems from high water events beyond +100 cm) and between 8.5 and 10 billion lire for the other Lagoon towns and villages.

The situation would become far more critical in the event of an increase in mean sea level, rising to between 94 and 128 billion per year if there were a 10 cm rise in sea level (85% of which would be due to high water events exceeding +100 cm), to between 215 and 296 billion per year in the case of a 20 cm rise in sea level, or to between 426 and 679 billion per year with a 30 cm rise in sea level.

The long-term damaging effects of flooding

This includes all the damage to the physical structures of the city and Lagoon (the buildings, canal banks, Lagoon embankments, civil and technological services) caused by high water. The economic costs arising from damage to the physical structures of the urban areas do not become apparent as the direct result of single high water events; they manifest themselves in the form of higher costs for maintenance and preventive measures in order to ensure conditions of public safety and the usability of services.

For some of these measures, the maintenance costs are essentially evenly distributed in time, whereas for situations that require urgent action to guarantee an acceptable level of public safety without delay, the related costs depend on a longer-term time horizon. On the whole, the average costs of the maintenance work and preventive measures needed on canal banks and Lagoon banking, on masonry (to contain seepage), on sewers and cable ducts, etc., spread out on a yearly basis (which naturally have to be added to the short-term costs), can be summarised as follows:

Mean sea level	**Average annual cost in billions of lire**	
	Without defence interventions	**With defence interventions**
+0 cm	82.2	3.1
+10 cm	108.4	8.1
+20 cm	140.9	13.1
+30 cm	190.3	20.1

High water events and the scenarios of socio-economic development

Depending on the different hypotheses of socio-economic development for the city of Venice and the Venetian area, there are feasibly three main potential scenarios.

A first scenario assumes that no specific action is taken to relaunch the area and predicts a further specialisation in the tourist trade. Though it retains a considerable earning power, this scenario would isolate the historical town centre from the local and regional productive reality, reducing any opportunities for diversifying the economy for future generations.

A second scenario focuses partly on the conversion of Marghera, paying particular attention to the activities of the port, and partly on improving the internal and external mobility for the historical city, with favourable repercussions on its use for residential purposes.

The third scenario considers the development of the new activities, giving priority particularly to business services and research undertakings. This scenario suggests a better use of the cultural heritage, a reorganisation of the tourist trade and the identification of economic activities compatible with the urban fabric, e.g. the university, research and training activities.

Considering the second and third scenarios, in particular, it would seem essential to take specific action to overcome the problem of high waters. In fact, while the hypothesis of taking no action to defend Venice from high water flooding becomes a factor tending strongly to perpetuate a model of development specialising in the tourist trade, any other, diversified development hypotheses would necessarily call for the recovery of stable conditions to ensure:

- improvements in the habitability of the buildings, even on the lower floors;
- the development of the communication infrastructure in a manner that responds to the needs of business service enterprises;
- the introduction of incentives to facilitate the location of new productive activities inside the historical town centre.

Any consideration for the future development of Venice other than as a tourist attraction can hardly be entertained without an effort to control the effects of high water flooding in the city.

2.4.2 The various alternatives and their effectiveness

Numerous hypotheses have been studied to establish whether and to what degree, alone or in a suitable combination, they could serve the purpose of protecting the Lagoon urban areas from exceptional high water flooding episodes. The types of action considered during the design stages can be essentially summarised in three different attitudes:

a) to protect urban centres from high water flooding by taking action on the physical structure of the Lagoon, on the assumption that it would thus be possible to reduce the tidal peaks and the frequency of the flooding episodes;
b) to construct localised, *insulae* defence works by raising the perimeters, or even the entire surface area, of the areas of land subjected to flooding;
c) to defend the Lagoon from episodes of excessively high water by means of mobile barriers at the inlets, raising them every time the tidal conditions appear to be critical, but leaving the average tidal exchanges between the sea and the Lagoon substantially unaffected.

a) Intervention on the physical structure of the Lagoon

The design possibilities for eventual intervention on the physical structure of the Lagoon that were considered in the preparation of the Preliminary Design for the project include (Fig. 2.4.1):

1. opening the fish farm enclosures;
2. reducing the cross-section of the Lagoon inlets;
3. closing the Malamocco-Marghera navigation canal.

1. Opening the fish farm enclosures

This action proposes to make the storage capacity of the 23 fish farm enclosures available in the event of high water episodes by creating openings along the banks of the enclosures, building structures for supervising these openings and drains inside the enclosures, in addition to recalibrating the channels, mudflats and salt marshes in the area adjacent to the fish farms. The results of the analysis indicate that these works would have the effect of a marginal reduction in the mean high tide at Punta della Salute (about 1 cm) and an increase in the volumes entering the Lagoon (which would be 1.5% greater).

2. *Reducing the cross-section of the canals through the Lagoon inlets*
   This action proposes to contain the sea levels inside the Lagoon by introducing a marked reduction in exchange volume at the Lagoon inlets by means of a smaller cross-section for the passage of the sea flow obtained by decreasing the depth of the channels at the Lagoon inlets from the present 10 m at Lido, 12 m at Malamocco and 8 m at Chioggia. Assuming a reduction in the mean inlet cross-section of 15% at Lido, 25% at Malamocco and 12% at Chioggia, the results of the analyses performed suggest only a modest effect in reducing the tidal levels at Punta della Salute (about 4 cm in the case of "steep" incoming tides), accompanied by a 13% reduction in the overall water volumes coming into the Lagoon (which would mean a deterioration in water quality as a result of the reduced exchange between the sea and the Lagoon) and a considerable negative effect on naval traffic.

3. *Closing the Malamocco-Marghera navigation channel (the so-called Oil-Tanker Canal (Canale dei Petroli))*
   This intervention proposes to counter the morphological and hydrodynamic changes induced in the Lagoon by the building of the navigation channel for tankers sailing from Malamocco to Marghera (*Canale dei Petroli*). The design solution examined involves filling-in up to the level of the surrounding shallows a 5000 m long stretch of the channel, from the Malamocco inlet to the first bend in the Canale Litoraneo, and redimensioning the Fisolo Canal to provide alternative transit for shipping with a draft of up to 33 feet. The analyses performed on this possibility have shown that the effects would be negligible in terms of reducing the sea levels at Punta della Salute (by a few millimetres), whereas there would be

a drastic penalisation of the traffic of larger ships destined for the port of Venice, with a considerable negative economic fallout.

As for the other, so-called *wide area measures* (such as opening the reclaimed areas and the Val di Brenta, restoring the salt marshes and shallows, changing the size and orientation of the protective breakwaters) that are often discussed locally and have long been proposed as a means to reduce the sea level in Venice, simulations have been developed using mathematical models (Annex 6, Topic 6, and Annex 4 on the mathematical models employed). Given that little or no effect in reducing the tidal peaks in the city of Venice would be achieved by any of the above-described actions if it were taken alone, an analysis was also performed to establish the effectiveness of a combination of all the aforementioned actions. The results show that the reduction in tidal levels at Punta della Salute would still be extremely limited (around 7 cm).

b) *Local defence works*

The localised *insulae* intervention in the historical centres would not have any effect in terms of changing the tidal levels; it would simply provide a passive defence against high tides. The extent of flood protection that such local defence works can offer depends entirely on the elevation to which they can be raised. Such action is effective in protecting the inhabited centers from relatively limited high water levels, which are the most common, but also the least destructive. The various types of action examined are as follows (Fig. 2.4.2):

- Elevating the pavements
  This involves building public walkways to a higher elevation than the pavement elevations of today, complete with suitable gradients to facilitate the runoff of rainwater into the existing drains.
- Raising perimeter barriers
  This action consists in increasing the elevation of the sea walls and embankments around the areas requiring protection so that they are no longer exceeded at high water. This must always be associated with a system for draining off rainwater and with anti-filtration structures comprising vertical diaphragms in the banking, or horizontal waterproof elements in the road surface.

Analyses were also performed on the intervention involving the raising of single structures or buildings, or whole areas of territory. These suggestions were rejected, however, because of the considerable uncertainties as to the means to such an end and the final outcome, given that only very limited changes in elevation are feasible. The above two types of action were analysed at different levels of detail and applied to different situations in the historical centres.

For each area, a protected elevation was defined on the basis of information provided by the Superintendent of the Environmental and Architectural Heritage, and on the recommendations of the Local Governments of Venice and Chioggia and of the Neighbourhood Committees. Some of these works, e.g. for Sottomarina, Pellestrina, Malamocco and Treporti, have already been implemented or are well underway.

c) Intervention at the Lagoon inlets

The purpose of the works for temporarily shutting off the openings that communicate between the sea and the Lagoon is to reduce tidal peaks on the Lagoon side below a predetermined threshold by controlling the sea flow. Several different options were studied for these interventions at the Lagoon inlets:

- Mobile barriers installed at only one or two of the three Lagoon inlets

  The results of the analyses of all the possible combinations deriving from the closure of one or two inlets indicate reductions in sea level at Punta della Salute that vary between 1 cm and 45 cm. This reduction is not sufficient to defend all the Lagoon urban areas from flooding.

  With the closure of one or two inlets, it would be feasible to defend a part of the Lagoon providing the work at the inlets is integrated with other interventions inside the Lagoon, such as the division of the expanse of water in the Lagoon into two sub-basins by means of a dam to isolate the areas requiring protection. This proposition does not appear feasible, however, partly because it counters one of the fundamental requirements of the law for safeguarding Venice, which is to avoid interfering with the unity and physical continuity of the Lagoon.

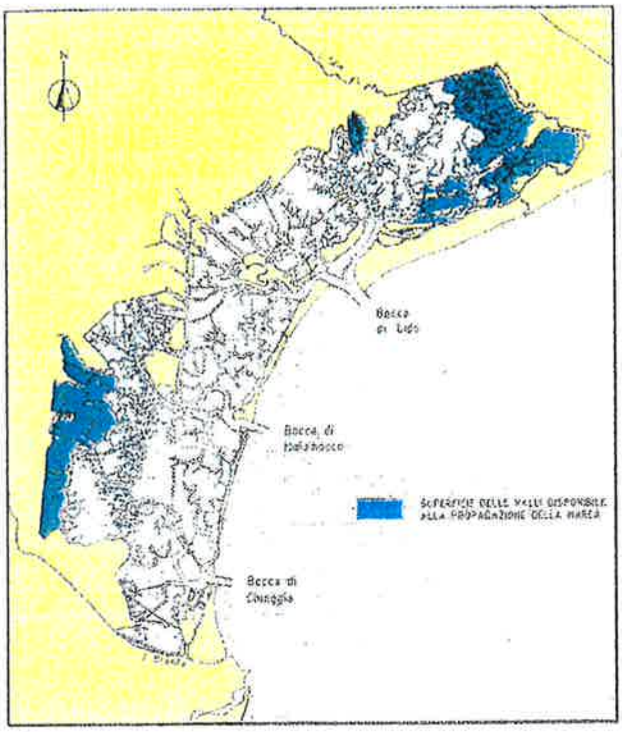
- Mobile barriers at all three Lagoon inlets

This solution is capable of satisfying the main objective of completely protecting the Lagoon from flooding due either to moderate-to-high or even to exceptionally high water episodes, in that raising the mobile barriers serves the purpose of temporarily but totally cutting off the sea flow through the Lagoon inlets.

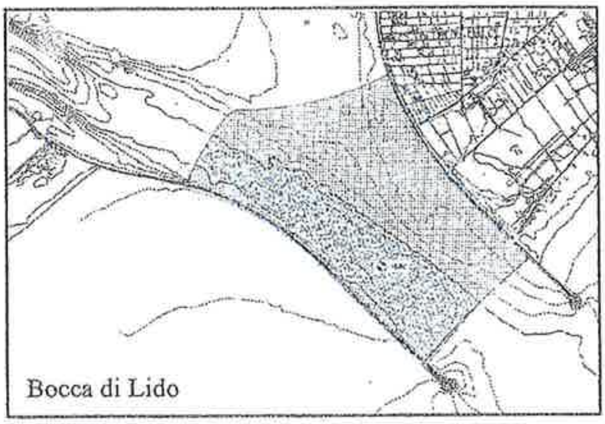
2.4.3 The proposed intervention and the reasons behind the choice

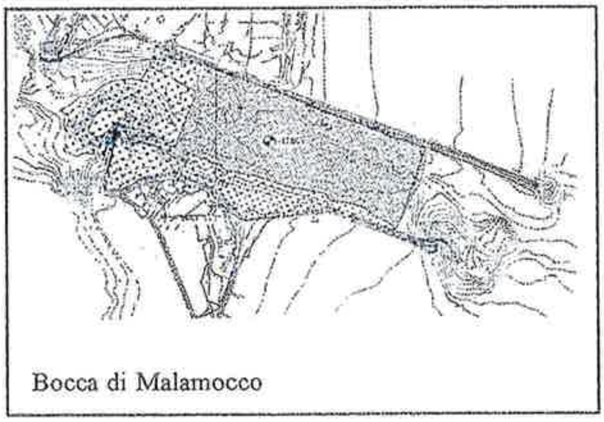
The only solution that achieves the goal of defending the Venetian Lagoon from high waters is therefore to provide mobile barrier structures for the temporary but complete closure of all three Lagoon inlets in the event of particularly high water levels. Since the potential interferences of such a solution on the Lagoon environment mainly concern the water circulation and the port activities, the potential advantage, (in terms of a lower annual number of closures) obtained by setting the threshold elevation for barrier operation at +100 cm (which would mean 7 to 10 closures per year) instead of +80 cm (the level at which the first signs of flooding occur) was evident.

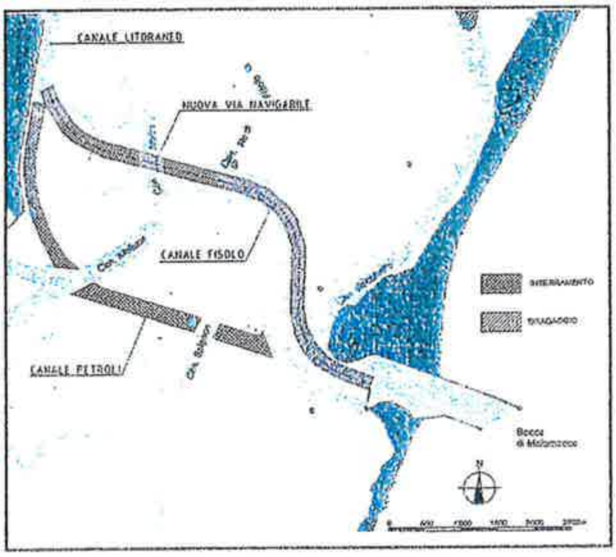
To permit use of this threshold, the installation of mobile gates at the Lagoon inlets was associated with the systematic use of local *insulae* defence works. These interventions, to be implemented in combination with the *insulae (*restoration and repair work on the embankment and perimeter sea walls of the Lagoon inhabited centres) are capable of preventing flooding due to water levels of up to at least +100 cm. Thus, the mobile gates, would only be closed when the need arises to provide protection against higher tidal levels. A schematic diagram of the intervention is given in Figure 2.4.3.



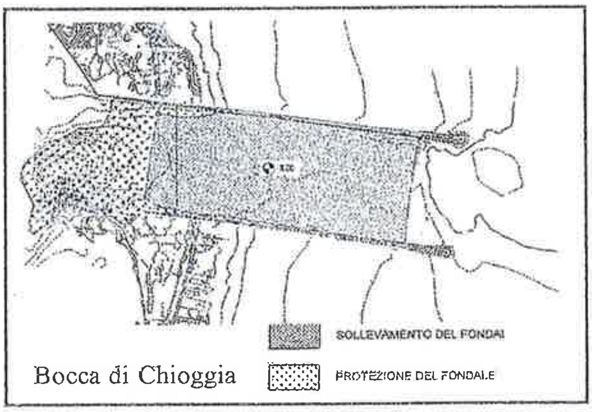
1) Apertura delle valli da pesca





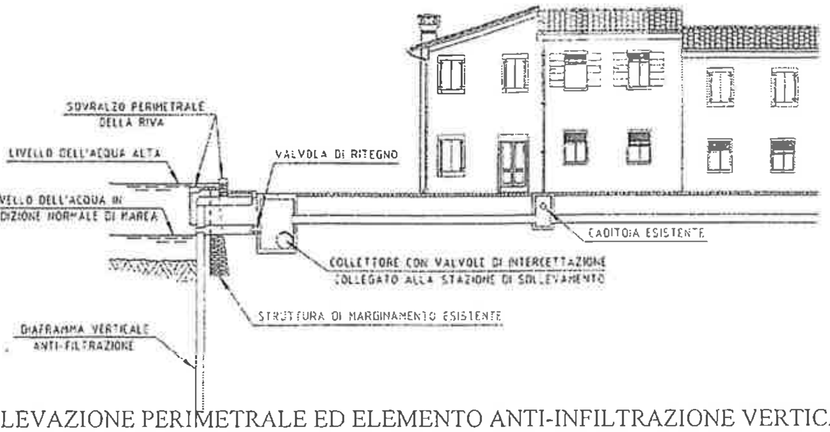


3) Chiusura del canale Malamocco - Marghera

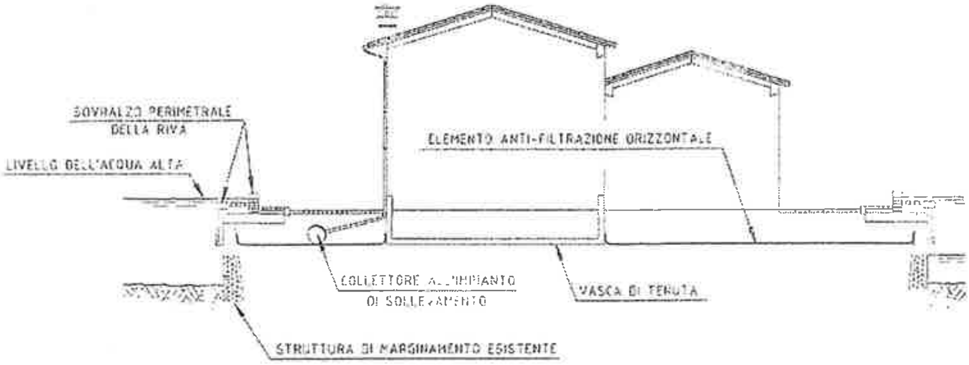


2) Riduzione della sezione dei canali delle bocche di porto

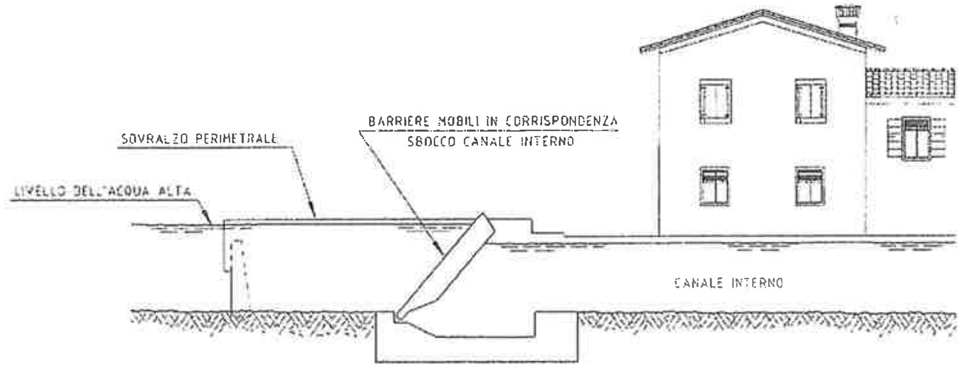
Fig. 2.4.1 - Interventi sulla struttura fisica della Laguna.
Works on the physical structure of the Lagoon.



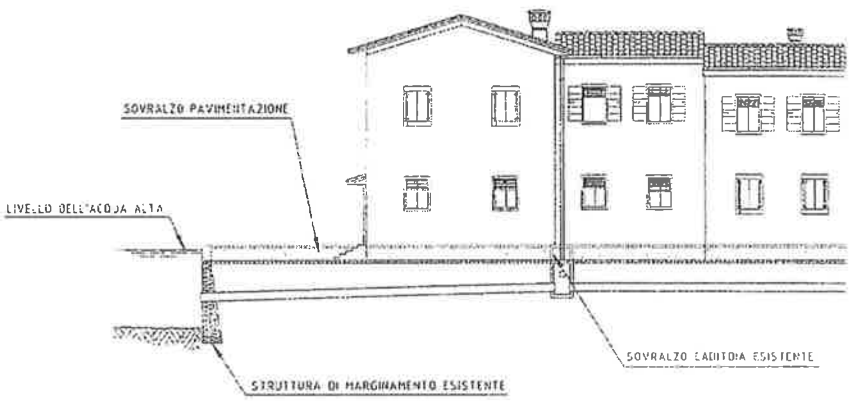
SOPRAELEVAZIONE PERIMETRALE ED ELEMENTO ANTI-INFILTRAZIONE VERTICALE



SOPRAELEVAZIONE PERIMETRALE ED ELEMENTO ANTI-INFILTRAZIONE ORIZZONTALE

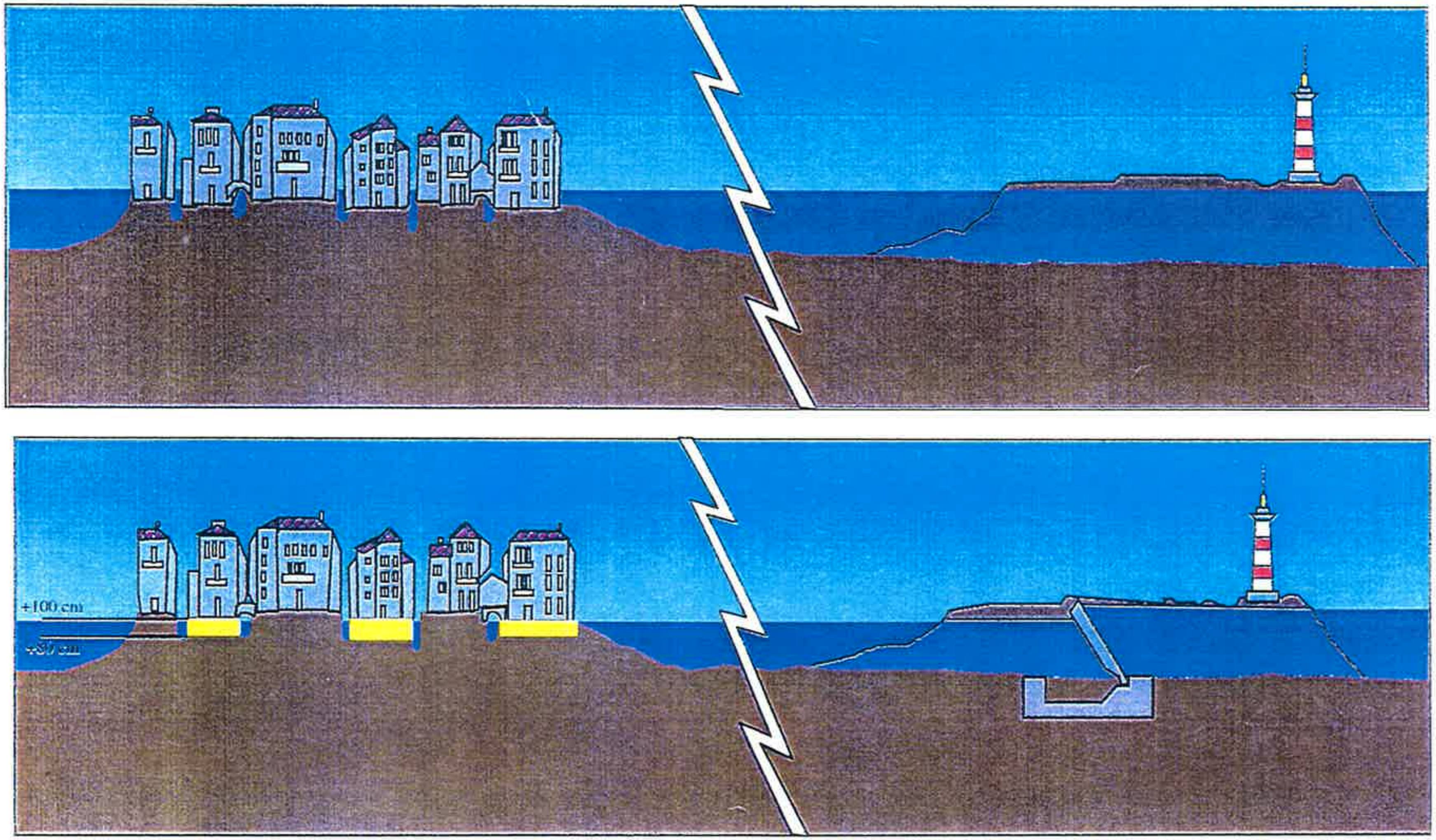


SOPRAELEVAZIONE PERIMETRALE E CHIUSURE MOBILI AGLI SBOCCHI DEI CANALI INTERNI



SOPRAELEVAZIONE DELLE PAVIMENTAZIONI

Fig. 2.4.2 - Interventi di difesa locale degli abitati.
Local defense works.



a)

b)

Fig. 2.4.3 - Sistema di difesa dei centri lagunari dalle acque alte
a) Situazione attuale
b) Difesa dei centri abitati mediante interventi locali (insulae) fino a +1.00 m e con paratoie alle bocche per quote superiori.

Flood protection system by "insulae" and "mobile barriers"

2.5 The mobile gates at the inlets for controlling tidal flow in the Lagoon.

2.5.1 The defence system

The solution adopted for the mobile works comprises a modular series of independent buoyant gates lying side by side, each hinged to the inlet channel floor. Each gate consists of a hollow metal structure filled with water, which normally remains at-rest in a recess in the foundations installed in the inlet channels. When the water it contains is expelled by means of compressed air, the gate rises, rotating around the axis of the hinges (two for each gate) and coming into a position of equilibrium that depends on the weight of the gate, on the amount of air delivered and on the desired difference in elevation between the sea and the Lagoon.

All the fixed structures are situated below the level of the shallows or in the areas alongside the channel inlets. These structures house the electromechanical system for operating the gates and include havens and locks for enabling the transit of smaller shipping vessels while the mobile gates are closed. The abutments, foundations and plant have different shapes and sizes in relation to the depth of the sea floor, the width of the inlet and, more in general, the configuration of the existing structures and features of the surrounding territory and landscape. When the mobile gates are not in use, the Lagoon inlets remain completely unrestricted. When the gates are raised, only the parts emerging from the sea will be visible while they are in operation (Fig. 2.5.1). The abutment structures provide the link between dry land and the gates themselves, maintaining a relatively low profile consistent with the other buildings in the surrounding territory.

Four barriers are planned in all at the three Lagoon inlets, i.e. two at the Lido (Treporti and San Nicolò), one at Malamocco and one at Chioggia (Fig. 2.5.2). The width of the Lido inlet, which is twice that of the other two, would be impossible to span with a single set of gates because of the different depths of the Treporti and San Nicolò canals. A separating element (an artificial intermediate island) was therefore necessary to allow for the installation of two sets of gates.

2.5.2 Description of the Project

The main components of the system are:

a) the individual gates;

b) the foundation structures for housing the gates and the abutments;

c) the electromechanical systems;

d) the refuge ports and locks.

Figure 2.5.3 illustrates the project for the works at the Lido inlet.

a) Gates

The metallic structure of each gate is similar to that of a small marine pontoon. The gates are attached by means of hinges to the foundation structures. When they are raised, the gates can oscillate freely and independently under the effect of wave motion, but they nonetheless maintain the difference in level between the sea and the Lagoon as established in the project with a negligible passage of sea water into the Lagoon through the gaps between adjacent gates.

b) The foundation structures for housing the gates

The gates are housed in the prefabricated reinforced concrete caissons (Fig. 2.5.4), forming the foundations for the barrier works, that are situated on the bottom of the inlet channels in an excavation, with the upper part flush with the sea floor. Inside the foundation elements there are tunnels and chambers for housing the mechanical equipment and hydraulics for operating the gates. The prefabricated reinforced concrete caissons are installed over soil previously reinforced with an array of piles.

c) The electromechanical system

The electromechanical equipment for operating the gate system is installed inside the foundation and abutment structures. It includes:

- the equipment for generating the compressed air for raising the gates (by filling them with air);
- the emergency electricity generators;
- the equipment for releasing the air from the gates;
- the ventilation system of all the tunnels and chambers under sea level;

- the monitoring systems;
- piping and cabling;
- auxiliary plant.

The main mechanical system components have been duplicated and the reserve equipment is installed in totally separate chambers so as to avoid any accident affecting the whole system.

d) *Refuge port and locks*

For safety reasons and to avoid interrupting the transit of fishing and public service or sporting vessels during the closure of the gates, each inlet is provided with a small craft refuge port (harbour) and a lock (at the Lido and Malamocco) or two (at Chioggia). These structures offer haven to the smaller boats in the event of adverse weather conditions at sea and enable the transit of vessels for surveillance and rescue operations during the temporary closure of the Lagoon inlets.

Maintenance

The gates are removed, in turn, every five years and are replaced with spare gate elements while they undergo routine maintenance, which includes cleaning the inside and outside of the gate itself, restoring the paintwork and cathode protection, and checking and replacing any accessories. The removal of the gates from their foundation structures is done by means of a special jack-up platform.

The reliability of the mobile gates

The analysis of the system's reliability has demonstrated that the risk of one or more gates failing to rise is lower than the thresholds considered acceptable in standard design practice. This holds for both the case of current mean sea level conditions and the hypothetical case of an increase in mean sea level due to subsidence and eustasy within the limits predicted in the scenarios described in section 2.2.1.

2.5.3 Installation of the mobile barrier project

The predicted time for construction is approximately eight years. The construction procedures for the project have been designed to restrict the phases that interfere with the environment and with the activities in the Lagoon. In particular, the implementation of the project aspires to the following general principles:

- the division of the structures into elements of relatively small size and their prefabrication in special basins or areas, situated even some distance from the Lagoon, that the planning schemes of the local authorities have already established as compatible for this use;
- the occupation by construction sites of selected expanses of water at the inlets in order to minimise the interference with any dry land areas of relevant naturalistic interest in the vicinity;
- the performance in the Lagoon only of such activities as are compatible with its morphology (limiting the presence of prefabrication sites and onshore and offshore storage deposits);
- the procurement of materials mainly via water routes;
- the use of procedures for the operations and installations at the inlets that keep interference with shipping to a minimum;
- the use of the dredged material removed from the Lagoon inlets for restoration of the Lagoon floor or for the reconstruction of salt marshes.

The realisation of the Project involves:

- the prefabrication of reinforced concrete elements for the foundation structures housing the gates and for the abutments;
- the construction of the gates;
- the construction and installation of the electromechanical equipment and mains network;
- the activities at the inlet channels and in the adjacent areas;
- the activities at the bases created in the Lagoon for providing logistic support;

- the temporary storage of the prefabricated elements in the expanses water in the Lagoon.

Prefabrication of the reinforced concrete caissons

The analysis on the construction procedures established the advisability of constructing the majority of the 157 hollow reinforced concrete caissons outside the Venetian Lagoon. The plan is to use three industrial zones or expanses of water in ports where the local permitting allows for their temporary use in the construction of the caissons needed for the Project. The prefabricated caissons would then be floated and towed from the construction sites (probably Ravenna and Brindisi) to the Lagoon by means of high sea tugs.

The choice of location for the prefabrication sites within the Lagoon has been based on specific requirements, i.e. to avoid the need for any more dredging than is strictly necessary for the permanent works, to locate the construction sites in "compatible" areas, to comply with environmental requirements and standards, to minimise the interference with shipping and port activities. Two prefabrication sites have been planned in the Lagoon: one inside the Treporti refuge port currently under construction and the other at the logistical base in Marghera. The job site at Treporti will avoid the need for any additional dredging that would otherwise have been necessary to enable the floating and towing of the caissons from the construction site to installation sites beyond that at the Lido inlet.

Construction of the gates

The construction of the gates involves the conventional activities and techniques typical of naval constructions. The construction sites will be selected on the basis of availability and, of course, on the strength of economic and commercial considerations. The gates will be transported from the construction sites to the installation sites aboard barges.

Activities at the inlet channels and in the immediate vicinity

The activities at the inlet channels for placing the prefabricated caissons for the gate and abutment foundations involve the following:

- general dredging of the area adjacent to the barriers, on both the seaward and the Lagoon sides, and placing rip-rap layers of stone material for anti-erosion purposes using special, suitably-equipped floating apparatus (with hermetically sealed buckets, direct suction dredging systems, automatic controls, etc.) to prevent dispersion of the dredged material in the water. This procedure allows for transit through the inlets during the excavations, albeit at a slower than normal pace;
- preparing a foundation trench (for which excavation is done using suitable technologies, designed to prevent any dispersion of the dredged material in the water) and reinforcing the soil inside the trench by means of piling;
- installing the caissons by floating them into position and then sinking them;
- assembling the gates with the aid of a special, custom-made jack-up apparatus;
- installing and completing the abutment caissons and constructing the buildings on dry land.

The activities at the inlets may also include:

- preparing the small craft refuge ports and corresponding locks;
- creating the intermediate island at the Lido inlet.

Bases for logistical support

Several areas inside the Lagoon have been identified for supporting the construction activities at the inlets, i.e.:

- the construction site and logistic base at Marghera for prefabricating 18 caissons and for storage and embarkation of the construction materials and other equipment. Subject to its availability at the time of construction, the job site will be located in the industrial zone in an area about 6 hectares in size that is currently not in use;
- the logistic base at Chioggia for prefabrication of certain elements, and for storage and embarkation of construction materials for the civil works (mainly destined for the Chioggia inlet). The area covers about 6 hectares and will be located, subject

to availability at the time of construction, in the area of Val da Rio, facing onto the outer Lombardo canal.

Handling

All the prefabricated elements and the majority of the construction materials will be carried by boat to reduce to a minimum the storage and handling needs on dry ground. Moreover, an adequate procurement program will be adopted, with a view to working as much as possible on a *just-in-time* basis. The stocks of stone and cement materials have been sited at the logistic bases of Marghera and Chioggia while the sheet piles and steel piles are stored on board barges moored in the Lagoon.

Deposit for the prefabricated elements in the Lagoon

Some of the caissons coming from the prefabrication sites will be deposited in the Lagoon at the bend in the Spignon Channel, in the vicinity of the Malamocco-Marghera Channel, so that the caissons are always ready for installation when the weather, sea and tidal conditions are most favourable.

Labour

The overall effect, in occupational terms, of the construction phase of the Project (the direct effects of the investment on the productive system, both locally and elsewhere, plus the indirect effects) can be estimated to involve around 5,680 people.

This occupational effect has been calculated on an annual basis and on the assumption of an even distribution of the construction activities over the entire time span of the Project (see Enclosure 3 "Socio-economic studies")

The cost of the works

The cost of the Project amounts to about 3700 billion lire (excluding VAT) (according to the 1992 estimate based on the Preliminary Design).

2.5.4 Operation of the barrier system

The inlet closing procedure

The schematic sequence of operations for closing and opening the mobile gates, together with the corresponding timing, is given in Figure 2.5.5. Generally speaking, the need to close the barrier will be predicted at least 24 hours in advance. In the hours following the prediction of a barrier closure, the evolution of the tide and weather conditions is monitored. If the need to close the gates is confirmed, the procedures for mobilising the necessary staff are implemented in order to ensure that all the posts are manned at least 3 hours before the predicted high water event. From three hours before the event and onward, the levels at the inlets and in the Lagoon are constantly measured and final checks are done on the barrier system (a procedure that takes an hour). Incoming and outgoing shipping traffic in the Lagoon is suspended two hours prior to the forecast event while the air compressors are started only a half hour before the event. Once the air compressors have been started and the valves have been opened, the automatic raising of the gates takes 30 minutes and closure is then confirmed. The gate raising sequence can also be completed manually in the event that both the principal and the stand-by automatic control systems fail to function.

The gates are kept in their working position by the air compressors for as long as the tide continues to rise and throughout the high water phase. The opening of the relief valves on the gates subsequently enables the gates to return progressively to their resting position as the tide ebbs.

The analysis of the sea weather conditions indicates when the time is right to lower the barrier; in operational terms, this phase begins when the seaward level at the inlets drops below the established threshold (the gates take about 15 minutes to open). Taking into account that it takes less time to lower the gates than to raise them, the inlets become accessible again within an hour. On the basis of the statistics available on past and predicted high water episodes, the mean duration of the closure is 4.5 hours.

As a result of procedures described above for operating the gates, the frequency of the closures will be greater than the annual number of actual high water events. These procedures call for the gates to be raised some time before a predicted high water event on the basis of objective criteria, allowing for a certain safety margin, so the gates may sometimes be raised on the basis of predictions that do not actually occur (i.e. false alarms).

The scenarios for impact analysis

In operation, the degree to which the barriers interfere with the environment and with the shipping traffic depends on the number of closures a year and on their overall duration. With reference to the different scenarios predicting a rise in mean sea level in the next century (see section 2.4.1), the following parameters can be identified for impact analysis.

Mean sea level	Mean No. of events	No. of false alarms	Total closures No.	Total closures Hours
Present day	7	5	12	42
Scenario A (+4 cm)	11	8	19	66
Scenario B (+20 cm)	43	27	70	248
Scenario C (+ 50 cm)	350	-	-	-

As already mentioned, if scenario C were to occur and no barriers had been installed at the Lagoon inlets, the effects would be catastrophic for Venice and the Venetian Lagoon because of the very high frequency of flooding episodes. Even with the mobile gates installed, such an increase in sea level would make it necessary to take further action during the working life of the barrier, the precise nature of which would be defined at a later date and would probably focus on the priority of preserving Venice. Such ulterior interventions could be effected if the rise in sea level were to come between 20 and 30 cm during the course of the next century.

Such further interventions could involve, for example, raising the local *insulae* defences by another 10 to 20 cm, creating a lock, dividing the Lagoon into sub-basins (an option that is currently not legally permissible), or other solutions, either alone or in combination. Any decisions of this kind, to be planned well in advance of the onset of the critical conditions, would be very demanding, not only technically but also politically and economically.

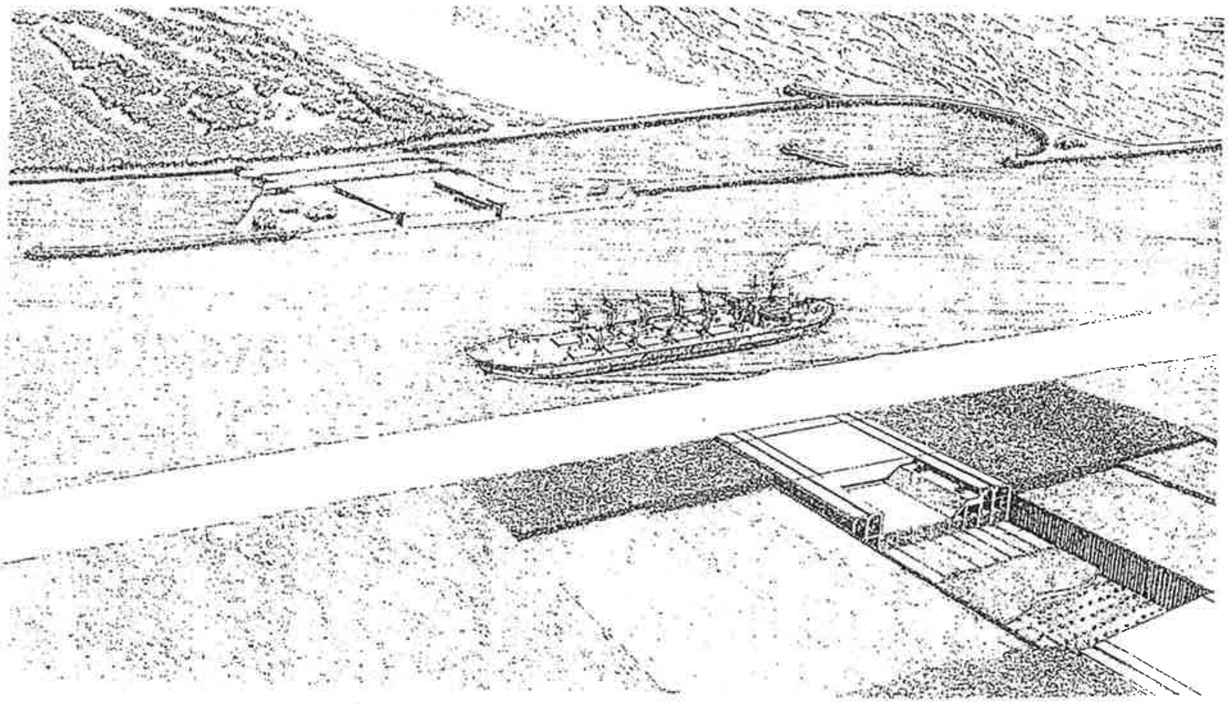
The mobile gates have been designed in such a way that the consequences of any extraordinary or accidental events can be repaired without placing the system out of commission.

2.5.5 The barrier management system

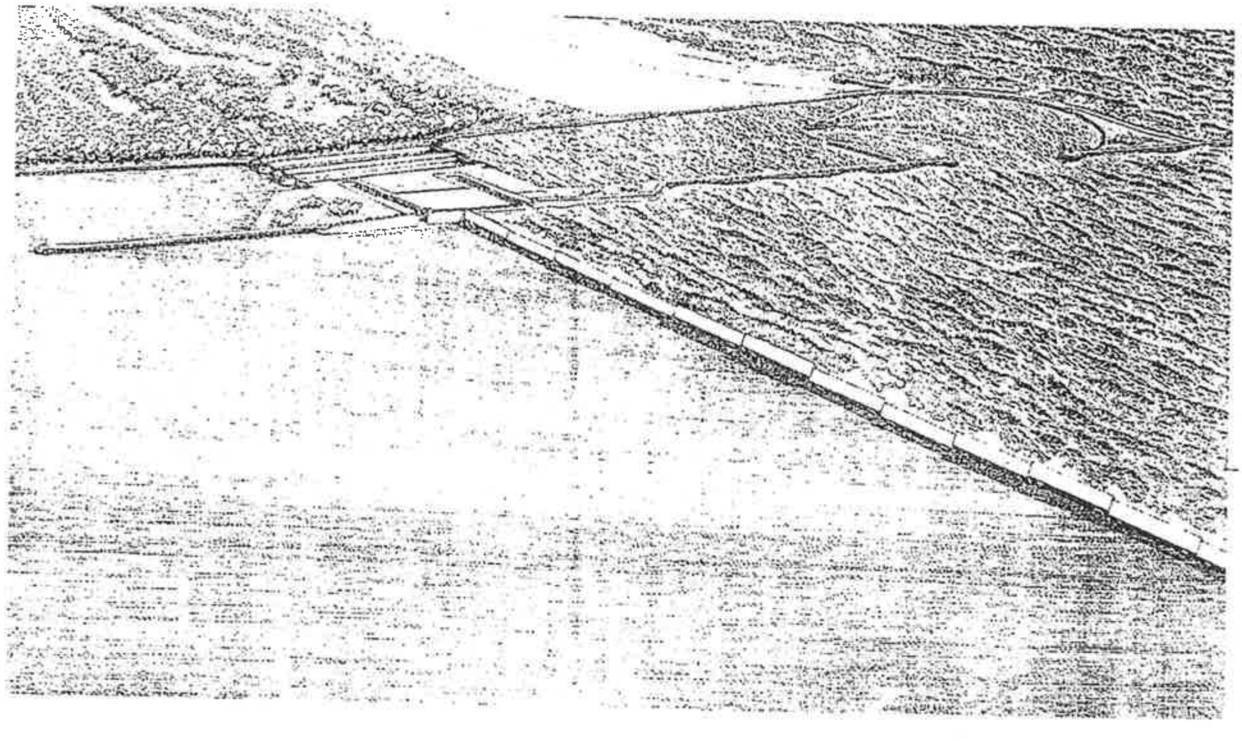
The mobile gates will be operated from a special Operations Centre that will receive all the information necessary to apply the procedures for their operation and maintenance (which will be defined during the executive design phase). An institutional supervisory structure will be set above the Operations Centre.

The gate closing strategy, based on a given classification of tidal events, will enable straightforward procedures to be followed to establish when to start the operations for raising the gates. The closure takes place in such a way as to ensure that the volume of water remaining in the Lagoon is capable of accommodating further increase in water level due to rainfall, run-off from the watershed, the passage of water while the gates are closing and through the gaps between the raised gates, and the water level differences caused by wind blowing along the Lagoon.

The operation of the barriers at all three inlets will be commanded by a central station and will be implemented by the three local stations situated at each inlet by means of an automatic operation management system. In the event of the central station being "out of order", the coordination and supervision functions will be transferred, following a pre-established routine, to any of the three local stations, which will temporarily take over for the purpose of supervision and coordination.



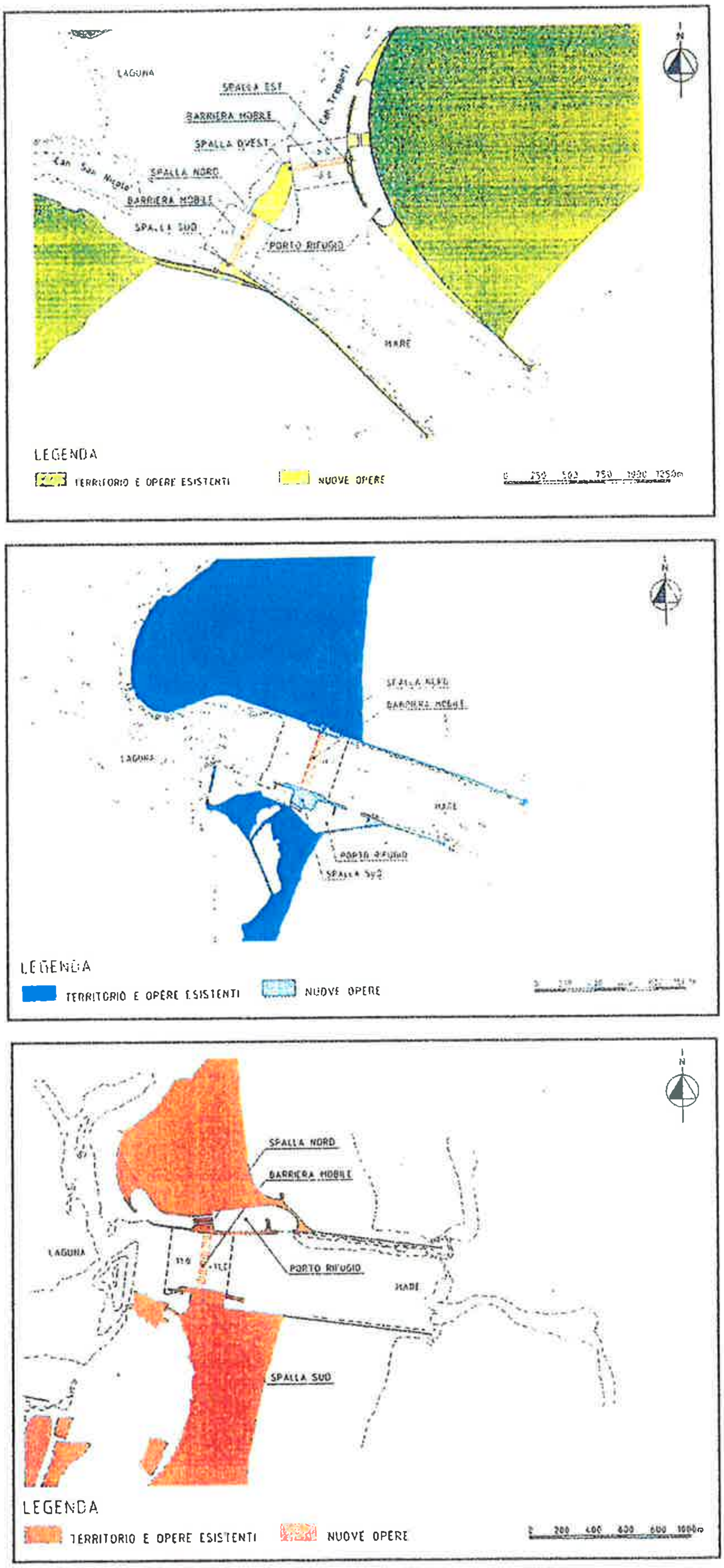
a)



b)

Fig. 2.5.1 - Vista generale delle opere alla bocca di Chioggia.
a) schiera di paratoie a riposo e vista dell'alloggiamento e della protezione del fondale
b) schiera di paratoie in esercizio

General view of the works at Chioggia inlet.



a)

b)

c)

Fig. 2.5.2 - Interventi alle bocche lagunari per la regolazione dei flussi di marea: Bocca di Lido (a), Bocca di Malamocco (b), Bocca di Chioggia (c)- (dal Progetto di Massima dei cantieri.)
Overall configuration of the gate at the Lido (a), Malamocco (b) and Chioggia (c) mouths (from Yard Basic Design)

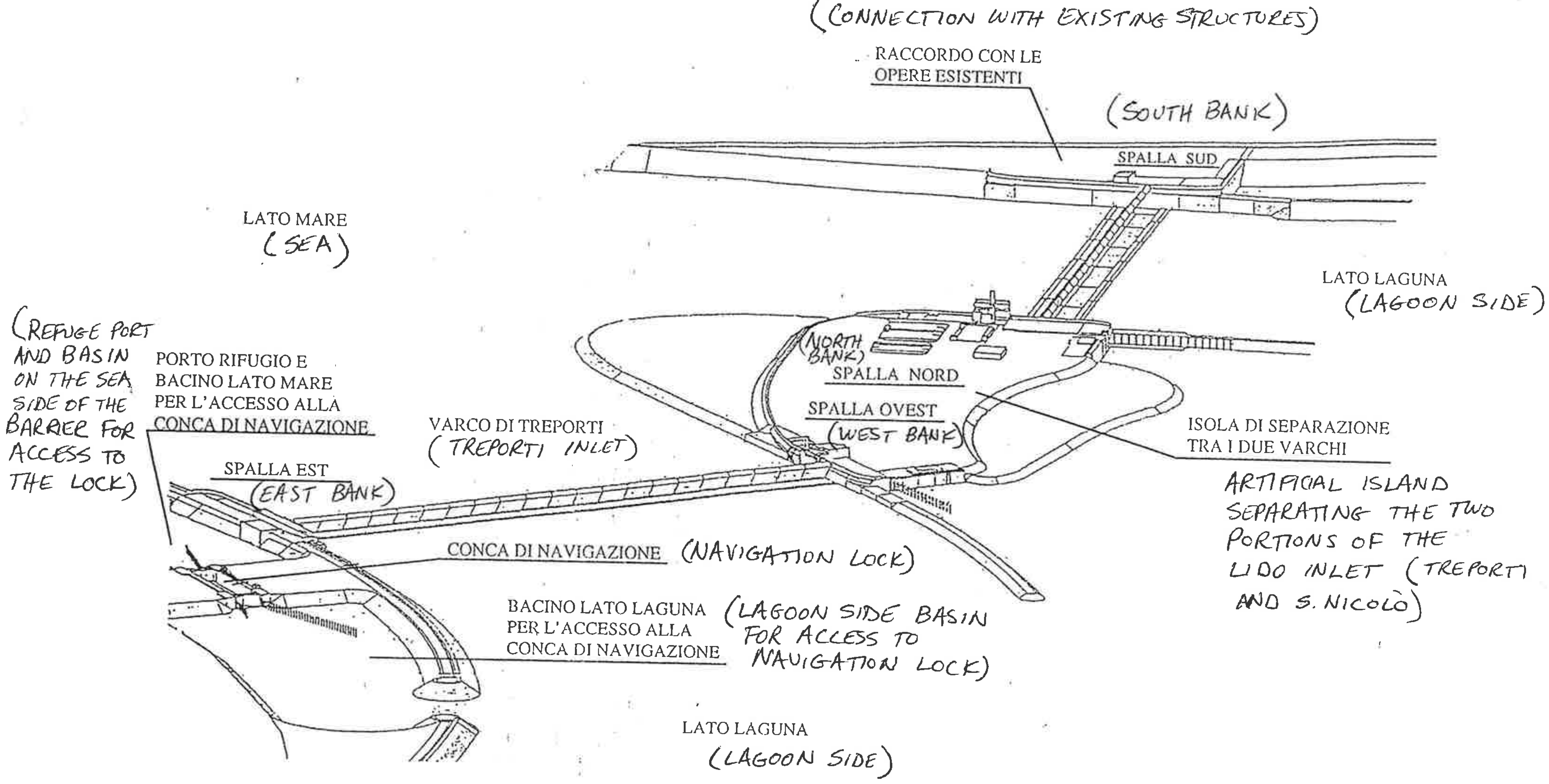


Fig. 2.5.3 - Vista complessiva delle opere alla bocca di Lido - Paratoie in posizione
Overall view of the barriers at port of Lido - Barriers functioning for high tides

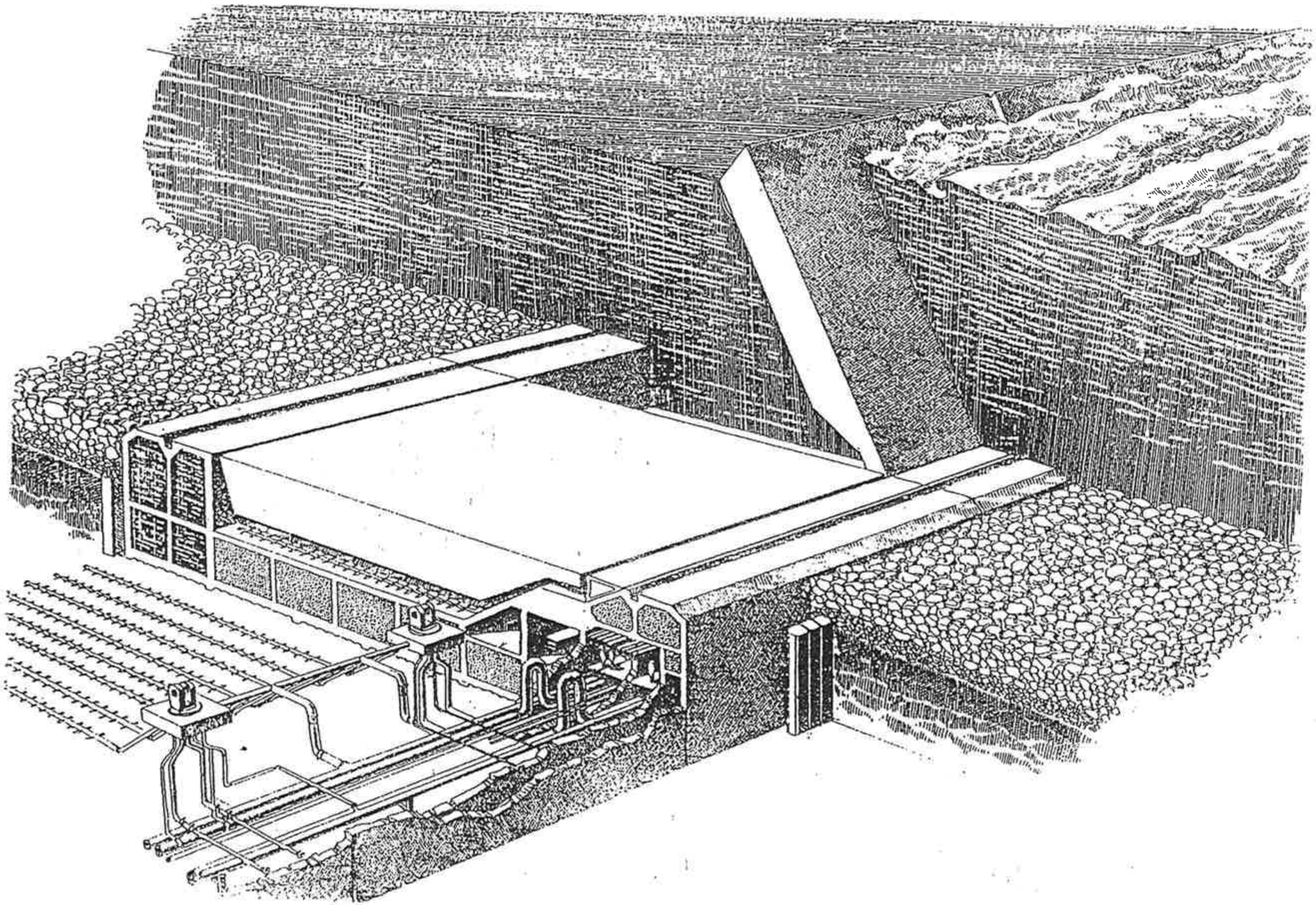


Fig. 2.5.4 - Vista e sezione di una schiera di paratoie
View and section of the barrier

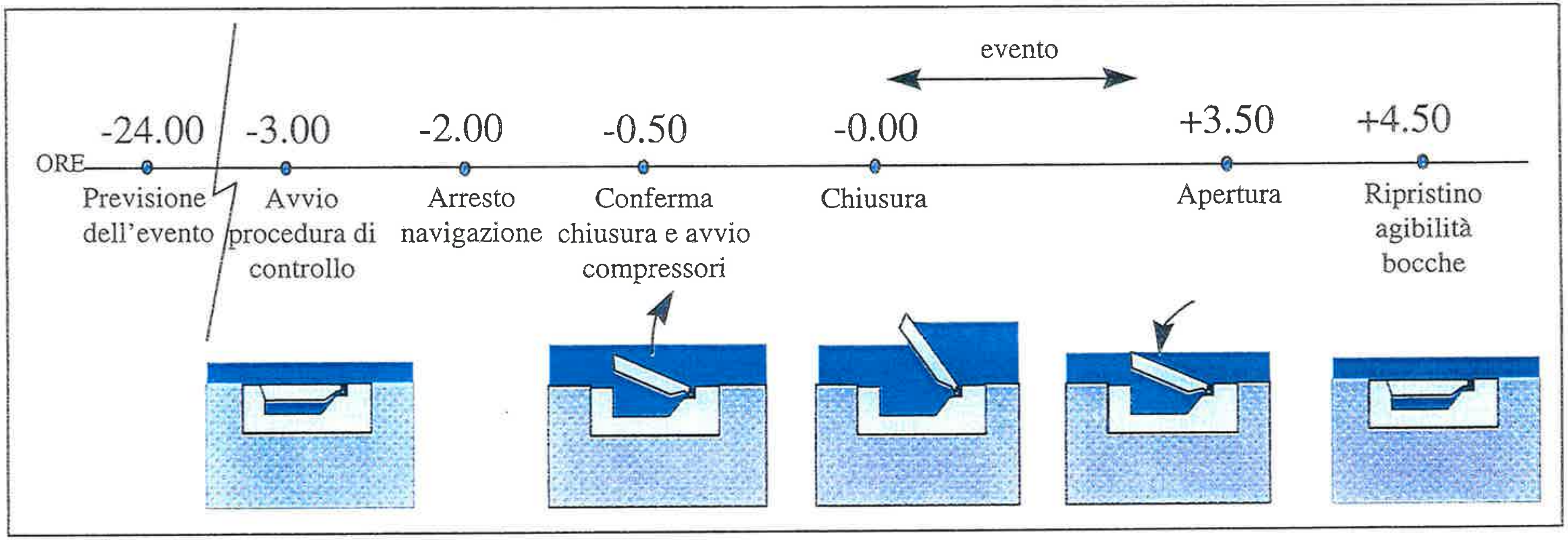


Fig. 2.5.5 - Modalità di chiusura delle bocche di porto.

Flapgates operating procedure.

3. THE ENVIRONMENTAL REFERENCE FRAMEWORK

3.1 The study area

The area involved in the EIS can be divided into four parts that differ considerably from each other:

- the Drainage Basin(watershed);
- the Venetian Lagoon (including the expanses of water, islands, coastlines and reclaimed areas);
- the Lagoon inlets;
- the Adriatic coast (extending a bathymetric depth of -18 m).

- The Drainage Basin

To the west the Lagoon borders an ample drainage basin (i.e. the area where water is collected and conveyed from the mainland into the Lagoon), with a surface area of about 1800 km^2, that includes 98 communities belonging to three different provinces: Venice, Padua and Treviso.

- The Lagoon

Situated between the mouths of the River Piave to the north-east and the River Brenta to the south-west, the Venetian Lagoon is the largest wetland area on the Mediterranean (50 km long by 11 km wide), with a surface area of 550 km^2, 420 km^2 of which are occupied by expanses of water and salt marshes , 90 km^2 by fish farm enclosures, and 40 km^2 by dry land (coasts, reclaimed areas and islands).

- The Lagoon inlets

The circulation of the water between the Adriatic sea and the Lagoon takes place through openings (the inlets), which have varied in number over the course of time. At present there are only three inlets, the contours of which are artificially defined by the presence of breakwaters or jetties.

- The coast

The coast includes the beaches as far as the water's edge and also the submerged area extending to a water depth of 18 m. The coast is generally divided into the following sections:

- Isola Verde;
- Sottomarina: from the mouth of the River Brenta to the Chioggia inlet;
- Pellestrina: from the Chioggia inlet to the Malamocco inlet;
- Lido: from the Malamocco inlet to the Lido inlet;
- Cavallino: from the Lido inlet to the mouth of the River Piave.

From a climatic point of view, the area belongs to a temperate zone and is characterised by the absence of periods of drought.

3.2 Environmental aspects

3.2.1 The current situation

The present-day situation has been established on the basis of information collected from public and private bodies and institutions, emphasising the aspects of major concern from the environmental standpoint with respect to any effects induced by the interventions contemplated in the Project.

Atmosphere

From the meteorological viewpoint, and mainly as concerns the parameters that govern the dispersion of pollutants in the atmosphere, the Venetian Lagoon can be considered as a single, homogeneous area. This is demonstrated by the similar anemometer readings obtained at the weather stations in Venice, at San Nicolò and at the Cavanis Institute.

As for the winds, which affect the dispersion of pollutants in the atmosphere, the relative prevailing direction is from the SSE in unstable weather and NNE in stable weather conditions. Fog covers the Lagoon about 45 days per year and is indicative of conditions of high atmospheric stability.

Findings regarding air quality indicate that:

- the air in the historical city centre is less polluted than in the industrial zones of Mestre and Porto Marghera;
- the current tendency is for substantial improvement in the quality of the air, at least relative to the data on dusts and sulphur oxides. Since 1984, it has become increasingly rare for the limits established for these two parameters by Presidential decree No. 203/88 to be exceeded, and virtually never occurs today.

Hydraulic environment

The main phenomena characterising the hydraulic environment that are relevant to the mobile gates at the Lagoon inlets are: a lowering of the sea floor level (subsidence), a rise in sea level (eustatism), the tides, wave motion, flow rates through the inlets, sediment transport, and the quality of the water and of the sediment.

- Hydrodynamics and solid transport

As mentioned above, the difference in elevation between dry land and sea level in Venice has decreased since the turn of the century by move than 23 cm due to a combination of subsidence (more than 12 cm) and eustatism (11 cm). Currently, since the intensive exploitation of underground water resources has been terminated, the mean annual subsidence in the Venetian area is 0.4 mm. Over the last century, the sea level in the city of Venice increased at a rate of 1.27 mm/year.

The tidal excursions in the Lagoon, which amount to about one meter, are among the highest in the Adriatic. The trend of the tides at the Lagoon inlets and inside the Lagoon depends on an astronomical component, on the morphology of the Adriatic basin and on weather conditions over the Mediterranean (Fig. 2.1.1). Data obtained from the Venice Local Government Centre for tide prediction show that, since 1923, the tide has reached the following extremes (ENEA, 1990) as measured by the marigraph at Punta della Salute:

- max. elevation	+194 cm	Nov. 4, 1966
- min. elevation	-121 cm	Feb. 14, 1934
- max. excursion from high to low tide	163 cm	Jan 28, 1949 & Dec. 28, 1970
- max. excursion from low to high tide	146 cm	Feb. 23-24, 1928 & Jan 25, 1966

Upon integrating data processed for the 1955-1984 period (by the National Research Council (CNR) in Venice) with findings recorded up to 1992, CVN obtained the following values for the mean annual number and duration of events exceeding or equalling certain tidal levels at Punta della Salute:

Tidal levels (cm)	Mean No. of events/year	Mean duration of each event
+60	204	3.4
+80	39	3.0
+100	7	2.8
+120	1	2.8
+140	1 every 6 years	2.6 (*)
+195	1 every 180 years	-

(*) The values in the table up to +120 cm also take into account the event of 1966, which lasted a total of 21 hours and reached a level of +194 cm. For the +140 cm level, the mean duration changes from 2.6 hours to 4.3 hours, respectively, for excluding or including the 1966 floods.

Table 3.2.1 - Tidal levels in Venice: mean frequency and duration (Consorzio Venezia Nuova, 1996)

The wave motion in the Lagoon is generated by the north-easterly (*bora*) and south-easterly (*sirocco*) winds and is attenuated progressively proceeding from the open Lagoon towards the Lido and Malamocco inlets, in comparison with the situation in Chioggia. During the winter months, there can be episodes of persistent, strong winds over the Lagoon that give rise to an correspondingly intense wave motion.

Wave motion is mainly responsible for the resuspension of sediment from the Lagoon floor, especially in the shallows; the waves also exert a dynamic action on the salt marshes , causing erosion and damage.

The overall hydrodynamic behaviour of the Lagoon depends on the tides that, as they rise, bring sea water into the channels and canals, and from there to the shallows. As the tide ebbs, the circulation is reversed, with water flowing back from the shallows into the canals and channels and from there to the open sea through the Lagoon inlets.

The mean daily volume of water entering the Lagoon between 1979 and 1983 was 385 million cubic meters. Since the volume of the Lagoon is 593 million cubic meters, the amount of water that is exchanged daily corresponds to 65% of the total volume.

Hydrodynamically, the Lagoon can be divided into three sub-basins: Lido, Malamocco and Chioggia. Between the three, exchanges of water occur at a rather slow pace (Fig. 3.2.1).

The watershed has a surface area of about 1,800 km^2, which is less than it was at the start of this century (about 2,100 km^2) because of interventions performed to divert its water ways. The hydrographic features of the Drainage Basin are essentially the result of hydrographic networks regulated artificially by the presence of areas subjected to irrigation schemes and of interventions for local shipping. The complex hydrographic network is composed of trunk lines that cover 60% of the territory, with alternating mechanical and natural drainage, and the remaining 40% under continuous mechanical drainage. The mechanically-drained areas are situated at the southern end of the basin and along the edges of the Lagoon. On the Lagoon including border, 27 delivery points have been identified where the watershed drains into the Lagoon, not only natural water ways, but also man made hydraulic structures.

The sediment carried into the Lagoon arrives both from the sea and from the Drainage Basin. The aspects of interest relative to the sediments of marine origin include longitudinal transport in the area of wave-breaking and in the more seaward belt, and transverse transport due essentially to the different seasonal distribution of the wave motion (Fig. 3.2.2). For the purpose of littoral transport, the wave motion generated by the north-easterly winds would prove the most effective. Currently, the net transport in the wave-breaking zone is in a prevailing southbound direction along the Cavallino coast (with volumes of around 150,000 m^3 of sediment per year) and also, in decreasing order, along the Lido and Pellestrina beaches, fading away completely at the southern end of the Pellestrina section of coastline. Beyond the Chioggia inlet, on the Sottomarina beaches, the net transport is in the opposite direction (northwards) and involves between 50,000 and 100,000 m^3 per year (Fig. 3.2.3).

An overall evaluation of the sediment transport through the inlets (Consorzio Venezia Nuova, 1992) indicates that the total annual transfer of solids involves about 1,500,000 m^3 entering the Lagoon and about 2,200,000 m^3 exiting to sea. Hence, there is a negative balance of the sediment passing through the inlets of about 700,000 m^3 a year, which coincides very closely with the figures obtained from a comparison of the bathymetric measurements.

As for the solid transport the Lagoon, there is a flow of sediment into the canals and channels from the shallows, which are in turn recharged by sediment arriving from the watershed. The sediment coming from the watershed currently varies between 15,000 and 30,000 m^3 a year.

- The quality of the water and sediment

Evaluation of the water quality requires consideration of the eutrophication of the water in the Lagoon and its contamination by organic and inorganic micro-pollutants, mainly of industrial origin. Both aspects are strongly related to the amount of pollution coming now and in the recent past from the watershed. The most up-to-date estimate (1994) for the amount of nitrogen and phosphorous introduced into the Lagoon is 6,500 tons per year and 760 tons per year, respectively.

More in general, there is evidence that 70% to 75% of the total nitrogen and phosphorus loads into the northern part of the Lagoon basin that flows towards the Lido inlet. The principal sources of nitrogen, in order of importance, are civilian, agricultural and zootechnical. The amount attributable to the historical centre of Venice is about 500 tons per year.

The eutrophication of the Venetian Lagoon leads mainly to an abnormal proliferation between March and October of a type macro-algae called *Ulva*, the growth of which varies according to the typical weather conditions from year to year. This situation has the effect of altering the original ecosystem balances (e.g., by reducing the phytoplankton) and inducing a series of acute crises (anoxia, the death of benthic organisms and the presence of hydrogen sulphide in the water) caused by the decomposing algal biomass.

The problem of the trophic state of the Lagoon and, more in particular, of the proliferation of Ulva, is associated with the complex interaction between the nutrient concentrations in the water, the weather conditions, the hydrodynamic conditions (particularly those concerning the sea-Lagoon tidal exchanges, which depend on the tidal cycles and on the local current velocities that can interfere with the macro-algal growth and with any displacement of the *Ulva* meadows).

In the Venetian Lagoon, particularly in the central-to-northern part and in the vicinity of its margin, the nutrient concentrations are generally high. The enrichment factors, relative to the values typical of the Adriatic sea lying outside the Lagoon, can vary considerably, depending on the parameter considered (e.g., for phosphorous, the mean enrichment factor is about 10 times) and on the season of the year. During the spring and summer months, the average situation for total inorganic nitrogen is sometimes reversed due to a drop in the contribution from the watershed, leading to higher concentrations in the Adriatic than the average values measured in the Lagoon.

The micro-pollutant load, both organic (IPA, PCB, chlorinated pesticides, dioxins and furans) and inorganic (heavy metals), originates mainly from the industrial zones, marine traffic and agricultural activities, although no quantitative estimates are available on the amounts involved. It is common knowledge that, in the past, the industrial area of Porto Marghera discharged non-negligible quantities of heavy metals, zinc in particular, into the Lagoon. Although organic and inorganic micro-pollutants tend to associate with the sediment, the water in the Lagoon shows significantly increased concentrations for some metals (Zn, Pb and Cr), ranging from 2 to 10 times the values measured in the Adriatic.

The distribution of the sediment (especially its finer fraction) contaminated by heavy metals reveals enriched patches mainly in the area between the industrial zone of Porto Marghera and the historical city centre of Venice. The enrichment factors for zinc are 10-15 times the natural baseline values, whereas the other metals have enrichment factors generally less than 3. Higher contamination values are generally observed in the industrial channels and in the canals in the city of Venice, to such a degree that the sediment can often be classified as special, or toxic, harmful waste. Though the source of the metals Zn, Pb and Cr is mainly industrial, their distribution confirms a non-negligible contribution from atmospheric, agricultural and civil sources.

As for the organic pollutants (IPA, PCB, chlorinated pesticides, dioxins and furans), the sediment in the shallows shows non-negligible levels of contamination in the submerged areas offshore near Marghera and at the mouth of the Dese river, and even higher levels are measured in the industrial channels and in the canals in the historical city centre of Venice.

The physical and chemical features of the Lagoon water, include a temperature that varies from 5° to 8°C in winter to 25°C in summer. The salinity of Lagoon water is generally around 30 PSU (practical salinity units) near the inlets, dropping to 5 PSU in the northern part of the Lagoon and near the mouths of the rivers. The turbidity is lower at the Lagoon inlets (3 m on the Secchi disk) and higher (0.5 m) at the northern end of the Lagoon. The distribution of dissolved oxygen, which usually presents values nearing saturation, can drop to as low as 60% of saturation level. There are also areas where the oxygen value in the vicinity of Lagoon floor can sometimes temporarily approach anoxic levels because of the lower solubility at higher temperatures, the oxygen demand from the sediment and the nocturnal respiration of the algae (especially in summer),.

Because of its morphological and oceanographic features, the marine area adjacent to the Venetian Lagoon coast has less dramatic environmental problems than those within the Lagoon. The nutrient concentrations are generally lower than in the Lagoon and give rise to generally mesotrophic conditions. These concentrations originate mainly from fluvial emissions and that is why there are often episodes of algal blooms (typical of a eutrophic environment) in the area to the south of Chioggia, as it is affected by the water arriving from the River Po.

Finally, the sediment along the littoral area reveals a localised presence of heavy metals and organic contaminants, with non-negligible enrichment levels. These are due to the contaminated fine sediment arriving from the Lagoon and occasional to the dumping of dredged Lagoon sediment and industrial waste.

Soil and subsurface

The Lagoon environment is the result of anthropic interventions that have led to changes in its overall arrangement. The total surface area considered includes the following classes of land usage and coverage:

- urban (historic and new inhabited centres, commercial centres, offices, stadiums, airport): 6.2%;
- industrial: 0.5%;
- services and tourism: 2.9%;
- non-urban and non-agricultural: 1.2%;
- agricultural: 77%;
- Lagoon: 11.5%;
- vegetation: 0.7%.

The Lagoon territory has been characterised by an extremely complex evolution and, from a geological viewpoint, it has undergone profound change even in relatively recent times. It has been converted from a "marine environment" to a "dry land environment" and then, about 6,000 years ago, to a "coastal Lagoon environment". Thus, even 6,000 years ago, there was already a Lagoon between the estuaries of the Rivers Adige to the south and Piave to the north, also fed by several other rivers (the Brenta, the Bacchiglione, and several secondary branches of the Adige and Piave) as well as by other lesser waterways of resurgent origin, such as the Dese and the Sile.

The evolutionary trend of the Lagoon and its effects on the single components (watershed, Lagoon, inlets and coastline) depend on the natural and artificial agents that have come to bear on the area.

The most salient feature associated with the Drainage Basin is the reduction in the fluvial solids load, as already mentioned in the paragraphs on the hydrodynamics and sediment transport.

Within the Lagoon basin, there is a complex network of major channels and meandering secondary channels (*ghebi*) criss-crossing the salt marshes (emerged areas that are sometimes submerge in that their elevations are within those of tidal excursion), and terminating in shallow ponds of rain or brackish water (*chiare*) enclosed in the salt marshes. On either side of the channels are vast expanses of shallows, including the mudflats that emerge under certain tidal conditions.

Between the Lagoon proper (the "open" Lagoon) and the mainland there are fish farming enclosures (called *valli da pesca*) that consist of wetland areas with an artificially controlled hydraulic regime, separated from the adjacent Lagoon by means of impermeable embankments. Finally the swamps (*paludi*) are large shallow expanses of water surrounded by salt marshes.

This inter-penetration of land and water, presently demonstrates the following surface distribution:

- the dry land system : 8% (islands 6.4 %, embankments 1.6%).
- the water system : 92% (canals and channels 11.9 %, shallows, mudflats and salt marshes 80.1%).

The areas at the Lagoon inlets are where the greatest and most obvious morphological changes have taken place, both in width and in depth. Since the construction of the protective breakwaters, the depth of the inlets has progressively increased to reach the present-day configuration. The channels at the inlets are now relatively stable, with a tendency to increase in average cross-section at Malamocco (+4.1% between 1970 and 1990) and Chioggia (+7.3%), balanced by a tendency toward the reduction of the cross-section of the Lido inlet (-2.3%) (Consorzio Venezia Nuova, 1992).

Finally, as far as the littoral zone is concerned, most of the coastal front that separates the Lagoon from the sea is in critical equilibrium conditions, which are apparent from the general, progressive deepening of the floor, the receding of the shore line and the disappearance of the dunes.

Vegetation, flora e fauna

- Terrestrial (onshore) Vegetation and flora.

The natural associations of different types of vegetation in the Venetian Lagoon occupy fairly extensive salt marsh areas, where there is a group of plant formations typical of saline environments, fairly similar to one another and basically belonging to the *Puccinellio-Salicornietea* classes. Along the shores, on the other hand, there are only isolated patched of these formations altered in various ways, comprising fragments of psammophile formations (typical of the coastal dunes) and artificially-planted pine woods that have replaced the original vegetative populations.

Important examples of the original psammophile phytocenoses (plant communities) can be seen in the area of Ca' Savio-Ca' Pasquali, at the bio-phenological research station at Cavallino, in the Ca' Ballarin and Punta Sabbioni areas, and in the sand dunes of Alberoni and of Ca' Roman (Caniglia, 1978; Caniglia & Velluti, 1990; Bonometto, 1989).

In particular, the shores adjacent to the Lagoon inlets feature certain areas of interest:

- the Chioggia inlet has a small wooded area on the southern side called San Felice, dominated by elements of anthropic origin (*Tamarix gallica* and *Elaeagnus angustifoliae*). On the northern side, (Ca' Roman) there are relatively well-preserved dunes with typical psammophile vegetation dune grass ("marram grass" (*ammofileti*)). The dunes furthest inland are more degraded because of the planting of trees foreign to the dune environment;

- the Malamocco inlet features an interesting variety of environments on its southern side (Santa Maria del Mare) that are situated very closely to one another. To the north (Punta Alberoni) there are rows of some of the most important dunes in the Lagoon territory, with dunal psammophile formations and patches of retrodunal plant communities;
- the Lido is characterised to the south (San Nicolò) by the presence of a sandy shore accommodating only a few traces of the original psammophile formations, the north (Punta Sabbioni), there is a variety of environments and plant associations, including reeds(*giuncheti*), "*schoeneti*" and marram grass.
- Terrestrial Fauna

There are several types of fauna living on dry land in some areas, with interesting and varied ornithological and entomological populations. The area of Ca' Roman, an important nesting zone for the Kentish plover (*Fratino*) swimming birds and the Little Tern (*Fraticello*) (with almost 400 pairs nesting in the Lagoon), while both Ca' Roman and the Lido Alberoni are inhabited by invertebrates (mostly insects) of considerable interest (endemic in the northern Adriatic).

The emerged Lagoon environments (salt marshes, reclaimed areas and fish farms) have rich and diversified populations, especially of birds, and the salt marshes, in particular, provide nesting ground for the Little terns, the Common Terns (*Sterna Commune*) and the Redshank (*Pettegola*).

An important area for wintering and for stopping over during migration is the Bacan, a sand bar in front of the Lido inlet. The most common species in this area is the black-breasted Sandpiper (*Piovanello pancianera*). The fish farms also provide suitable shelter for a variety of fauna, especially the Herons (*Ardedi)* that nest in colonies (*garzaei*) the most important areas for the nesting of these birds are Valle Dogà, Valle Figheri, Valle Cornio Alto and Valle Averto. An area of particular interest for the wintering bird life is Valle Millecampi, a wetland area of international importance according to the Ramsar Convention.

Finally, the area on the margin of the Lagoon has small, fragmented populations of various ornithological species (woodpeckers, night-time predators and small sparrows) and amphibians (such as the frogs of Lataste), concentrated in what remains of the natural or semi-natural environment, and an interesting contingent of migrating and wintering species (e.g. limicolous species (*limicoli*) , storks (*ciconidi*) and ducks (*anatidi*).

- Aquatic vegetation and flora

The principal vegetative populations on the floor of the Lagoon are composed phanerogam (spermatophyte) meadows indicative of good-quality environmental conditions (Fig. 3.2.4), and populations of benthic macro-algae, indicative of eutrophic environment.

The phanerogams, or eelgrass, include three species (*Zostera noltii*, *Zostera marina* and *Cymodocea nodosa*) which generate both pure and mixed, continuous and discontinuous populations. Their distribution can vary, even quite considerably, within a matter of a few years and is influenced by several factors (the particle size distribution of the sediment, water quality, turbidity, the presence of macro-algae, etc.).

The macro-algal populations are mainly composed of *Ulva rigida*, which has a great capacity for adapting to changes in its environment and a high potential for growth (with two peaks during the course of the year, one in April-May, when it reaches its maximum levels, the other in October, with slightly lower levels). With its considerable biomass levels and seasonal cycle, *Ulva* is capable of controlling the features of its environment, giving rise to alternate periods of intensive oxygen production and the immobilisation of minerals in its biomass, followed by periods of intensive oxygen consumption and the release of minerals and organic substances from the decomposing thalli (Fig. 3.2.5).

In the last five years, there has been a decline in the coverage, biomass and production of *Ulva rigida* (Sfriso, 1996, Curiel *et al.*, 1995), though it is still the dominant macro-alga throughout the Lagoon. The reasons for this decline (Sfriso, 1996; Sfriso & Marcomini, 1996) have been correlated with the unfavourable climatic conditions that have coincided for several years running with the time of its peak growth, followed by an increase in the grazing pressure and a greater resuspension of sediment that then settles on the thalli, all of which favour a reduction in the biomass (Sfriso & Pavoni, 1994). Another factor responsible for the decline of the *Ulva* is the harvesting of the biomass, which has reduced the trophic load (Solazzi *et al.*, 1991).

- Aquatic fauna

The aquatic fauna in the Lagoon is mainly composed of zooplankton, benthic species and fish. Most of the zooplankton is of marine origin and essentially comprises Crustaceans, Copepods and Cladocerans, and larval forms. The greatest variety is found near the Lagoon inlets, whereas in some of the innermost parts of the Lagoon there is a characteristic plankton differing from that of the sea, comprising only a few species but with a large number of individuals.

The most strongly represented benthic communities in the area of the Lagoon inlets were found to be the molluscs, including several Gastropoda that can be found in the coastal marine areas, whereas in the areas further from the inlets inside the Lagoon, there are also important populations of annelids (*Annelida Polychaeta*) and, in some cases, the dominant types are bivalve molluscs of the *Abra* genus or of the *Cerastoderma glaucum* species (Figs. 3.2.6 and 3.2.7).

Analysis of the benthic animal communities has shown that the most severely deteriorated areas are those located in the move internal areas of the Lagoon, both to north and south, and in the areas most exposed to pollution and to the accumulation of organic substances, i.e. around Venice, the Lido and Chioggia. The least degraded areas are found around the Malamocco inlet and in the central basin, between the Malamocco and Chioggia inlets.

The fish communities in the Lagoon are represented by a relatively large variety of species, albeit less numerous than those found in the sea along the coasts adjacent to the Lagoon. A group of fish of particular interest that breeds in the Lagoon includes several Gobies, benthic species with a limited geographical distribution (brackish water of the Adriatic), such as the local types of gudgeon ("*Ghiozzo cenerino*" and "*Ghiozzetto di Laguna*").

Being so rich in trophic resources, the Lagoon environment promotes seasonal oscillations of certain fish species between the sea and the Lagoon (such as mullet), that swim into the Lagoon in spring and back out again late in autumn. In particular, the Zostera meadows - with their wealth of nutrients, benthic invertebrates and microenvironments -represent an important habitat for the young forms of fish species, acting as a genuine fish *nursery*.

The areas of the fish farms along the edge of the Lagoon and the waterway mouths and final stretches of the rivers provide a home for a typical freshwater ichthiofauna represented by various species such as the Stickleback, the *Gambusia*, the Tench, and Carp.

The marine littoral zone adjacent to the Venetian Lagoon is characterised by the presence of biotopes of exceptional ecological importance for the Adriatic system that differ considerably from the sandy-muddy sea bed of the surrounding area. They are areas of *beach-rock* (calcareous sandstone of clastic origin resulting from the carbonate cementing of various kinds of shore sediment) and organogenous rock characterised by a rich animal population of Bryozoa, Molluscs, Anthozoa, and Serpulids.

Ecosystems

The surviving natural ecosystems in the rows of dunes and in the retro-dunal areas along the shores, are fragmented and demonstrate variable degrees of conservation. They are characterised by a particularly dynamic ecological sequences that follow the variations in environmental parameters or human activities and by the presence of biotic communities of considerable biogeographical interest.

At the Lagoon inlets, at Ca' Roman, Lido Alberoni and Punta Sabbioni, there are several biotopes of interest, with valuable psammophile biotic communities. The natural ecosystems of the Lagoon areas above water, which are extensive and relatively continuous, are represented mainly by the salt marshes environments, where there are endemic plant communities and important nesting bird populations.

Other interesting environments are the reclaimed areas (because of the presence of plant communities in dynamic evolution and some interesting animal life) and also the fish farms, which enable the survival and breeding of a variety of bird life.

At the margin of the Lagoon, the survival of the natural or semi-natural ecosystems is very limited, dominated by the agricultural areas and intensive human activity. The features of the Lagoon ecosystem, vary both in time, in that they follow cyclic variations in the environmental and ecological parameters, and in space, as the hydraulic and chemical gradients change from the Lagoon inlets towards the innermost parts of the Lagoon.

The living organisms can be grouped into three basic categories (benthos, plankton and nektonic organisms), which are inter-related by a complex network of energetic and trophic exchanges. The seasonal cycles of the chemical, physical and biological features of the ecosystem suffer from the presence of the *Ulva rigida*. The gradual reduction in the *Ulva* biomass in the last few years may bring changes in the structure and functions of the whole community.

Finally, the ecosystem of the sea shore, which receives most of its nutrients from the Lagoon, is mainly characterised by a certain biological homogeneity (a sea bed of mobile sediments and constant ecological parameters). Only particular, localised ecological conditions (where the sea bottom is solid) enable the development of a rich biotic community.

Public health

Data were considered relative to contaminants found in aquatic animals and in the water where people swim, contaminant levels of toxicological interest in the sediment, and the statistical information on any mortality possibly related to certain problems specifically linked to the Venetian territory such as the damp climate or the presence of atmospheric pollutants.

Analysis of the data available on the concentration of certain toxic contaminants in the aquatic organisms in the Venetian Lagoon (PCB, pp'-DDT, benzo(a)pyrene (B(a)P) and dibenzanthracene) has shown that the highest values are found at the Lido inlet. Comparing these findings with the concentrations associated with a negligible cancer risk ($1x10^{-6}$), calculated by the American *Environmental Protection Agency* (EPA) shows that these limits are exceeded in some cases. Judging from the data provided in a recent report by the Veneto Regional Authority, the conditions of the water for swimming outside the Venetian Lagoon seem to be at least as good as those of other areas in the region, if not better.

An analysis was performed on the environment-related mortality data collected by the Venice Local Health Unit between 1980 and 1982 and by the Venice Provincial

Authority between 1983 and 1992. For certain causes of mortality that are a function of exposure to environmental pollution factors, the values observed were higher than the regional and national averages. However, findings for the decade 1983-1992 showed a declining trend, comparable with the regional and national figures, for all causes of mortality. Moreover, for some types of pathology typical of cold or damp climates (chronic rheumatism and chronic rheumatic cardiopathies), the situation in the province of Venice was consistent with the regional levels which are lower than the national levels.

Landscape

From a landscape perspective, the Venetian Lagoon can be divided roughly into four main interdependent reference systems, characterised by typological and morphological similarities although each presents certain differences within the system: i.e.

- the historical and monumental centres on the islands (Venice, Chioggia, Murano, Burano, etc.);
- the mainland;
- the Lagoon proper, i.e. the expanses of water, the canals, the system of mudflats and salt marshes, and the fish farms;
- the shores.

The historical and monumental town centre system, which draws tourists from all over the world, is distinctive for its extreme sensitivity. The historical centres of the Lagoon are highly vulnerable because of their location in an environment that not only emphasises their value, but also represents a fundamental threat, and for their fundamental uniqueness.

The mainland system, on the other contrary, is certainly of less value, because it has been damaged and dismembered (in terms of the landscape) and has consequently lost its original role as an area of transition between the Lagoon and the inland areas. This system belongs increasingly to the urban logic of the Po valley and less and less to the fragile and refined balance between man and nature so typical of the Lagoon. It can therefore be considered as the least sensitive area.

The Lagoon landscape, on the other hand, understood as including the expanses of water characterised by its mudflats and salt marshes, the fish farms and navigable channels, intermediate sensitivity because it is less visited and less vulnerable than the historical towns in the Lagoon, but of unquestionable value as a whole given its unusual landscape features that express a delicate balance between man and nature.

For essentially similar reasons, the sensitivity of the shoreline system characterised by evocative sea-Lagoon balances is also considered as intermediate as it includes some elements of historical and architectural value. This system bears witness to the centuries-old battle conducted by man to safeguard the Lagoon as a means of defence, social interchange, as a way of life and source of income.

The Venetian littoral zone in its entirety, extending from Punta Sabbioni to Sottomarina, is characterised in terms of its landscape by the fact that it is a particularised linear system, complex but still recognisable as a unit (albeit with certain discontinuities), partly due to the lack of contours. Although low-lying, the coastal system stands out distinctly against the landscape as a whole because of the contrast it strikes with the surrounding water of the Lagoon basin and sea. The littoral cordon unequivocally serves as a margin between the Lagoon landscape system and the open sea while contemporaneously constituting the point of transition between the landscape of the Venetian Lagoon and that of the Adriatic coastline. In this linear system, very extensive lengthwise but modest altimetric proportions, the rare anthropic components that do emerge become very important, marking the landscape and lending it proportion.

Generally speaking, for a series of contextual and design reasons (size, correlation with the open spaces, etc.), the structural elements of interventions in the Lagoon fail to become exclusive or dominant features in the context of the landscape, however large in scale they may be (e.g. the interventions at the Lagoon inlets); they merely emphasise its typically horizontal nature. Even when they achieve considerable heights (as in the case of the sea walls, their longitudinal continuity preserves the horizontal line.

Any tall and slender constructions, apart from the towers, lighthouses and other functional infrastructures that have little influence and fail to interfere with the fundamental features of the landscape - tend to adapt to the perceptual relationships dictated by the landscape itself, i.e. ample dimensions in tune with the morphology of the surrounding land.

Another characteristic of this landscape is the close-knit weave of its artificial features (the result of recurrent activities, of large and small adjustments and maintenance work that has been essential to keep the whole territory from falling into decline) with the natural features, not only of the marine and Lagoon aquatic areas, but also of several littoral areas, and the widespread presence of vegetation that, in some cases, still has the typical features of natural growth. On the whole, the area is of a high quality in terms of landscape, primarily due to its dynamic inter-penetration between the natural context and the interventions and activities of man. This landscape can also be roughly classified according to its natural and human components.

The natural component comprises:

- the littoral zones, the vegetation;
- the Lagoon;

whereas the human component comprises:

- the systems for defending the area from the sea, from wave motion and from the currents;
- the protective breakwaters at the Lagoon inlets;
- the residential and tourist system;
- the fortification system at the Lagoon inlets;
- the agricultural areas.

Of the Lagoon inlets, the most sensitive, on the whole, are Lido and Chioggia, since the former is often visited and is distinguished by wide open spaces (with a sort of "enclave" inside the inlet), whereas the latter has very natural features, with a fortification typical of the Lagoon and coastal environment (Forte San Felice). The Malamocco inlet would seem less sensitive, since it is less structured and, above all, and is less frequented.

Fig. 3.2.1 - Suddivisione della Laguna in tre sottobacini da spartiacque idraulici (Consorzio Venezia Nuova, 1989).

Division of Lagoon in three subbasins by hydraulic watersheds.

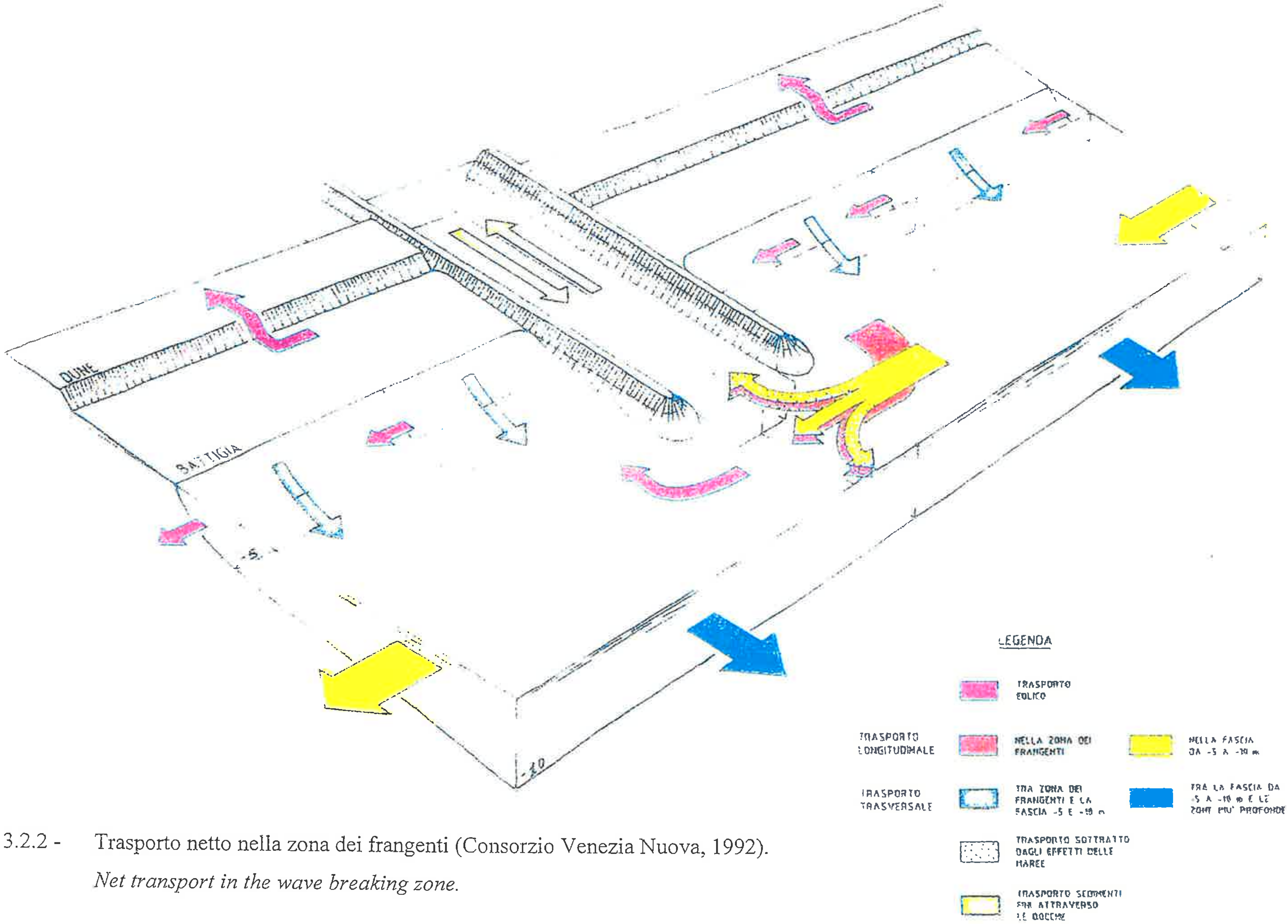


Fig. 3.2.2 - Trasporto netto nella zona dei frangenti (Consorzio Venezia Nuova, 1992).

Net transport in the wave breaking zone.

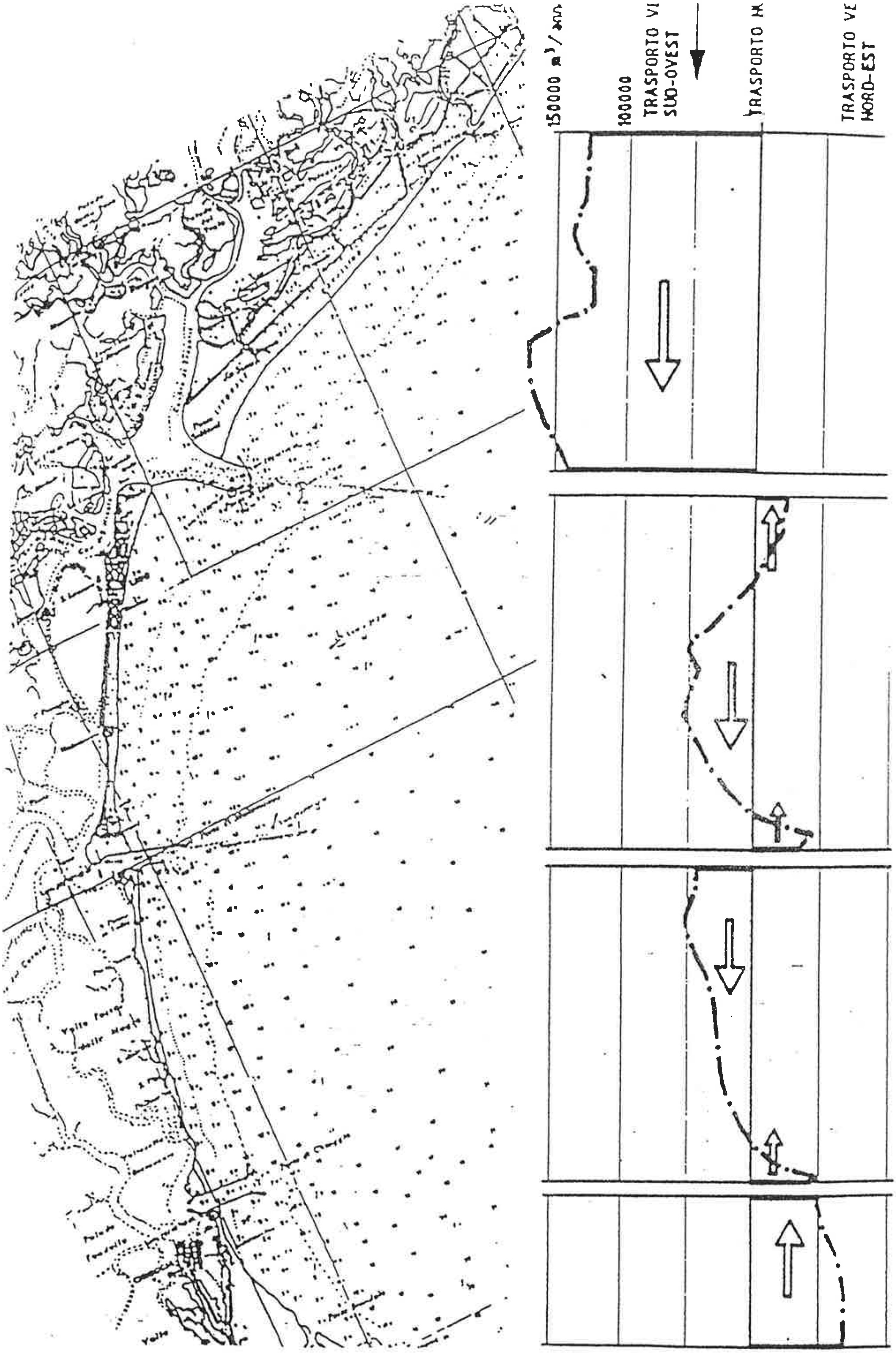


Fig. 3.2.3 - Trasporto netto nella zona dei frangenti (Consorzio Venezia Nuova, 1992).
Net transport in the wave breaking zone.

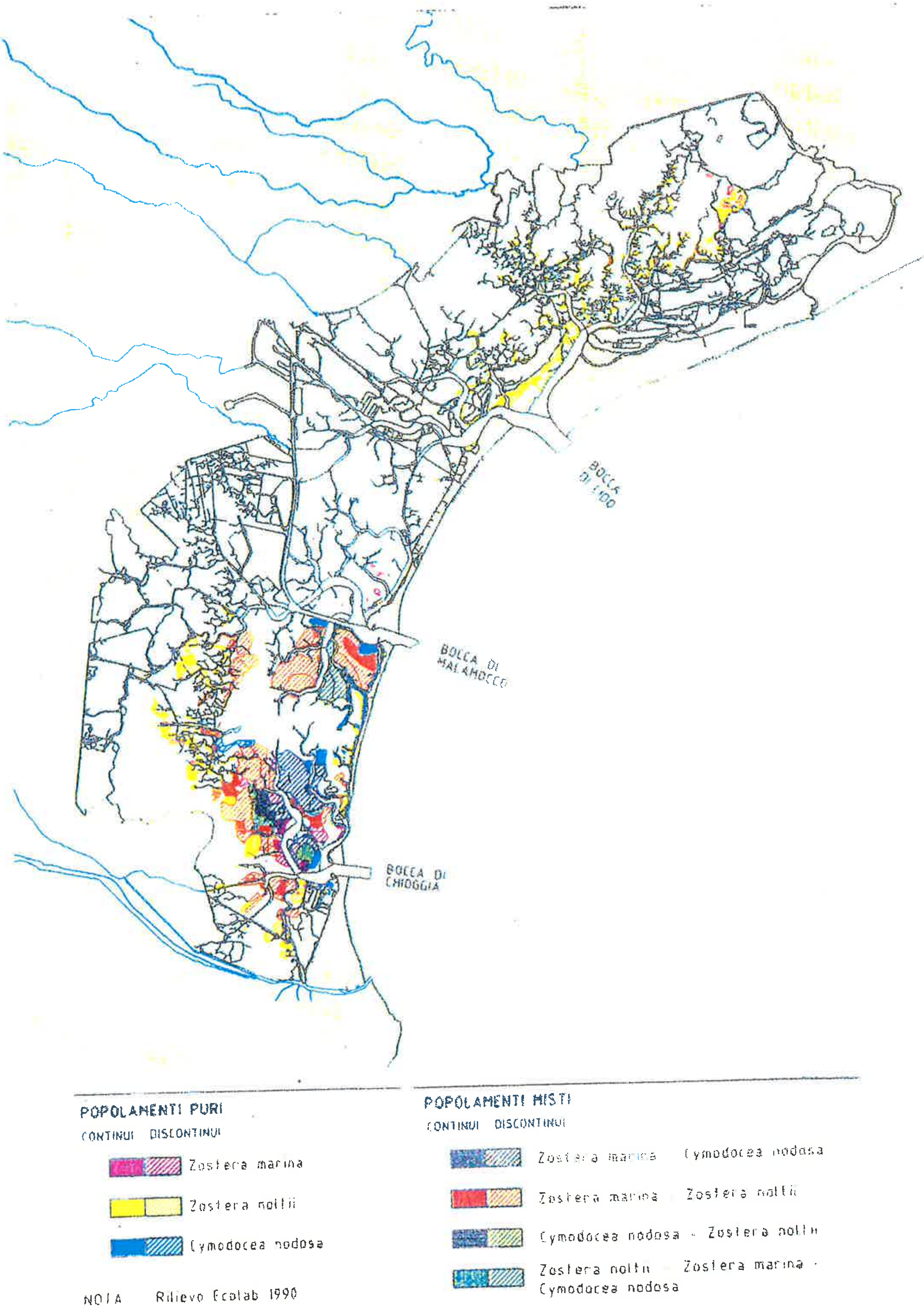


Fig. 3.2.4 - Carta distributiva delle fanerogame marine (Consorzio Venezia Nuova, 1993).
Map of seagrass distribution.

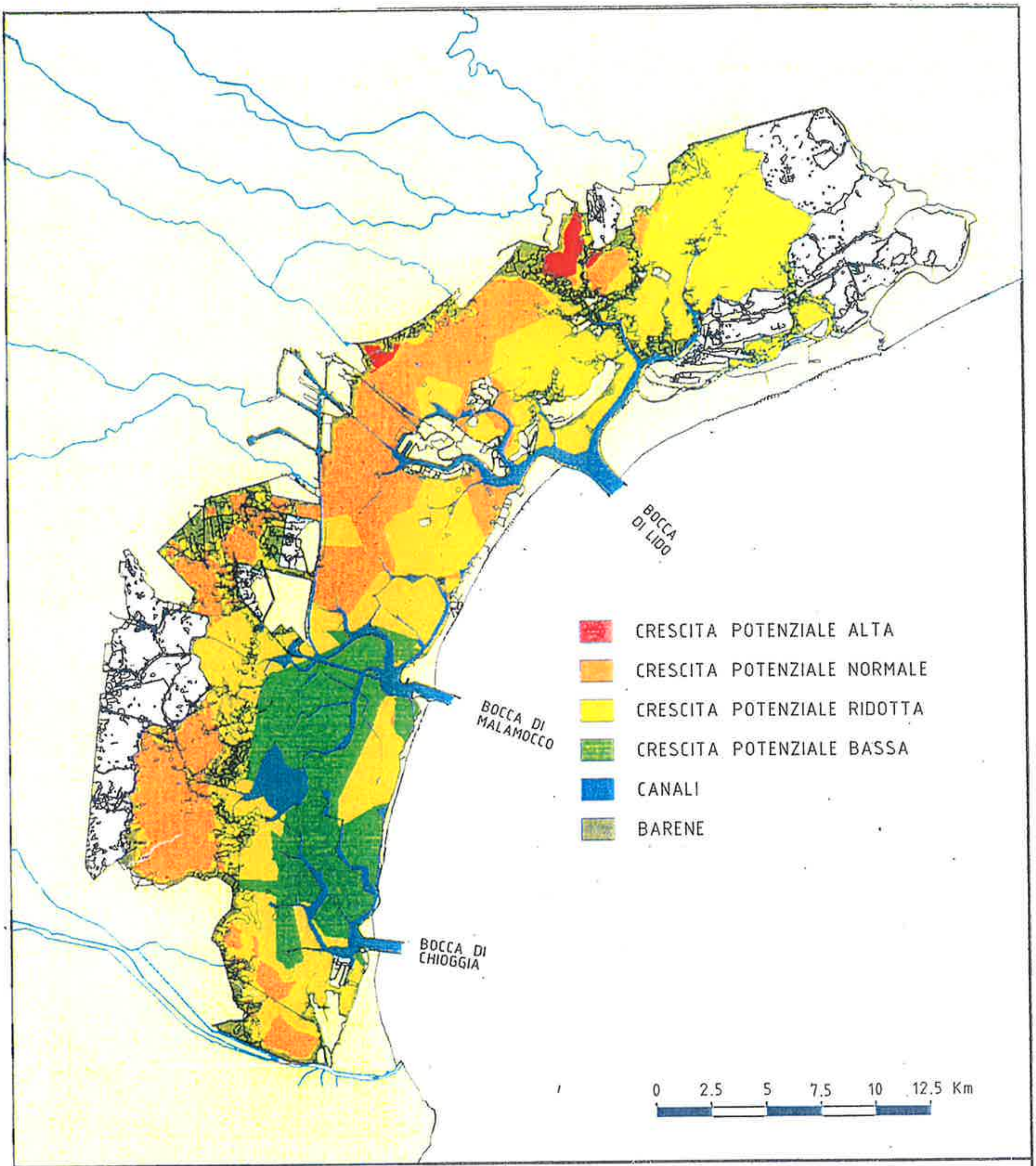


Fig. 3.2.5 - Zonazione della Laguna in funzione della crescita potenziale dell'*Ulva* (Consorzio Venezia Nuova, 1993).

Zones of potential growth of Ulva in the Lagoon.

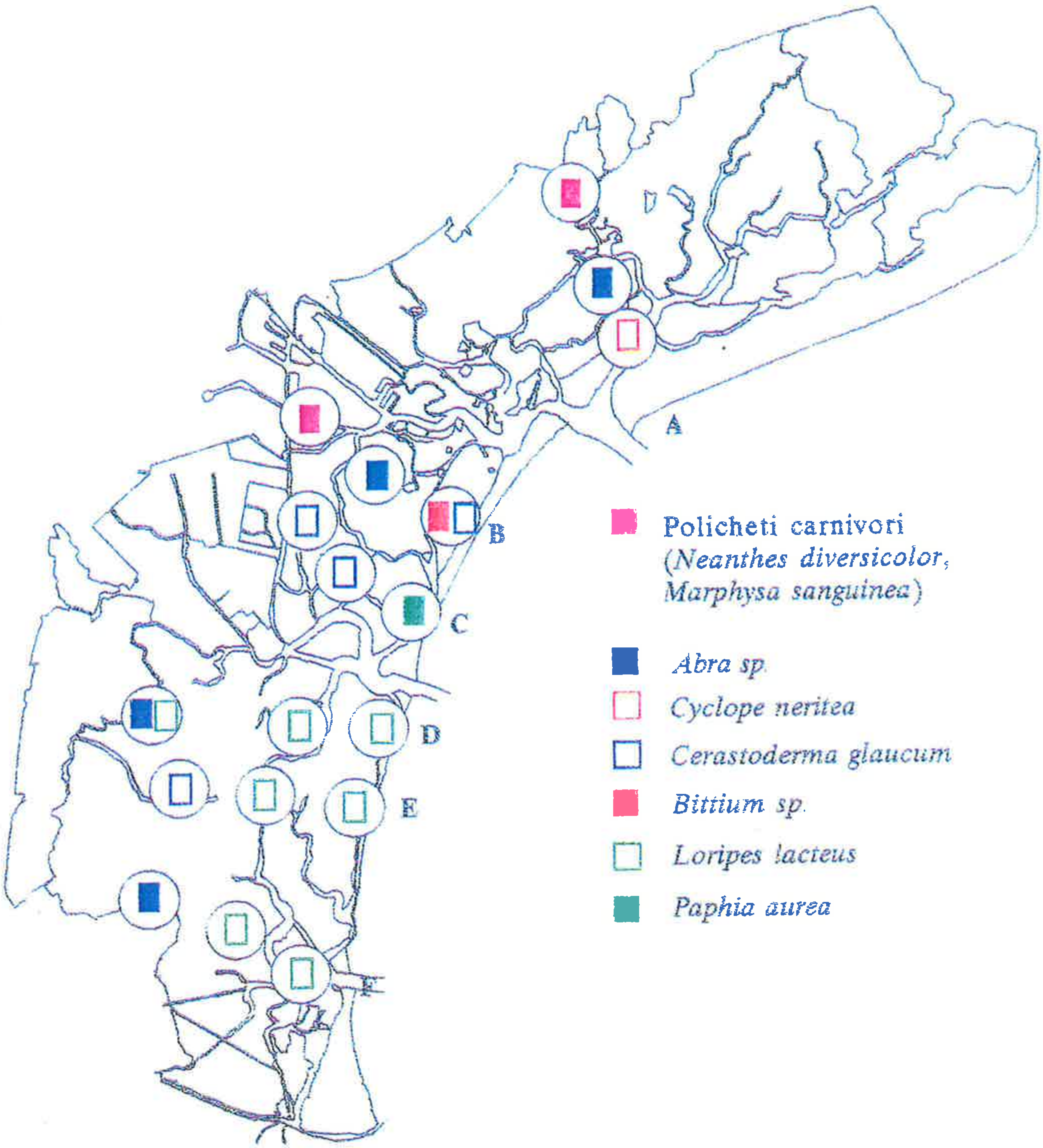


Fig. 3.2.6 - Specie bentoniche dominanti presenti nelle aree di indagine (Consorzio Venezia Nuova, 1992).

Dominant benthic species present in the study areas.

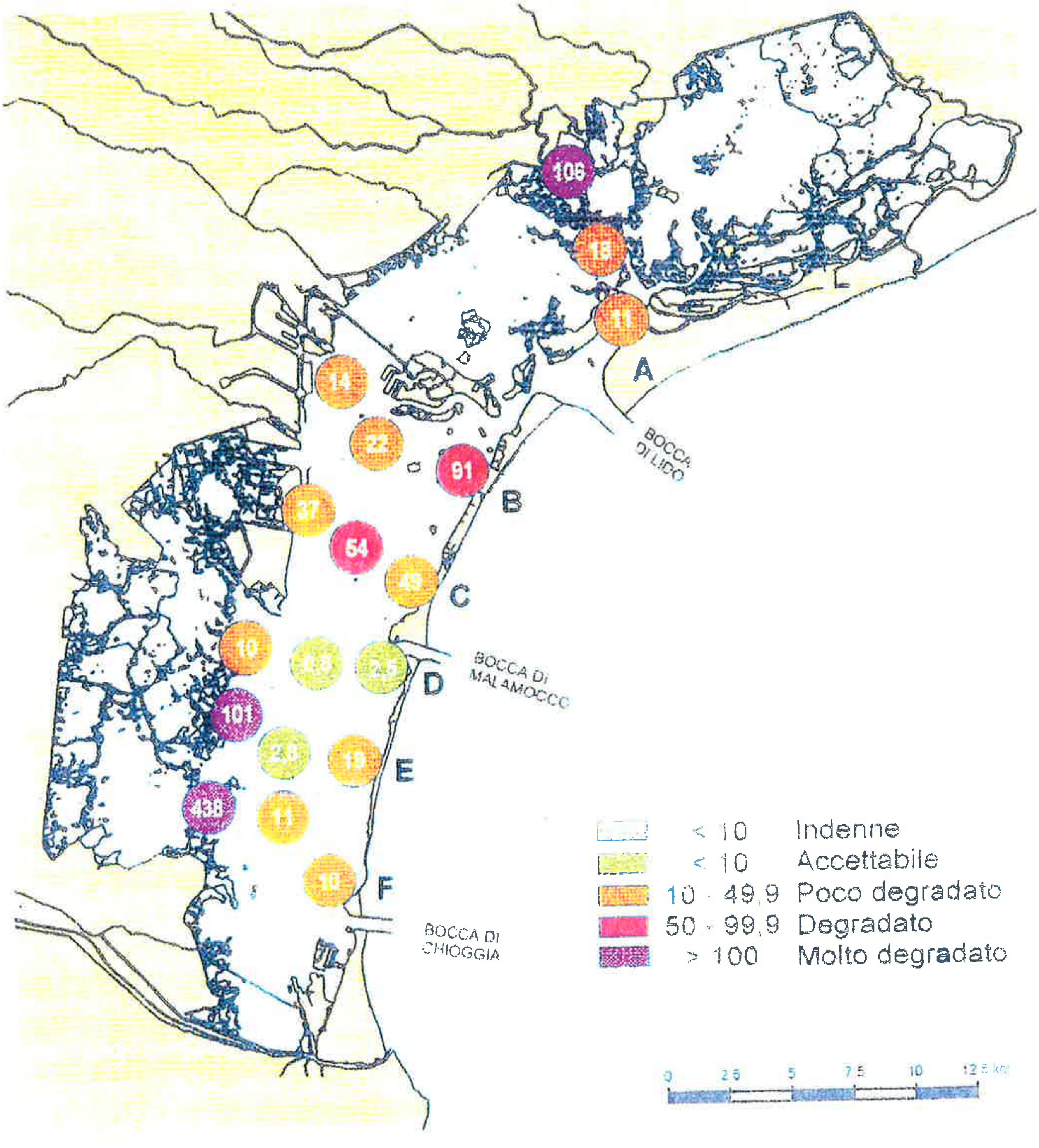


Fig. 3.2.7 - Distribuzione di *Cerastoderma glaucum*. Possibili raggruppamenti in classi di qualità (individui/m^2) (Consorzio Venezia Nuova, 1993).

Cerastoderma glaucum distribution. Possible classification according to quality (individuals/m^2).

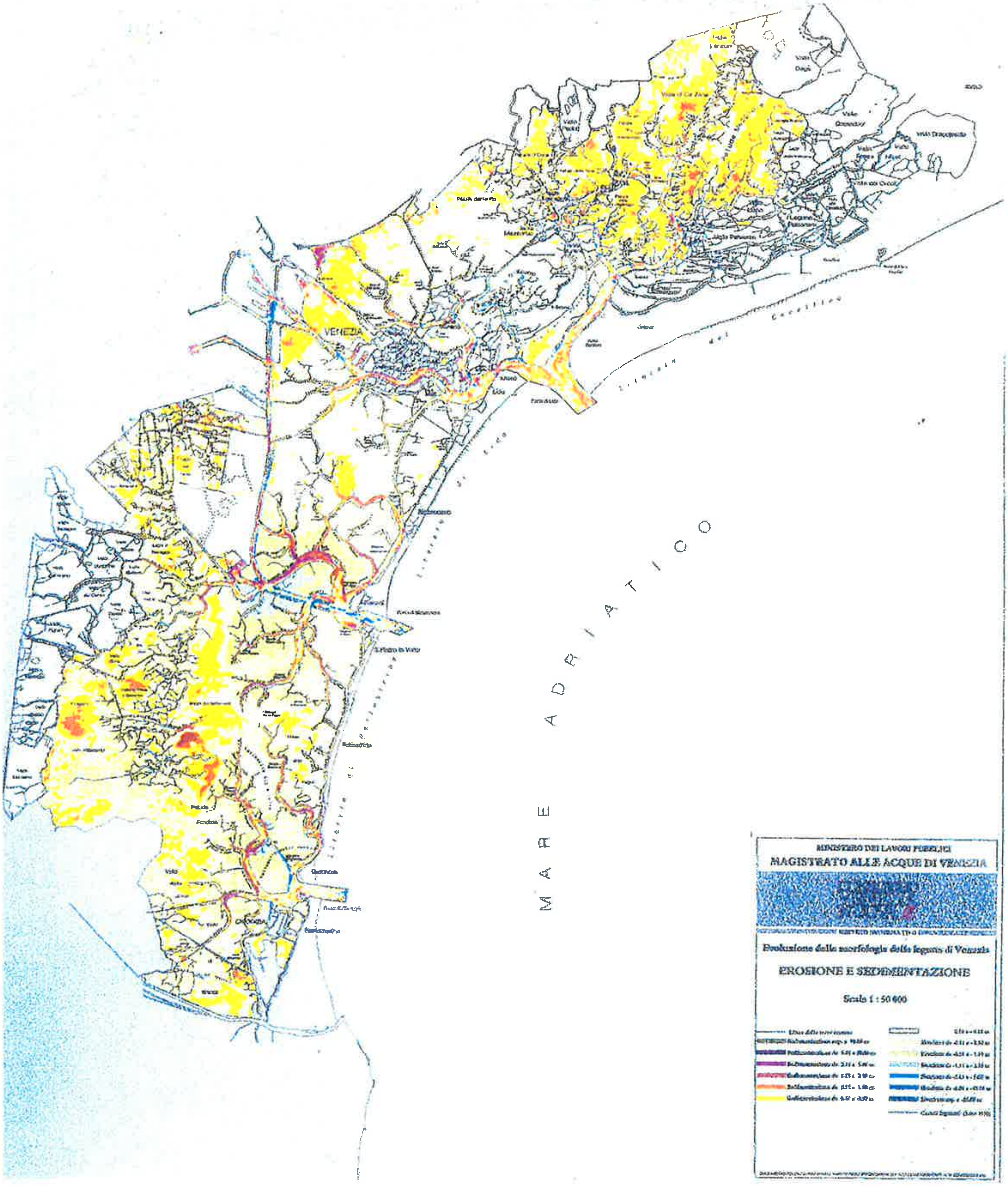


Fig. 3.2.8 - Erosione e sedimentazione nella Laguna di Venezia (Magistrato alle Acque, 1996).
Erosion and sedimentation in the Venice Lagoon.

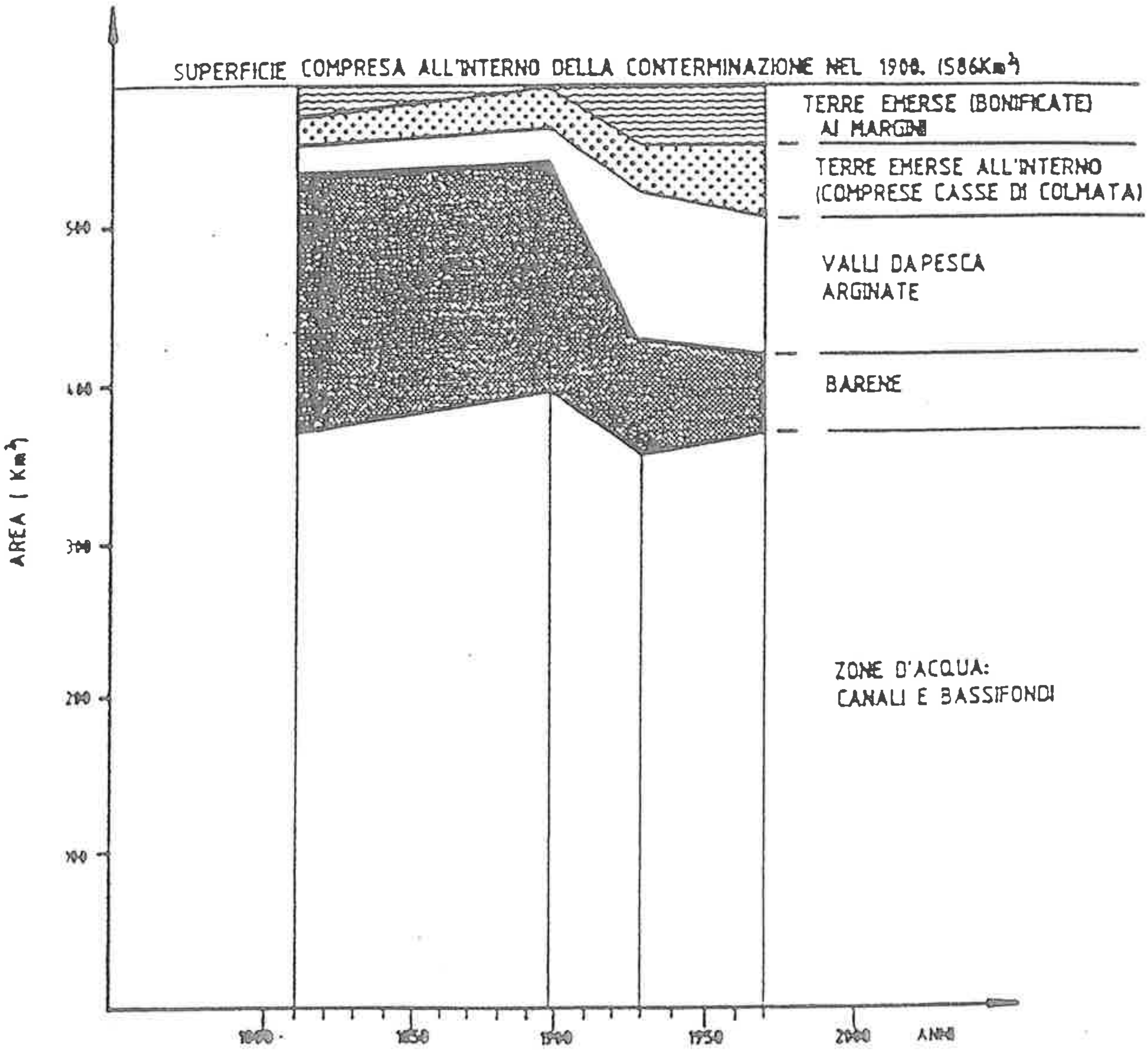


Fig. 3.2.9 - Evoluzione delle superfici lagunari (Consorzio Venezia Nuova, 1992).

Evolution of the distribution of the Lagoon surface.

3.2.2 Future evolution in the absence of the Project

The future evolution of the study area considered in this study without realisation of the mobile barrier Project is estimated in light of the subsidence and eustatism that could occur in the course of the next hundred years (the estimated working life of the mobile gate project). For the time being, reference will be made to the three scenarios identified in chapter 2.

A first scenario assumes virtually no eustatism, with an evolution that will essentially retain the mean sea level of today. A second scenario assumes that there will be an increase in mean sea level of about 20 cm by the end of the next century; and a third scenario predicts a rise in mean sea level of 50 cm over the same time span.

As far as the *Atmosphere* component is concerned, the improvement in air quality will probably stabilise as a result of the progressive reduction in emissions that has already been underway since 1980.

For the *Hydrodynamics and Solid Transport* subcomponent, the estimated mean frequency of certain peak tidal levels, as a function of increases in mean sea level is given in Table 3.2.2.

Tidal peaks (cm)	Mean annual frequency for current m.s.l.	Mean annual frequency for m.s.l. +10 cm	Mean annual frequency for m.s.l. +20 cm	Mean annual frequency for m.s.l. +30 cm
+ 80	39	94	204	356
+ 100	7	16	39	94
+120	1	3	7	16
+140	1 event every 6 years	1 event every 2 years	1	3
+195	1 event every 180 years	1 event every 74 years	1 event every 39 years	1 event every 21 years

Table 3.2.2 - *Annual frequency of specific peak tidal levels.*

The liquid volumes being exchanged between the sea and the Lagoon at the present mean sea level will undergo a slight increase (0.2% a year) because of the progressive erosion of the salt marshes. With this negligible increase in the volume of fluids exchanged, the loss of sediment from the Lagoon will remain virtually constant.

The situation will remain more or less unchanged for *Quality of the water and sediment*. However, there have been signs of a reduction in the proliferation of macro-algae in the last four to five years, probably due more to climatic and biological factors than to a reduction in the concentration of nutrients in solution. Should this situation persist, the reductions will affect the carbon, nitrogen and phosphorus bio-geochemical cycles, tending to restore the typical features of the Lagoon towards those characteristic of environments in good natural condition.

If the measures being taken by the Veneto Regional Authorities in the drainage basin, which are expected to be completed by the year 2003, are also taken into account, there should be a further significant reduction in the nutrient load to the Lagoon. The estimates for 2003 suggest that about 6,000 tons a year of nitrogen will be generated and 4,000 tons a year will be released into the Lagoon while about 800 tons a year of phosphorus will be generated and 500 tons a year of which will enter the Lagoon. In reality, the predicted reduction in the contaminant concentration, and particularly that of the eutrophic compounds, will probably be masked for a certain period by pollution emitted by the sediment on the Lagoon floor. The quality of the sediment is likely to improve, although more slowly than water quality, by being progressively buried, by dilution of contaminated sediment by the arrival of cleaner sediment or by erosion, and by a decline in the amount of organic debris sedimenting from the water column during abnormal proliferation of macro-algae. The marine area adjacent to the Lagoon, is also expected to demonstrate improvements in the quality of the water and sediment as a result of measures being taken to reduce the pollution coming from the hydrographic basins flowing into the northern Adriatic.

Within the context of the *Soil and subsurface* component, an accentuation of the artificial features of the territory is expected due to the interventions necessary to maintain the Lagoon environment. Relative to the morphological dynamics, a tendency towards the typical features of a marine environment, is foreseen, with a progressive reduction in the lagunal features. This is due, in particular, to the negative balance of sediment transport in the Lagoon, to the flattening of the Lagoon floor as a result of erosion of the mudflats and salt marshes and to the filling in, due to the deposition of sediment, of the deeper features (the natural channels).

As for the biological features of the area (V*egetation, flora and fauna*), it is conceivable that there will be a general tendency towards a reduction in the amount of dry land surface, leading to a progressive decline of certain plants and the loss of important habitat for several interesting ornithological species. The predictable decrease in the surface area occupied by salt marshes will lead to some changes in the terrestrial biocenoses that rely on this habitat for nourishment and nesting. The submerged surfaces, on the other hand, are likely to experience improvement in the environment, that could generally benefit all the aquatic biocenoses and hence the ecosystems, particularly thanks to the better quality of the water.

Finally, as far as the *Public health* and the *Landscape* components are concerned, there are no apparent tendencies for change with respect to the present situation which has previously been described.

In the event of an increase in mean sea level due to eustatism and subsidence, several components are not expect to be subject to appreciable variations, whereas others could be modified to a degree which will increase with increasing rise in mean sea level.

It is presumed that air quality (*Atmosphere)* would remain unaffected, in that it depends on the meteorological and climatic features of the area and on pollution levels, but not, per se, on changes in sea level.

On the other hand, there would be a substantial change in the Lagoon's *Hydrodynamics*, relative to:

- a greater volume of water contained in the Lagoon, giving rise to more modest increase in the liquid exchange between the sea and the Lagoon, and hence to a reduction in the mean daily recycling ratio;
- an increase in the mean wave height produced by the wind as a result of the increased water depth, with a consequently greater wave energy available for the erosion of the shallows, mudflats and salt marshes;

- an increase in the frequency of high water events beyond +100 cm (100 times a year with a mean sea level increase of +30 cm), with a consequent increase in the frequency of flooding episodes in Venice and the other islands.

Relative to *Solid Transport*, the Lagoon would continue to suffer a net loss of sediment and the shores would suffer a marked increase in the extent of erosion.

Regarding the *Quality of the water and sediment*, the increase in the lagoon water level due to the increase in mean sea level, would contribute to a reduced oxygenation of the water on the Lagoon floor, a greater dilution of the contaminants coming from the drainage basin and a greater vivification of the Lagoon. The increase in the liquid exchange between the sea and the Lagoon would increase the mean salinity and the Lagoon water temperature would approach that of the sea.

The *Soil and subsurface* component would be particularly affected as some areas will be submerged, with the loss of considerable percentages of surface area above the water. This would mean a reduction in the terrestrial (onshore) vegetation and in the habitat for the animal life. On the other hand, because of the greater vivification of the Lagoon water, the *aquatic plants and animals* and the *aquatic ecosystems* would be positively affected. An accentuated "marinization" of the Lagoon in terms of the vegetation, fauna and ecosystems is conceivable.

The rise in sea level would cause more flooding of the inhabited areas, further exposing the human population to contact with the polluted water, with potentially negative consequences on *Public health*.

As for the *Landscape*, the greater the rise in sea level, the more the Lagoon landscape would change. Venice's priceless historical and monumental heritage would be increasingly threatened and damaged, with negative repercussions on the Venetian Lagoon system as a whole.

3.2.3 Future evolution in the absence of the mobile gates project but in the presence of the wide area measures

As explained in section 2.3, the project for the mobile gates at the Lagoon inlets forms part of a series of measures distributed throughout the Lagoon for safeguarding Venice and its Lagoon, that fall under the responsibility of various administrative entities. Together with the mobile gates, these wide area measures, which represent a logical integration of the Project, are intended to preserve the Lagoon as a whole and improve its overall environmental condition.

The effects of their implementation on the evolutional tendencies of the environmental components described in the previous paragraphs can be deduced from the objectives that the measures propose to achieve. These effects can be considered as applicable to the evolution of the environment considering both the present mean sea level as well as the different scenarios for future levels on the basis of predicted subsidence and eustatism.

Atmosphere

As previously mentioned, the positive trend in air quality that is currently underway could be indirectly assisted by measures designed to improve the quality of the Lagoon environment.

Hydraulic environment

The principal wide area measures for which it is possible to predict a direct or indirect effect on the Lagoon's hydrodynamics are those designed to restore the morphology of the Lagoon, to reduce the contaminant loads of water conveyed into the Lagoon from the watershed, and to arrest and to reverse the trend of deterioration of the Lagoon environment. Other, more localised, wide area measures are those concerning the sanitary and structural restoration of the city of Venice, with obvious benefits in terms of the city's value and utility, and the plans to open the fish farms.

More precisely, the hydrodynamic and solid transport component of will be primarily affected by interventions aimed at-restoration of the Lagoon morphology, i.e. the reconstruction of the mudflats and salt marshes. These measures will result in a reduced wave motion (in the areas concerned) - consequently attenuating the progressive erosion of the Lagoon and the net loss of sediment towards to sea - and to a locally improved hydrodynamism.

The wide area measures will ensure an improvement in the quality of the water and sediment due to the reduction in the nutrient load entering the Lagoon (with a reduction in the production of macro-algae), to the remediation of the landfills and to the improvement of sediment quality in the inlet channels. The expected effects of the measure for reducing the nutrient load have already been considered in the impact analysis for the Quality of Water and Sediment subcomponent.

Soil and subsurface

This component will be affected by those measures taken to restore Lagoon morphology and those involving coastline defences aimed at protecting the morphology of the Lagoon, and also, more indirectly, by the water quality improvement measures. Though they cannot reverse the current erosive tendency, the measures to restore the morphology will counter these natural trends and tend to maintain the admittedly artificial maintenance of the typical features of the Lagoon environment. An improvement in the quality of the water, on the other hand, may enable the return of the phanerogam (eelgrass) meadows which would help to consolidate the Lagoon floor and naturally combat erosion.

Vegetation, flora and fauna and *Ecosystems*

For the dry land areas, implementing certain measures for restoring the morphology and protecting the coastline will coincide with an attenuation of the processes described in section 3.2.2, postponing the loss of the salt marshes, mudflats and beach surfaces that provide an important habitat for plants, ornithological species and biotic communities. As for the aquatic areas, an accentuation in the positive trend already predicted (even if no further action is taken could be expected), thanks to the effects of steps already taken to improve water quality and therefore also the aquatic environment.

Public health

The improvement in the healthiness of the Venetian buildings, as part of the intervention the sanitary and structural restoration of the inhabited centres, will lead to an improvement in the general state of health of the resident population (although this will be difficult to quantify). The elimination of the emissions from abandoned landfills and from polluted sediment as result of the plans to arrestand to reverse the environmental deterioration, will reduce the risks associated with consumption of molluscs and fish.

Landscape

The considerations previously presented in paragraph 3.2.2. for this component are further emphasised in this case because the threat due to rising sea level would be greater.

4. IMPACT ASSESSMENT

Any project can induce changes (or "potential interferences") in the territorial context in which it is set. Such interferences depend on the specific features of the project, on the nature and sensitivity of the territory involved. Once the area interested the direct and indirect potential interferences induced by the Project has been defined, the EIS first verifies that these interferences actually exist and identifies parameters or indicators for each component (Atmosphere, Hydraulic Environment, Soil and subsurface, Vegetation, flora and fauna, Ecosystems, Public health and Landscape) that can suitably represent the environmental quality levels of components and the changes induced by the in the Project. The selected indicators are used to calibrate scales created for estimating the impact level which describes the degree of the positive or negative effect of the interferences on the environmental component.

For each component, an estimate is made of the impact due to the effects of individual interferences (elemental impact) on the basis of the individual indicators used for its characterisation. An overall impact assessment (resultant impact) is made based on a rationalised averaging of the elemental impacts.

4.1 Criteria for defining the impact scales

4.1.1 The "top-down" approach

The specific activities and relative perturbing factors associated with the realisation of the mobile gate project were correlated with the environmental features to identify the potential interferences with the various environmental components. From all the potential interferences identified, those considered related to the most important potential impacts were selected for further deeper analyses of the corresponding impacts according to a "top-down" approach. Such an approach concentrates the analysis on the components most affected, directly or indirectly, by the intervention without neglecting all the other components subject to lower priority impacts.

Figures 4.1.1, 4.1.2, 4.1.3 and 4.1.4 present the schematic diagrams of the higher priority effects foreseen both during construction and its operation of the Project. The components and sub-components for which priority impacts can be expected are as follows:

- the Hydraulic environment, including its sub-components water quality, hydrodynamics and the solid transport;
- the Soil and subsurface, including its sub-components land use and soil cover and geomorphology
- Terrestrial Flora and Fauna
- Public health;
- Landscape.

The principal effects of the Project on these components can also induce indirect lower priority effects on the vegetation, flora and fauna and ecosystems components.

4.1.2 The indicators and impact scales

The evaluation of the impacts must include the identification, for each component, of parameters capable of describing and qualifying the effects of the Project on the component concerned. These parameters, called indicators, are selected because they are considered as suitable for representing, alone and in combination, the environmental quality levels of the individual components and the corresponding changes that could be induced by the project. The environmental components are then characterised in terms of these indicators permitting definition of a reference point for the current environmental conditions.

In order to proceed with the impact analysis, that would require the comparison of aspects that, by their very nature, are impossible to quantify with others that are readily quantifiable, a process based on a repeatable logical criteria was implemented to transform quantitative values to a qualitative scale. This process involved three principal methodological steps:

- an in-depth understanding of the individual components in the specific context;

- a comparative analysis of the components by experts for the various sectors who proceeded together to establish the criteria to use for qualitatively characterising the components concerned;
- the characterisation of the components and definition of the impact levels for the individual scales on the basis of judgement provided by the respective component experts appointed to implement the study.

To enhance conceptual coherence and compatibility between the individual impact scales for all components, all the scales involve a total of nine impact levels:

- three positive levels (*high, medium* and *low impact*);
- one *negligible/none* impact level;
- five negative levels (*low, medium-low, medium, medium-high,* and *high impact*).

These scales were created considering various "magnitudes" (e.g. variation of a given quantity, extension, duration and frequency with respect to the present situation) and of "importance" (e.g., value of the resource, value of the recovery of a resource, degree of reversibility, resilience, i.e. the rate of recovery of the resource, vulnerability, stability, rarity, type or level of usage), taking into account the significance of values for each components. The general criteria employed in definition of the impact scales for each component are highlighted below.

Atmosphere

The impact scales were developed considering that the estimated values can be compared with existing standards for acceptable levels and that any increment in the concentration of pollutants must be considered as having some impact, unless the increment calculated is negligible with respect to the baseline values. Reference was made to the duration of the emissions of pollutants into the atmosphere and their fallout concentrations on the ground.

Hydraulic environment

- Hydrodynamics and solid transport

Hydrodynamic indicators included the mean annual volume of water exchanged between the sea and the Lagoon, the mean annual volume of sediment transported between the sea and the Lagoon, and the maximum flow rate of the water passing through the Lagoon inlets. Impact scale criteria consisted in evaluation of the degree of change in these indicators with respect to the reference situation and the level of overall change experienced by the hydraulic environment in general, in combination with the extension of the area involved, and the frequency and reversibility of the change concerned.

- Quality of water and sediment

Several indicators were considered:

- for the water quality: the frequency of oxygen deficient states (dissolved oxygen less than 2 mg/l), turbidity, total dissolved inorganic nitrogen (TDIN) and zinc;
- for the quality of the sediment: the content of organic substances, zinc, PCB, and DDT and its derivatives.

For definition of impact levels, the changes induced in these parameters with respect to the reference situation were evaluated, taking into account the extent of the area affected, the value and type of usage of the said area, the level of contamination induced, the duration, frequency and seasonal distribution of the episodes of contamination and the duration and reversibility of the effects of the impact.

Soil and subsurface

- Land use and soil cover

The impact scales were based on any loss or gain of ground resources, the reversibility of such loss or gain, the extent of such area affected and the value of the class of usage and type of cover involved.

- Geomorphology

The criteria for establishing the impact scale for this sub-component took into account the geomorphologic element indicator, evaluating its modification or losses, the area involved, its value - both intrinsic and as a substrate for biological communities, as well as the indicators of sediment distribution in the Lagoon (as a result new direction of sediment transport and subsequent sediment deposition) and the Lagoon's sediment balance, expressed in terms of the volumes exchanged between the Lagoon and the sea.

Vegetation, flora and fauna

- Terrestrial Vegetation and flora

These impact scale criteria included the extent of modifications suffered by in the plant community, expressed in terms of its reversibility/irreversibility, intensity and extent, and the value of the plant communities involved, in relation to whether they were natural, their rarity, their botanical and phytogeographical interest, their floral consistency (i.e. the congruence of the floral composition of a plant community in a given environment), and their resilience, in the sense of their rate of recovery after they have been disturbed.

- Terrestrial fauna

Taking ornithological (bird) species as an indicator capable of revealing environmental changes affecting all terrestrial animal species, impact scale criteria included the degree of modification of bird populations, in terms of an irreversible change, or a reversible/irreversible reduction or increment in the local populations affected by the interference , and their zoological value, a measure of the importance of the species on a national and international scale in relation to aspects such as the biogeographical value, rarity and number.

- Aquatic vegetation and flora

Two indicators were considered (*Ulva* and marine phanerogams) each of which are sensitive to changes in the quality of the water and sediment, to which they react with changes in their productivity, biomass and coverage. For the *Ulva*, in particular, the presence of which is a negative indicator of environmental quality, reference was made to the amount of increase in the biomass coverage. For the marine phanerogams (eelgrass), on the other hand, whose presence is an indication of good environmental conditions, reference was made to any reversible/irreversible decline in their coverage.

- Aquatic fauna

To the Lagoon's benthic communities (the variety of animal communities living on the Lagoon floor), comprising organisms linked more or less closely to the floor itself were considered the most relevant indicator. These were analysed in terms of their composition and transformation over time since these organisms are sensitive to complex situations and their behaviour reflects the entire aquatic community and the ecosystem as a whole. Impact evaluation criteria included the degree of change in said communities (expressed in terms of irreversible change or irreversible/reversible impairment in the short and long term) and their diversity, which qualifies their ecological value.

Ecosystems

- Terrestrial Ecosystems

Reference was made to the biocenoses (plant and animal communities) intended as indicators of changes reflecting on the ecosystem as a whole. In particular, criteria for evaluating impact level included consideration of the degree of change in the biotic communities expressed in terms of reversibility/irreversibility, intensity and extent, their value in relation to the parameters of naturalness, rarity, and level of deterioration, and the rate of their recovery in response to any disturbance (i.e. resilience).

- Aquatic ecosystems

To define the level of quality or deterioration that these ecosystems achieve as a result of being disturbed, reference was made to the biotic communities indicator. Again the degree of change in the biotic communities (expressed in terms of irreversible change or irreversible/reversible impairment in the short or long term) and their ecological value, in terms of their diversity and complexity were employed as criteria in analysis of the level of impact.

Public health

Any estimate of the impact on public health can only be in the form of a forecast. Thus, indicators included those disturbing factors (i.e. an increment in the environmental concentration of toxic compounds and higher noise levels) for which a quantitative cause-effect relationship could be established. The evaluation of the chemical and toxicological risk involved the environmental indicators relating to procedures approved by international and national bodies (the World Health Organisation, the European Union, the Italian Istituto Superiore della Sanità), i.e.

- changes in the concentration of pollutants of toxicological interest in the various environmental compartments (water, air, aquatic biota);
- changes in conditions that can be linked by means of dose/effect correlations with the state of health of the population;
- changes in the living habits of the population sufficient to suggest a greater or lesser exposure to pollutants currently existing in the environment, bearing in mind the type of effects and their intensity.

Landscape

Modifications both on a small scale (in detail) and on a large scale (in general) were considered resulting in the definition of two parameters indicative of landscape change:

- changes in the local landscape system;
- changes in the landscape system of the Lagoon as a whole.

These indicators were attributed qualitative values of sensitivity and disturbance, where a *disturbing* modification was intended as a change in the status quo characterised by generally negative connotations for the landscape, whereas an *improvement* in the landscape conditions was intended as identifying those unequivocally positive consequences, that also contributed towards conservation of the present conditions and protecting the values currently expressed by the Lagoon landscape.

1. **EXCAVATION**
2. **GENERATION & DISPOSAL OF SOLID AND LIQUID WASTE**
3. **SWIMMING**
4. **FOOD CHAIN**
5. **NOISE**

6. **DUST and/OR COMBUSTIBLE GAS EMISSION**
7. **COLLISION WITH CONSTRUCTION and/or TRANSPORT VEHICLES**
8. **ELIMINATION OF HABITAT**
9. **NOCTURNAL ILLUMINATION**
10. **CONSUMPTION OF RESOURCES**

11. **PHYSICAL PRESENCE OF STRUCTURES and/or EQUIPMENT**
12. **TURBIDITY and/or CONTAMINATION**
13. **DIRECT ELIMINATION**
14. **MOVEMENT OF HEAVY VEHICLES**
15. **REMOVAL OF UNDERWATER SEDIMENTS AND MATERIAL**

16. **PLACEMENT OF FILL MATERIAL**
17. **MODIFICATION OF LIQUID & SOLIDS EXCHANGE BETWEEN SEA AND LAGOON**
18. **RELEASE OF SUBSTANCES IN THE HYDRAULIC ENVIRONMENT (e.g. CHLORINE DURING OPERATION OF SEDIMENT REMOVAL)**
19. **ACCUMULATION OF CONTAMINANTS / DYSTROPHIC CRISES DURING CLOSURE**
20. **GAS EMISSIONS TO ATMOSPHERE (AIR EXPELLED FROM MOBILE BARRIER ELEMENTS)**

21 **RELEASE OF SUBSTANCES IN HYDRAULIC ENVIRONMENT (e.g. PAINT AND OTHER SUBSTANCES DERIVING FROM MAINTENANCE OPERATIONS)**
22. **MODIFICATION OF HABITAT (BACAN AREA)**
23. **MOVEMENT OF SEDIMENT**
24. **EVENTUAL MODIFICATION OF SEDIMENTS**
25. **REDUCTION/OXYGENATION OF WATER (H_2S, ODORS, etc.)**

26. **CHANGE IN USUAL HYDRODYNAMICS (INFLUENCING TRANSPORT AND FLOW REGIMES)**
27. **INCREASE IN LOCAL FLOW DUE TO MALFUNCTIONING OF ONE OR MORE BARRIER ELEMENTS DURING CLOSURE**
28. **LOWER VOLUME OF LIQUID EXCHANGE WITH SEA LEADING TO INCREASED RESIDENCE TIME & DECREASED DILUTION OF NUTRIENTS DISCHARGED FROM DRAINAGE BASIN**

Fig. 4.1.1 - Legenda relativa alle possibile interferenze indicate nelle scheme "top-down".
Legend of possible interferences indicated in the "top-down" diagrams.

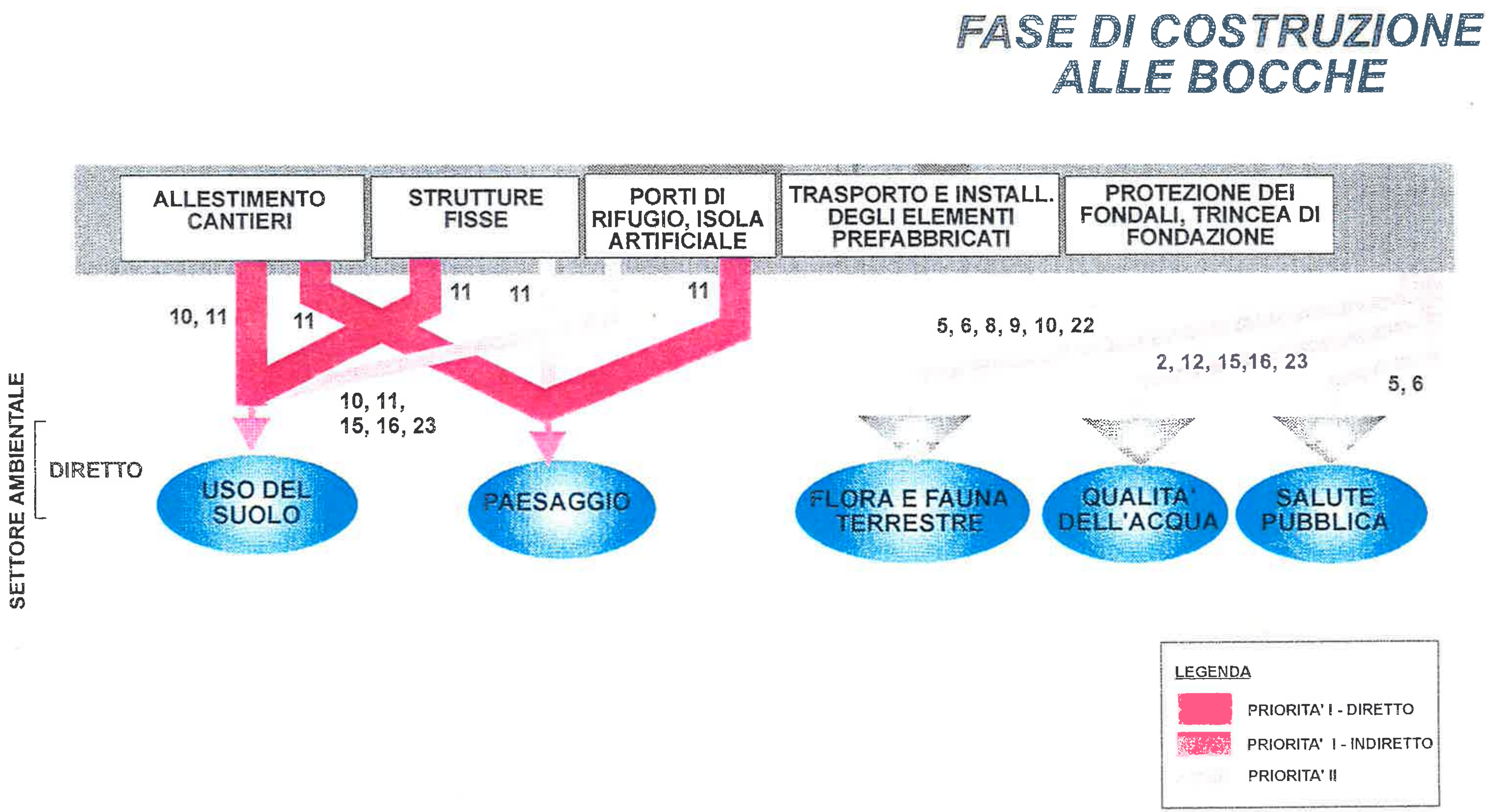


Fig. 4.1.2 - Schema delle interferenze potenziali prioritarie della fase di costruzione alle bocche del progetto seguendo l'approccio "top-down".

"Top-down" schematic diagram of the priority potential interferences for the construction phase of the project at the ports.

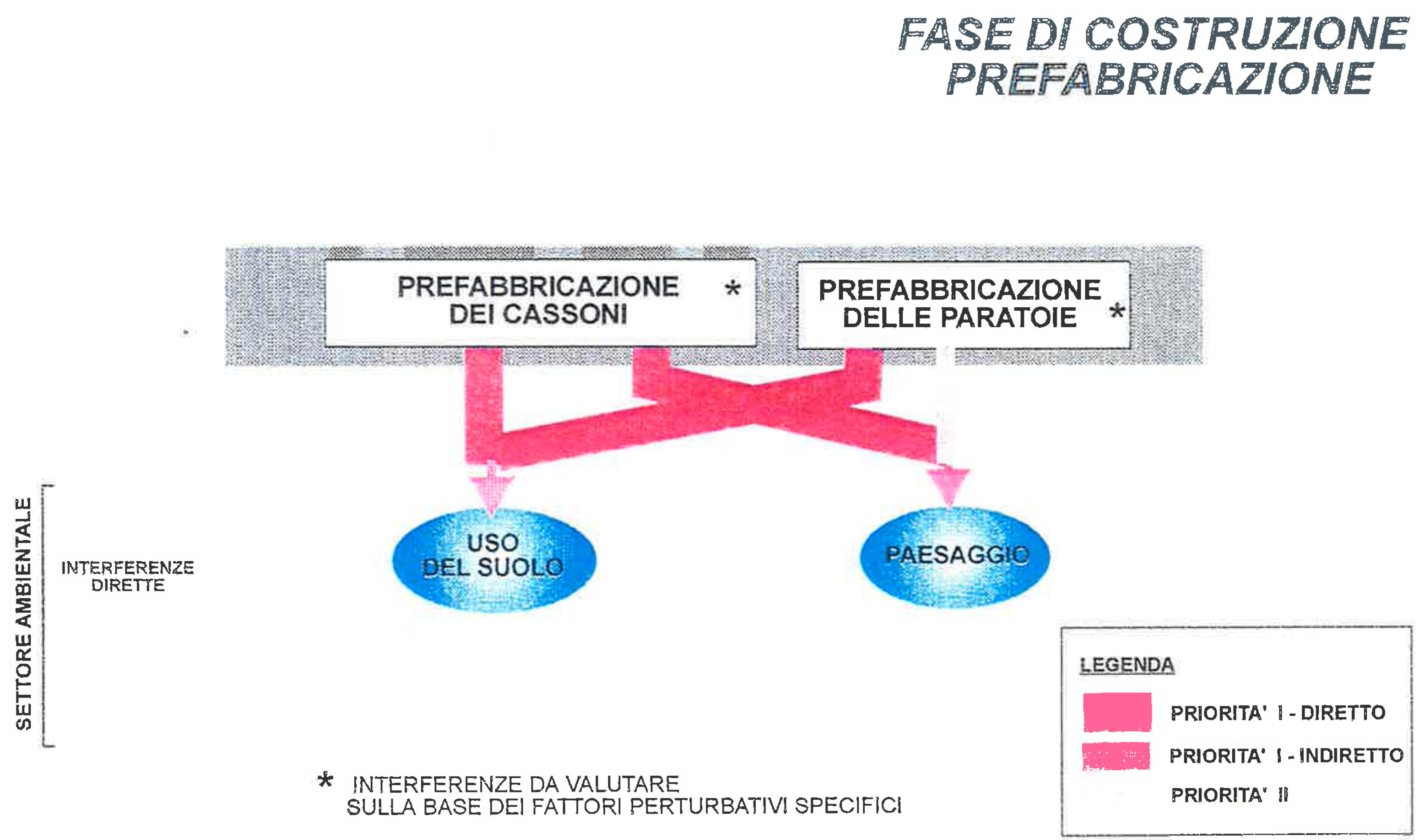


Fig. 4.1.3 - Schema delle interferenze potenziali prioritarie della fase di costruzione - prefabbricazione del progetto seguendo l'approccio "top-down".

"Top-down" schematic diagram of the priority potential interferences for the prefabrication construction phase of the project.

FASE DI ESERCIZIO

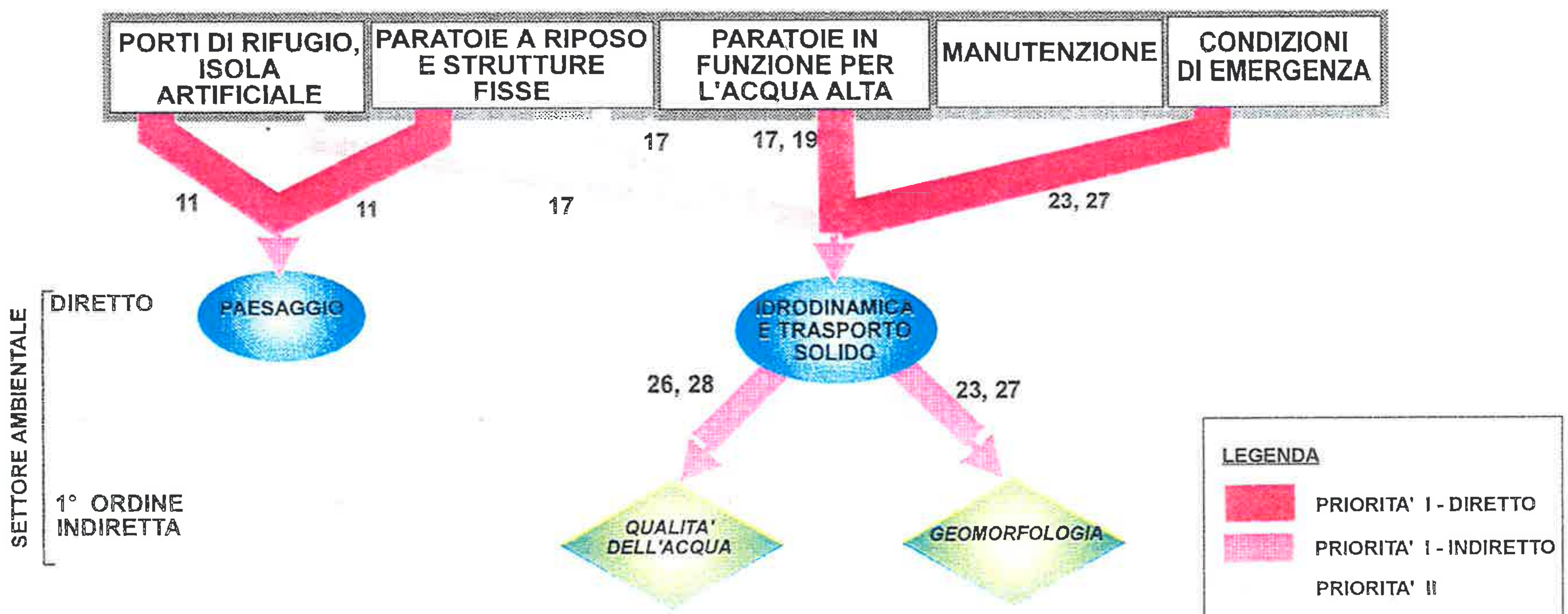


Fig. 4.1.4 - Schema delle interferenze potenziali prioritarie della fase di esercizio del progetto seguendo l'approccio "top-down".

"Top-down" diagram of the priority potential interferences for the operation phase of the project.

4.2 Reference scenarios

Impacts have been estimated for the following three phases concerning the life of the project:

- construction phase,
- in operation phase (both with the gates at-rest and with the gates raised) at the present mean sea level;
- operation phase throughout the predicted working life of the Project (100 years), considering different scenarios for the magnitude of rise in mean sea level due to eustatism and subsidence (Table 4.2.1). The scenarios considered (A, B, C) are identified and described in section 2.5.4.

Scenario A

This scenario assumes that eustatism is quiescent and the only phenomenon contributing to the rise in sea level is natural subsidence, which would lead to an increase in mean seal level of +4 cm by the end of the predicted life of the works.

Considering the fact that:

- a variation in the liquid exchange between the sea and the Lagoon is the aspect that most affects all the other environmental components; and
- the number of closures predicted for Scenario A and their total duration are not sufficient to appreciably modify the reduction in the sea-Lagoon exchange volume (5%) already due just to the presence and operation of the gates at today's sea level;

it was assumed that the impacts induced by the Project in the event of Scenario A would not differ significantly from the situation already described for current sea level. It was therefore not considered necessary to proceed with an impact analysis for this Scenario, relying, instead, on those evaluated for the current sea level situation. The acceptability of this assumption is subsequently verified by comparing the impacts assessed for the present situation with those for the case of a mean sea level 20 cm higher (Scenario B).

Scenario B

This scenario is based on the historical eustatic trend and natural subsidence for the Venetian area over the last 100 years. The combination of these two phenomena result a rise in mean sea level of +20 cm during the working life of the which was used as the basis of the impact assessment.

Scenario C

This scenario considers a rapid rise in sea level, as forecast by the United Nations' IPCC, to a mean sea level about 50 cm greater than the current mean by the year 2100. As already mentioned in section 2.5.4, such an increase in sea level would be catastrophic in many places and in Venice, in particular, because flooding would occur very frequently. It would therefore become necessary, during the working life of the project, to integrate the mobile gate system with other interventions in order to limit the overall number of closures and thus the effects thereof.

Given that the frequency of closures increases significantly for a rise in mean sea level of between 20 cm and 30 cm, and because it is difficult to predict at this moment the conditions of the environment and territory at that point in the future, the impact assessment made for Scenario B is invoked for the first part of the working life of the Project (for a mean sea level rise of up to 20 cm) under Scenario C. Operative decisions to be made in reference to the physical, environmental and political conditions at the future time are reserved for future political Authorities.

SITUATION		TYPE OF CLOSURE	NO. OF CLOSURES PER YEAR	INDIVIDUAL CLOSURE DURATION	TOTAL No. CLOSURES PER YEAR	TOTAL ANNUAL DURATION
Current mean sea level	Average	PROTECTION FOR SEA LEVEL ≥ +100 cm (P.d.S.)	7	4.5 hrs		32 hrs
		WARNING	5	2 hr		10 hrs
		TOTAL			12	42 hrs
	Maximum	PROTECTION FOR SEA LEVEL ≥ +100 cm (P.d.S.)	23	4.5 hrs		104 hrs
		WARNING	15	2 hr		30 hrs
		TOTAL			38	134 hrs
Scenario A (current m.s.l. + 4 cm)	Average	PROTECTION FOR SEA LEVEL ≥ +100 cm (P.d.S.)	11	4.5 hrs		50 hrs
		WARNING	8	2 hr		16 hrs
		TOTAL			19	66 hrs
Scenario B (current m.s.l. + 20 cm)	Average	PROTECTION FOR SEA LEVEL ≥ +100 cm (P.d.S.)	43	4.5 hrs		194 hrs
		WARNING	27	2 hr		54 hrs
		TOTAL			70	248 hrs
	Maximum	PROTECTION FOR SEA LEVEL ≥ +100 cm (P.d.S.)	80	4.5 hrs		360 hrs
		WARNING	40	2 hrs		80 hrs
		TOTAL			120	440 hrs
Scenario C (current m.s.l. +50 cm)		the project in its present configuration will be integrated with complementary interventions				

Note: Data obtained with reference to paragraph C3.5.4

Tab. 4.2.1 – Parametri generali per l'esercizio dell'opera.

General parameters for the operation of the mobile barrier system.

4.3 Impact assessment and mitigation measures

Impact assessment was performed for the phases and scenarios described in section 3.2, including: (a) the construction and operation of the mobile barrier system at current sea level, and (b) the operation of the mobile gates for the sea level conditions described in Scenario B. The impacts assessed for each of the environmental components are described according the following scheme:

- elemental impacts as a function of the individual perturbing factors related to the project and the effects they induce on the indicators;
- eventual measures to mitigate these elemental impacts;
- residual elemental impacts after the adoption of mitigation measures.

Atmosphere

During the construction phase, a *medium-high negative impact* was assessed for the dust emissions from the construction sites. This impact can be mitigated by restricting dust emissions to 10% by means of the following measures, some of which are merely consistent with proper job site management practice:

- covering the piles of dusty materials in stock with sheets of suitable synthetic material;
- systematic wetting down of the unpaved job site areas, especially during the summer season;
- resurrecting barriers to restrict the amount of wind-induced dust resuspension;
- paving the of unpaved job site areas with asphalt or other suitable material.

As a result of these mitigation measures, the effects of the dust can be considered as having a *low negative impact* (Table 4.3.1).

During the operation phase at current mean sea level (Table 4.2.1), the mobile barrier system does not facilitate the onset of degradation processes in the algal biomass which would lead to production of hydrogen sulfide, to a sufficient degree to affect air quality.

Moreover, the odour considered in H_2S equivalents, of the air flowing out of the gates as the barrier returns to its resting position is only just perceptible. The impact on air quality of these two perturbing factors can therefore be considered as *negligible/none* (Table 4.3.2).

During the operation phase considering Scenario B, the project again has no negative effects on air quality associated with any generation of H_2S. In fact, in this case, the concentration of gases, in H_2S equivalents, in the air escaping from the gates will be lower than the situation at present mean sea level because of the more frequent closures. It is considered that the impact on air quality evaluated for current sea level conditions will not be modified in any way, and thus the assessment remains *negligible/none* (Table 4.3.2).

Hydraulic environment

- Hydrodynamics and solid transport

During the construction phase, the hydrodynamics and solid transport subcomponents, any changes in which would affect the other environmental components, are characterised by the assessment of a *negligible/none* impact level. In fact, the reduction in the hydraulic section of the inlet will induce a reduction in the liquid exchange of less than 1%, with a consequent minimal variation in sediment transport (Table 4.3.3).

During the operation phase at current sea level, the presence of the barrier system with the mobile gates at-rest would lead to a reduction of about 12% in the hydraulic section of the inlet and a consequent increase in hydraulic resistance. These effects cause a reduction of about 2% in the volumes exchanged through the inlets. The presence of the artificial island at the Lido inlet would alter the rate of flow, but not to any significant degree and only in a very limited area consequently. Therefore, the impact due to the presence of the mobile gate system at-rest has been assessed as *negligible/none* (Table 4.3.4a).

When the gates are raised at current mean sea levels (Table 4.3.4b) to protect the Lagoon from high water levels in excess of +100 cm, the total annual volume of liquid exchanged between the sea and the Lagoon would be reduced by 5% at the Lagoon inlets. The impact of this reduction has been estimated as *negligible/none*.

On the other hand, the operation of the gates gives rise to three important effects with a positive impact:

- the elimination of any high water levels in excess of +100 cm with reference to the Punta della Salute datum, with consequent prevention of structural damage due to flooding of the historical town centres, for which a *high positive* impact is assessed;
- the limiting of the significant wave height in the Lagoon as a result of the Lagoon water level being maintained at or less them +100 cm, with a consequent positive effect on the Lagoon morphologic and civil structures, is assessed as a *low positive* impact;
- a reduction in the net loss of sediment from the Lagoon, which delays the erosion of the Lagoon's geomorphologic elements; assessed as a *medium positive* impact.

The case of a barrier system malfunction occurring has also been considered, wherein one or more gates fail to rise simultaneously with the others thus creating a concentrated, high-velocity flow. Given that the probability of the occurrence of such a situation is very low and that, in any case, the damage would be reversible, the impact has been assessed as *negligible/none.*

A sudden lowering of the gates. Was also considered, notwithstanding that this phenomenon is considered virtually impossible given the design of the gate system. In any case, such an event would cause a relatively slow increase in water level in the city of Venice. This, together with its near-zero probability of occurrence, leads to an impact assessment of *negligible/none* (Table 4.3.4c).

During the operation phase under in Scenario B conditions, with the mobile gates at-rest, the predicted rise in mean sea level would result in an increase of about 3% in the volume of water exchanged between the sea and the Lagoon; with a consequent assessment of a *negligible/none.*

With the barrier raised, the increased reduction in the volume of water entering the Lagoon (8% to 10%) is still not sufficiently significant to affect the Lagoon hydrodynamics. As a result, this impact has also been considered as *negligible/none* (Table 4.3.5a).

The positive effects of closing the gates, already described for the situation at current mean sea level, would be enhanced, although the same level of impact is assessed as those for current sea level condition.

For eventual emergency situations, the impact (*negligible/none*) would also remain similar to that for the current mean sea level since probabilities of occurrence remain low and the effects are approximately the same (Table 4.3.5b).

- Quality of water and sediment

During the construction phase, the most important effect is associated with the generation of turbidity during dredging of the sea bed. This would affect only a limited area near the Lagoon inlets and does not appreciably influence the transparencies of the water or the conditions for swimming. This, the impact related to the turbidity of the water has been assessed as *low negative*. The impact of all the other effects is considered *negligible/none*, except for a *low positive* impact on the quality of the sediment (Table 4.3.6).

During the operation phase at current sea level (Table 4.3.7), stagnation of the water in very localised areas could occur (between the island of Sant'Erasmo and the artificial island), but any alterations induced by these conditions would be so marginal that the resulting impact is assessed as *negligible/none*.

In general, the cumulative annual effect of the barrier closures at the inlets, distributed over the course of a year, does not determine appreciable variations in water quality since the number of hours of closure is limited and the closures occur predominantly in the winter. This the impact on water quality is considered to be *negligible/none*.

To help understand the potential effects of single closures or of repeated closures occurring at brief intervals on the onset of anoxic/hypoxic conditions, the natural conditions that lead to a temporary reduction in the hydrodynamics (neap tides) were considered. Such oxygen deficient conditions occur in localised areas, however, and only in the presence of other factors (e.g., high temperatures, night time, with organic substances in decomposition in the water column) that are independent of slow water movement such as that related to the closures.

Since the additional hours of stagnation due to the closures represents a marginal increment with respect to those already occurring naturally, and because the closures will be concentrated in the autumn-winter period, during which anoxic crises are unlikely, the resulting impact is estimated as *negligible/none.*

The mobile gates could be used to improve water quality by means of differentiated closure of the barriers. The artificial management of the water circulation in the Lagoon could prove capable of reducing the concentration of nutrients, particularly in the central region of the Lagoon, and of accelerating the recovery from conditions of severe oxygen deficiency. This situation is estimated to have a *medium positive* impact.

The release of zinc and other heavy metals by the cathode protection systems inside and outside the individual gate elements may temporarily increase the concentrations of these metals in the water. Since acceptable levels established by standards will not be exceeded, the impact is assessed as *low negative.*

Finally, the most important difference between the operation phase for Scenario B (Table 4.3.8), with respect to the current situation stems from the longer total closure duration which causes a reduction in the dilution of the water coming from the Drainage Basin possibly leading to an increase in the nutrient concentrations. However, considering that the closures take place mainly during the autumn-winter period and that, by the time Scenario B is expected to come into effect, the pollution coming from the watershed will have been reduced by the implementation of the measures described in section 3.2.3, this situation will have a *low negative* impact. Moreover, bearing in mind that phenomena of oxygen deficiency would be attenuated by the reduction in the biomass due to measures taken on the nutrient load from the watershed, the impact related to any increase in frequency of oxygen deficient states due to single gate closing operations has been assessed as *medium-to-low negative.*

Soil and subsurface

- Land use usage and soil cover

There are expected to be certain changes during the construction phase due to the creation of the artificial island at the Lido inlet and the beach at Chioggia, which are associated with a *medium-to-low negative* impact levels. On the other hand, the consumption of the ground resources and the loss of expanses of water for the structures above and below the waterline and for the refuge ports for the smaller vessels is assessed as having a *low negative* impact.

Since most of the changes in the Lagoon are of a temporary nature and only affect the areas occupied by the construction sites and the areas for storing the caissons and mooring naval vessels, the impact is *negligible/none* impact (Table 4.3.9). In fact, all the areas that are occupied temporarily will be restored to their original conditions or even improved upon completion of the work.
During the operation phase, for both the present sea level and the case of Scenario B, there are no interferences with this component since all modifications in land use soil and cover will have had their effect during the construction phase. Additional perturbing factors mainly affect the geomorphology subcomponent (Tables 4.3.10 and 4.3.11).

- Geomorphology

Conversely, during the construction phase there are no interferences on geomorphology as any repercussions on the environment induced by temporary and permanent changes associated with the Project affect exclusively land use and soil cover (Table 4.3.9).

However, the operation phase at present sea level is expected to provoke a reduction of about 100,000 m^3/year in the net loss of sediment from the Lagoon to the sea. Considering the current trend of increasing net loss in the evolution of the Lagoon this reduction will have a *low positive* impact. The very modest increase in sedimentation in the channels has been estimated as having a *negligible/none* impact.

In particular, the potential erosive effects at the Lido inlet due to the presence of the artificial island and the new navigable channel may affect the shallows and the adjacent beaches from whence the greater contribution of sediment would come. This has been assessed as having a *medium-low negative* impact, which can be mitigated, however, by means of local protection of the shallows between the artificial island and Sant'Erasmo, and could thus be reduced to a *low negative* impact. For the other inlets, the impact if the project on the balance and distribution of sediment is estimated as *negligible/none* (Table 4.3.10).

In the operation phase for Scenario B, the increase in the number of closures predicted will increase the repercussions on the Lagoon system. In particular:

- the reduction in the net loss of sediment to the sea would increase from the 100,000 m^3/year calculated for the present sea level situation to about 300,000 m^3/year, leading to a *medium positive* elemental impact level;
- the modifications due to the distribution of the sediment in the Lagoon would be greater than at present mean sea level, but they would affect primarily geomorphologic elements and structures that are already deteriorated; hence the elemental impact level is assessed as *negligible/none.*

Again, for this scenario, the *medium-low negative* impact on the shallows near the island of Sant'Erasmo can be reduced to a *low negative* impact by taking adequate measures to protect the Lagoon bed areas at risk.

Vegetation, flora and fauna

- Terrestrial Vegetation and flora

The important perturbing factors during the construction phase are the consumption of resources and the emission of dust and exhaust gases. As the construction and logistic bases are located in the already anthropically-altered areas of Marghera and Chioggia, or in the San Felice woods, an area with a plant community of scarce botanical interest, the impact is therefore estimated as *negligible/none.*

The construction of the abutment works and refuge ports, on the other hand, will mainly affect natural plant communities, with the following effects:

- a significant subtraction of psammophile plant communities of considerable botanical value at Pellestrina (*medium negative* impact);
- a more limited removal of psammophile plant communities of considerable botanical value at the Lido (*medium -low negative* impact);
- a reduced subtraction of plants in the wave breaking area of the shore at San Nicolò and Santa Maria del Mare, zones already virtually lacking in vegetation, (*negligible/none* impact);
- loss of the plant communities anthropically introduced in the San Felice woods (*negligible/none* impact).

It is worth mentioning that, during the construction phase, the work may also involve the natural plant communities immediately adjacent to the areas where plants are eliminated. Special attention must therefore be paid to restricting this interference with the natural vegetation wherever possible and, where damaging the plant communities is unavoidable, the areas must be restored after the works have been completed by replanting the species that were temporarily removed. In addition, the rest of the plants that have been removed will be cultivated on reclaimed land. Other Lagoon areas can also be developed or improved in compensation (Table 4.3.12).

During the operation phase at present mean sea level, the interferences will occur primarily in response to the cumulative effect of raising the barrier (Table 4.3.13), in that the reduction in the frequency of submersion of the salt marshes could favour the displacement of the halophile plant communities towards the lower elevations of the salt marshes and facilitate the growth of less halophilic species. This impact is estimated to be *negligible/none.*

Finally, in the operation phase for Scenario B, modest changes in the halophile plant communities are expected (removal and alteration), mainly due to additional erosion of the salt marshes (which tend to transform into mudflats unless artificially protected), although any interference of the proposed project would be absolutely insignificant, determining a *negligible/none* impact (Table 4.3.14).

- Terrestrial fauna

During the construction phase and, in particular, the construction of the refuge port, there would be a significant loss of habitat at the Chioggia inlet which has colonies of Little Terns (a species of high zoological value) and Kentish Plover (a species of moderately high zoological value) that nest along the sandy beaches. However, the construction activities are not expected to alter the local populations, so the impact is assessed as *negligible/none.*

The noise generated by the construction activities will be critical for the wildlife, particularly at the Chioggia inlet. The Little Tern population, a species rather sensitive to disturbances especially during its breeding period (between April and July), may experience the loss of some pairs as they abandon the area, consequently reducing the number of broods. Once the disturbance has ceased, however, there is expected to be a slow recolonization of the area. Thus, the impact on the Littel Terns is assessed as *medium negative*. The situation is similar for the Kentish Plover that also nests in the areas affected by the project, but since this species of slightly lower zoological value, the impact it is expected to suffer is of a slightly lower level (*medium-low negative)*. The impact on both these species can be reduced as low as *negligible/none* by suspending the activity in the sensitive areas between March and August, when these birds are breeding and consequently in a particularly delicate phase of their life cycle (Table 4.3.12).

In operation, both at current sea level and in the case of Scenario B, there are expected to be no significant interferences between the barrier system and the terrestrial fauna, and consequently no impact.

- Aquatic vegetation and flora

During the construction phase, the marine phanerogams will suffer a *low negative* impact while dredging is underway because of the increased turbidity that will affect the area in the vicinity of the inlets. These effects are rapidly reversed, however, and the meadows adjacent to the areas most affected can soon expand. On the other hand, there are no direct effects in the inlet areas where there are no eelgrass meadows and this so the estimated impact is *negligible/none* (Table 4.3.15).

In the operation phase at present sea level, with the mobile gates at-rest, there could be a localised and insignificant increase in the potential for the development of macro-algae, particularly between the artificial island at the Lido and the island of Sant'Erasmo. Thus, the presence of the mobile barrier system at-rest is estimated as having a *low negative* impact.

The slight deterioration in the quality of the sediment due to the cumulative effect of the barrier closures could also, where conditions are suitable, facilitate the growth of macro-algae. This possibility is considered slight given the modest change in sediment quality, so it is assessed as having a *low negative* impact.

A *negligible/none* impact is assessed for to the effect of the single closing operations, or of repeated closures, which would generally occur in autumn and winter, because no significant changes in the macro-algal biomass are expected. This is partly because the physical and chemical parameters that are related to algal growth tend to inhibit biomass development during the months when the barrier closures would be most frequent.

For the phanerogam meadows, the impact is considered *negligible/none* because their present locations do not coincide with areas of potential *Ulva* blooms or worsening water quality (Table 4.3.16).

As for operation of the gates in the presence of the increase in mean sea level predicted for scenario B, the impacts remain exactly the same as for the present sea level since the changes induced are not sufficient to alter them (Table 4.3.17).

- Aquatic fauna

Although removal of material from the Lagoon floor during the construction of the gates involves the physical subtraction of all benthic animals, recolonization of the substrate by populations from adjacent areas is expected to take place relatively quickly once the Project has been constructed. Since the changes induced are reversible and concern a variety of benthic communities, the impact is assessed as *medium -low negative*.
Furthermore the Lagoon's biotic communities are composed of organisms capable of withstanding even high levels of turbidity so although the expected increase in turbidity will persist for a relatively lengthy period (given the prolonged duration of construction), it will not significantly increase the strain on the benthic communities, and thus the impact can be considered as *negligible/none*.
The occupation of the lagoon floor in the Spignon Canal, and the corresponding removal of the benthic communities, will be temporary (4 years). Considering the vast diffusion of these communities in the Lagoon and the high water circulation in this area the resulting impact is *negligible/none*.

Finally, most of the dredged areas will subsequently be protected by placement of coarse materials of different particle size distributions from those of the existing floor, provoking eventual substitution of the existing animal communities in the mobile substrate with communities typical of solid substrates. Similarly, this phenomenon is also likely to occur in the area where the artificial island will be situated. The new communities will be comparable, in terms of the number and diversity of the species, with the current ones so there will be no appreciable modification in the local benthic communities and the impact will consequently be *negligible/none* (Table 4.3.15).

During the operation phase at current sea level, the perturbing factors (i.e., the presence of the gates at-rest, the cumulative effect of gate closures, the effect of single closures and of repeated closures at brief intervals) will generally produce very localised and insignificant effects on the benthic populations, and consequently, their impact has been estimated as *negligible/none*.

Influence of the Lagoon's hydrodynamics by means of a differentiated closure of the gates could lead to a recovery of oxygen deficient conditions affecting various benthic communities, albeit in relatively limited areas, especially during the most stressful period for the Lagoon fauna (late spring and summer), This situation leads to be a *medium positive* impact (Table 4.3.16).

The only aspects of any relevance during operation under Scenario B are related to the increased likelihood of multiple closures at brief intervals. In this situation, there is expected to be a reversible change in limited areas (the recovery of which would be delayed by the repeated closures) affecting various communities in places where there is a significant biomass of macro-algae. In this scenario, the component is therefore estimated as suffering a *medium-low negative* impact.

For all the other perturbing factors, there is no evidence of significant differences which would effect the assessment of impact in comparison with present mean sea level (Table 4.3.17).

Ecosystems

- Terrestrial Ecosystems

During the construction phase, the construction job sites and logistic bases (in the areas of Chioggia and Marghera) form part of a anthropically developed context where the biotic communities have entirely lost their natural features. The impact of the work will consequently be *negligible/none*. In the coastal areas, the Project construction will affect the sand dune systems of Cà Roman and Lido Alberoni, which, though partially deteriorated, are characterised by valuable, relict biotic communities that have locally become rare. Considering the surface area of these biotic communities being subtracted, the result is estimated as having a *medium negative* impact at Cà Roman, whereas for

Lido Alberoni, where the loss is more limited with respect to the local extent of the biotic communities, the impacts is estimated as *medium- low negative.*

For the other coastal areas (San Nicolò and Santa Maria del Mare) the impact is expected to be *negligible/none.* The impact is also *negligible/none* for the San Felice woods where the area that will be lost is extremely limited and the biotic communities involved are of little value (Table 4.3.18).

During the operation phase, on the other hand, both at today's mean sea level and in the event of Scenario B, the analysis has revealed no significant interaction between the project and the terrestrial ecosystems, so there is expected to be no impact (Tables 4.3.19 and 4.3.20).

- Aquatic ecosystems

During the construction phase, these ecosystems will suffer from the effects related to the removal of material from the Lagoon bed and from the generation of turbidity. The former, due to excavations and dredging activities, will result in the removal of various biotic communities of fairly high ecological value. However, material will be removed only from relatively small areas that are influenced by significant hydrodynamism that facilitates relatively rapid recolonization of the biotic communities. Bearing in mind that the work will also last for some time, the impact of this effect is therefore considered *low negative.*

The very limited increase in turbidity expected will affect areas containing biotic communities of high ecological value (extensive fields of marine phanerogams) which have an important role in the structure of the underwater ecosystem of the mobile sea bed. Notwithstanding the sensitivity of the eelgrass to changes in the turbidity, the slight, rapidly reversible changes predicted will not induce appreciable modifications nor consequent alterations in the dynamics and structure of this underwater ecosystem, and thus the impact is considered *negligible/none* (Table 4.3.18).

During the operation phase, at present sea level, the impact will be *negligible/none* with the mobile gates either raised or at-rest, since they have insignificant effects on the aquatic ecosystems. However, artificial control of the hydraulic circulation in the Lagoon, is expected to most benefit most from such closures is the central part of the Lagoon, to the south of Venice, where recovery from oxygen deficient states could be facilitated for biotic communities of fairly high ecological value, even over extensive areas. This would be significantly advantageous, particularly in the periods of greatest stress for the Lagoon ecosystems (late spring and summer), inducing a more rapid recovery from situations of hypoxia or anoxia in limited areas of water, reading to an assessment of a *low positive* impact (Table 4.3.19).

Impact assessment for operation of the gates for Scenario B generally presents no significant differences to that for present mean sea levels. The only relevant aspect concerns the cumulative effect of the rapidly repeated closures, which is more significant than at today's sea level, even during the late spring. In this case, there are expected to be reversible alterations among biotic communities of fairly high ecological value in limited areas where there is a significant presence of macro-algae. Hence impact is estimated as *low negative* (Table 4.3.20).

Public health

The generation of noise represents the most relevant perturbing factor during the construction phase, but the expected noise levels during the hours when the construction sites are in operation are not sufficient to cause severe pathologies in the population living in the area. However, since the estimated noise level in the areas close to the job sites could reach or even exceed the maximum limit of 70 dBA established for industrial zones, it has been assessed as having a *low negative* impact.

All impacts deriving from the production of solid and liquid waste, from the release of substances into the water and from the generation of turbidity are assessed as a *negligible/none* (Table 4.3.21).

In the operation phase at today's sea level, the effects associated with chlorinating during the operation of the system for sediment removal, painting operations for corrosion-proofing, and releasing of zinc from the cathode protection systems can all be considered as negligible, and hence, the impact on public health is estimated as being *negligible/none*.

Preventing contact with the unhealthy water by preventing flooding episodes can have a positive effect on the population's exposure to aqueous contaminants, as well as reducing the rheumatic pathologies due to the improvement in the healthiness of homes. These effects are assessed as having a *medium positive* impact (Table 4.3.22).

In the operation phase in scenario B, there would be no significant differences in terms of the hazards to public health with respect to the situation described for operation at today's mean sea level.

Landscape

First of all, it is worth mentioning that the potential impact on this component has to do with both the physical changes in the places where the project is constructed and the inclusion of new elements in the landscape that alter the previous spatial-perceptual relationships. The distribution of elements of the project at several sites and the spatial features of the areas involved (overall dimensions, open view, relationship between different places) actually give rise to local as well as overall impacts.

The three reference environments considered are as follows:

- the Lagoon area as a whole;
- the construction at the Lagoon inlets which, albeit in different landscape settings, involve similar technological and construction modalities;
- the logistic bases on the mainland, at Chioggia and Marghera, for supporting the construction sites.

Although construction is expected to last for eight years, the impact generally seems to be limited, involving marginal areas and, above all, activities that are not foreign to the Lagoon scene (dredging, naval traffic, and the transport of large volumes are absolutely typical activities) that will increase during the construction of the works to a degree that is not sufficient to induce important changes in the landscape. At the inlets, moreover, the construction will mainly involve operations performed on the seaward side, affecting the land only in terms of the space needed for the project in its final configuration.

The most important changes include (Table 4.3.23):

- the creation of the artificial island at the Lido inlet, which means a potentially significant change in the expanse of water defined as the internal "enclave" (an ample area of Lagoon coming between the inlet proper and the islands of Forte

Sant'Andrea and Sant'Erasmo) and consequently in the adjacent areas, with an estimated *medium negative* impact;

- the interventions at the Malamocco inlet, which locally affect the landscape at the sites where the project elements will be built but also influence the overall landscape, i.e. the relationships between the different parts of the territory, starting from that of the "enclave" of the Lagoon inlet itself. On the whole, however, the mainly horizontal nature of the landscape is preserved, with the introduction of elements appearing particularly significant only at the Lido Alberoni. Here the project will further increase the artificial nature of the scene, in a context where artificiality is already prevalent, though attenuated by the presence of wooded areas. Thus, the Malamocco inlet will be subjected to a *low negative* impact.
- the interventions at the Chioggia inlet also influence not only the local, but also the general landscape. While the Project elements on the southern bank involve the building of a platform that rests against the present coastline and expands into the channel, the work on the northern bank calls for a change to be made in the coastal contours, both on the seaward and the Lagoon sides. The morphology of the tip of Ca' Roman will also be modified for the construction of the refuge port and related work. Hence the impact at the Chioggia inlet is estimated as *medium-high negative.*

Taking into account the levels of sensitivity of the landscape environments defined during the characterisation of the landscape as subsystems of the more complex Venetian Lagoon system, the operation phase of the project at today's mean sea levels, is not expected to interfere directly with these subsystems as a whole, except for the specific areas of the Lagoon inlets, to the extent that they are visible from the surrounding areas.

Besides, the Lagoon landscape system is constantly affected by the tidal cycles, which have a non-negligible influence on the scenery (particularly in the medium and long term) because of the profound modifications that a change in tidal regime can induce, particularly on the most exterior physical features of the Lagoon. Disturbances to the tidal regime also undermine the healthiness and stability of the buildings, threatening their very survival, just as the delicate balance between dry and submerged land (the interaction between mudflats and salt marshes) can radically affected by an increase in mean water levels.

Hence, for the operation phase at current sea level, the impacts are in general negative, even up to *medium-to-high negative* impact levels, for the modifications induced on a local scale, whereas they are *positive,* with up to *medium positive* impact levels, for the overall Lagoon landscape system (Table 4.3.24).

In the operation phase in scenario B, the phenomena of subsidence and eustatism would further alter the Lagoon landscape, with a reduction in the surface area of the salt marshes, while Venice's historical and monumental system - of priceless value as a landscape - would be increasingly threatened and damaged by the more frequent flooding, consequently damaging the Lagoon landscape as a whole.

Operating the mobile gates in a scenario that envisages an increasing menace of high water episodes and consequently includes a greater utility of the barrier, results in a greater, i.e. *high positive,* impact on the Lagoon's landscape system associated with the avoidance of flooding, even though the changes on a local scale continue to give rise to the same negative impacts (up to a *medium-high negative* impact level, as were identified for the gates' operation at today's mean sea level (Table 4.3.25).

COMPONENT/ SUBCOMPONENT	*SITUATION/ PERTURBING FACTOR*	*INDICATOR*	*ELEMENTAL IMPACT DESCRIPTION*	*ELEMENTAL IMPACT ASSESSMENT*	*MITIGATION*	*RESIDUAL ELEMENTAL IMPACT*	*RESULTANT IMPACT*
ATMOSPHERE	EMISSIONS OF COMBUSTIBLE GAS FROM VEHICLES	EMISSION IN AIR: SOx , NOx, CO TOT. SUSP. SOLIDS VOLATILE ORG	Modest and temporary increase in atmospheric emissions relative to amounts currently emitted in the area (including the emissions in the industrial area)remaining within acceptable levels.	LOW NEGATIVE	—	LOW NEGATIVE	LOW NEGATIVE
		VARIATION IN CONCENTRATION SOx , NOx, CO TOT. SUSP. SOLIDS VOLATILE ORG	Increase in fallout concentration of all components at ground level (Sox, Nox, Particulates, CO and organic volatiles (COV)) much below acceptable levels both for annual average and peak conditions.	LOW NEGATIVE		LOW NEGATIVE	
	DUST EMISSIONS FROM SITES	ATMOSPHERIC CONCENTRATION OF SUSPENDED PARTICLES	• Concentration at ground level negligible if calculated over long period (1 yr); • Short term (1 day) concentrations elevated, in excess of acceptable levels, assuming adverse meteorological conditions.	MEDIUM-HIGH NEGATIVE	Limiting of dust by wetting surfaces, covering stockpiles of dusty materials, erecting wind barriers, asphalting or covering unpaved surfaces so as to keep dust producing surface to 10% of construction site	LOW NEGATIVE	

Tab. 4.3.1 - Schema riassuntivo degli impatti sulla componente Atmosfera per la fase di costruzione.

Summary of impacts on the Atmosphere component for the construction phase.

COMPONENT/ SUBCOMPONENT	*SITUATION/ PERTURBING FACTOR*	*INDICATOR*	*ELEMENTAL IMPACT DESCRIPTION*	*ELEMENTAL IMPACT ASSESSMENT*	*MITIGA-TION*	*RESIDUAL ELEMENTAL IMPACT*	*RESULTANT IMPACT*
ATMOSPHERE	EMISSIONS OF ODOR DUE TO EXPULSION OF AIR FROM GATE ELEMENTS DURING LOWERING PHASE	ATMOSPHERIC CONCENTRATION OF MALODORANT SUBSTANCES ASSOCIATED WITH FERMENTIVE PROCESSES	Negligible increase in atmospheric concentration of malodorant substances associated with fermentive processes.	NEGLIGIBLE/ NONE	——	NEGLIGIBLE/ NONE	NEGLIGIBLE/ NONE
	EMISSION FO H_2S OR MALODORANT SUBSTANCES WHILE BARRIERS ARE FUNCTIONING DUE TO DECREASED OXYGENATION OF LAGOON WATER		Negligible increase in atmospheric concentration of malodorant substances associated with fermentive processes especially since closures occur predominantly during the colder seasons.	NEGLIGIBLE/ NONE		NEGLIGIBLE/ NONE	

Tab. 4.3.2 - Schema riassuntivo degli impatti sulla componente Atmosfera per la fase di esercizio.
Summary of impacts on the Atmosphere component for the operation phase.

COMPONENT/ SUBCOMPONENT	SITUATION/ PERTURBING FACTOR	INDICATOR	ELEMENTAL IMPACT DESCRIPTION	ELEMENTAL IMPACT ASSESSMENT	MITIGATION	RESIDUAL ELEMENTAL IMPACT	RESULTANT IMPACT
HYDRODYNAMICS	• Reduction in sectional area of ports (less than the 12% for the completed project) • Construction of artificial island at the Lido inlet	LIQUID EXCHANGE BETWEEN SEA AND LAGOON	• Reduction in tidal volume exchanged (even less than 1% - 2% discussed for the completed project with gates at-rest. • Minimal local alteration of the velocity through ports.	NEGLIGIBLE/ NONE	---	NEGLIGIBLE/ NONE	NEGLIGIBLE/ NONE
SOLID TRANSPORT	• Sediment in suspension due to dredging activity	SOLIDS EXCHANGE BETWEEN SEA AND LAGOON	• Most critical increase in sediment concentration probably Chioggia (month 9) dredging about 30 m^3/day of fine grained material. With flow of about 50 million m^3/tide, concentration could approach 1 mg/l, small relative to natural 10 - 35 mg/l. • Trajectories of single particles of water entering inlets indicate that sediments in suspension will affect only zones only in the vicinity of the inlets.	NEGLIGIBLE/ NONE	---	NEGLIGIBLE/ NONE	

Tab. 4.3.3 - Schema riassuntivo degli impatti sulla sottocomponente Idrodinamica e trasporto solido per la fase di costruzione.
Summary of impacts on the Hydrodynamics and solid transport subcomponent for the construction phase.

COMPONENT/ SUBCOMPONENT	*SITUATION/ PERTURBING FACTOR*	*INDICATOR*	*ELEMENTAL IMPACT DESCRIPTION*	*ELEMENTAL IMPACT ASSESSMENT*	*MITIGATION*	*RESIDUAL ELEMENTAL IMPACT*	*RESULTANT IMPACT*
HYDRODYNAMICS	• Reduced inlet sectional area due to presence of new structures • Increased hydraulic resistance at lagoon inlets due to bottom protection • Presence of artificial island at Lido inlet	LIQUID EXCHANGE BETWEEN SEA AND LAGOON	• Numerical simulation of flow through lagoon inlets in presence of barriers at rest compared to situation without project indicates reduction in flow volume of about 5% for higher tides. This leads to the estimate of an annual reduction in exchange volumes between sea and Lagoon equal to about 1% to 2%. • Minimal increase in current velocity at inlet due to the presence of the new structures. • Artificial island is located in area of low flow, and thus will cause insignificant modification in the velocity field in areas of limited extension.	NEGLIGIBLE/ NONE	——	NEGLIGIBLE/ NONE	NEGLIGIBLE/ NONE
SOLID TRANSPORT	• Reduced inlet sectional area due to presence of new structures • Increased hydraulic resistance at lagoon inlets due to bottom protection • Presence of artificial island at Lido inlet	SOLIDS EXCHANGE BETWEEN SEA AND LAGOON	• Slight reduction in tidal liquid exchange between the lagoon and the sea will reduce sediment transport capacity provoking a negligible reduction in the loss of sediment to sea.	NEGLIGIBLE/ NONE	——	NEGLIGIBLE/ NONE	

Tab. 4.3.4a - Schema riassuntivo degli impatti sulla sottocomponente Idrodinamica e trasporto solido per la fase di esercizio - condizione di riposo con l'attuale livello medio mare.

Summary of impacts on the Hydrodydamics and solid transport subcomponente for the operation phase - barrier system at-rest for current mean sea level.

COMPONENT/ SUBCOMPONENT	*SITUATION/ PERTURBING FACTOR*	*INDICATOR*	*ELEMENTAL IMPACT DESCRIPTION*	*ELEMENTAL IMPACT ASSESSMENT*	*MITIGA-TION*	*RESIDUAL ELEMENTAL IMPACT*	*RESULTANT IMPACT*
HYDRODYNAMICS	• Closure of the barriers to safeguard lagoon level of +100 cm (Punta della Salute)	No. OF TIDAL EVENTS ≥ +100 cm P.S.	• Elimination of flooding events in lagoon for tides greater than +100 cm (Punta della Salute) also avoiding the effect of high tidal cycles on the foundation soil (microsettlements and filtration) and the deleterious effects of cyles of wetting / drying on porous building stones.	HIGH POSITIVE	—	HIGH POSITIVE	LOW POSITIVE
		MAX. SIGNIFICANT WAVE HEIGHT, Hs	• Reduction of Hs due to reduced water levels in the Lagoon & interruption of wave motion propagating from inlets, thus avoiding destabilizing effects on building foundation elements and bending stresses on buildings immediately beside lagoon.	LOW POSITIVE		LOW POSITIVE	
	• Closure of barriers to safeguard lagoon level of +100 cm (P.d.S.) • Reduced inlet sectional area (avg 12%) & increase in hydraulic	LIQUID EXCHANGE BETWEEN SEA AND LAGOON	• Closure to protect for levels ≥ +100 cm (max. 38 times/yr, 134 hrs) result in a reduction of less than 5% in annual tidal volume exchanged. • Direct effect of single closures on tidal liquid exchange will involve a limited lagoon area (primarily in the vicinity of lagoon inlets). • Closures, associated with higher tide levels, will reduce highest percentile inlet current velocity (about 4%).	NEGLIGIBLE/ NONE		NEGLIGIBLE/ NONE	
SOLID TRANSPORT	resistance due to new structures at inlets & bottom protection	SOLIDS EXCHANGE BETW. SEA & LAGOON	• Reduction in annual tidal liquid exchange will reduce solid transport capacity provoking a significant reduction in the loss of sediment to sea.	POSITIVE MEDIUM		POSITIVE MEDIUM	

Tab. 4.3.4b - Schema riassuntivo degli impatti sulla sottocomponente Idrodinamica e trasporto solido per la fase di esercizio - barriere in funzione per l'acqua alta con l'attuale livello medio mare.

Summary of impacts on Hydrodynamics and solid transport during operation phase - barrier system functioning for high waters at current actual mean sea level.

COMPONENT/ SUBCOMPONENT	SITUATION/ PERTURBING FACTOR	INDICATOR	ELEMENTAL IMPACT DESCRIPTION	ELEMENTAL IMPACT ASSESSMENT	MITIGATION	RESIDUAL ELEMENTAL IMPACT	RESULTANT IMPACT
HYDRODYNAMICS	• Failure of single gate to rise during closure of the barriers to safeguard lagoon level of +100 cm (P.S.)	LIQUID EXCHANGE BETWEEN SEA AND LAGOON	• Phenomenon with very low frequency of occurence that will produce a negligible change in annual tidal exchange. • Local increase in current velocity downstream of malfunctioning gate will affect very limited area.	NEGLIGIBLE/ NONE	—	NEGLIGIBLE/ NONE	NEGLIGIBLE/ NONE
SOLID TRANSPORT		SOLIDS EXCHANGE BETWEEN SEA AND LAGOON	• Phenomenon with very low frequency of occurence that will produce a negligible change in sediment exchange. • Local erosion effects downstream of malfunctioning element are repairable by filling with additional protection material.	NEGLIGIBLE/ NONE		NEGLIGIBLE/ NONE	
HYDRODYNAMICS	• Sudden opening of all barrier elements at one lagoon inlet	MAX. SIGNIF. WAVE HEIGHT, Hs	• Phenomenon, considered extremely improbable, would cause slow rise in level in the city of Venice at Punta della Salute	NEGLIGIBLE/ NONE		NEGLIGIBLE/ NONE	

Tab. 4.3.4c - Schema riassuntivo dell'impatto sulla sottocomponente Idrodinamica e trasporto solido per la fase di esercizio - condizione di emergenza con l'attuale livello medio mare.

Summary of impacts on the Hydrodynamics and solid transport subcomponent for the operation phase - emergency conditions at current mean sea level.

COMPONENT/ SUBCOMPONENT	SITUATION/ PERTURBING FACTOR	INDICATOR	ELEMENTAL IMPACT DESCRIPTION	ELEMENTAL IMPACT ASSESSMENT	MITIG-ATION	RESIDUAL ELEMENTAL IMPACT	RESULTANT IMPACT
HYDRODYNAMICS	BARRIER SYSTEM AT-REST • Increase in m.s.l. by + 20cm due to eustatism. • Reduced inlet sectional area & incr. hydr. resist. due to barrier presence at rest.	LIQUID EXCHANGE BETWEEN SEA AND LAGOON	• For +20 cm eustatism, exchange increases by about 10 million m^3/tide (5% with respect to present sea level with barriers at-rest). Considering the 2% decrease in volume exchanged due to effect of barriers at-rest without project, the net increase in tidal volume exchanged is about 3%.	NEGLIGIBLE/ NONE	—	NEGLIGIBLE/ NONE	MEDIUM POSITIVE
HYDRODYNAMICS	BARRIER FUNCTIONING • Increase in m.s.l. by + 20cm due to eustatism. • Reduced inlet sectional area &incr. hydr. resist due to new structures & bottom protection • Closure of gates to protect the level of +100 cm (Punta della Salute)	No. OF TIDAL EVENTS >100 cm P.S.	• Elimination of flooding events in lagoon for tides greater than +100 cm Punta della Salute avoiding the structural damage related to flooding.	HIGH POSITIVE		HIGH POSITIVE	
		MAX. SIGNIFICANT WAVE HEIGHT, Hs	• Reduction of Hs due to reduced water levels in shallows & interruption of wave motion at inlets, thus avoiding destabilizing effects on building foundation elements and bending stresses on buildings adjacent to lagoon.	LOW POSITIVE		LOW POSITIVE	
		LIQUID EXCHANGE BETWEEN SEA AND LAGOON	• Reduction in tidal volume of between 5% and 15% (probably less than 10%) for closure to safeguard + 100 cm P.d.S. • Closures, associated with higher tidal levels, will cause reduction of higher percentile inlet velocities (probably of less than 10%).	NEGLIGIBLE/ NONE		NEGLIGIBLE/ NONE	
SOLID TRANSPORT		SOLIDS EXCHANGE BETW. SEA & LAGOON	• Reduction in tidal liquid exchange will reduce solid transport capacity leading to a significant reduction in the loss of sediment from Lagoon to sea.	MEDIUM POSITIVE		MEDIUM POSITIVE	

Tab. 4.3.5a - Schema riassuntivo dell'impatto per la sottocomponente Idrodinamica e trasporto solido per la fase di esercizio - condizioni di emergenza per lo Scenario B.

Summary of impacts on the Hydrodynamics and solid transport subcomponent for the operation fase - emergency conditions for Scenario B.

COMPONENT/ SUBCOMPONENT	*SITUATION/ PERTURBING FACTOR*	*INDICATOR*	*ELEMENTAL IMPACT DESCRIPTION*	*ELEMENTAL IMPACT ASSESSMENT*	*MITIGA-TION*	*RESIDUAL ELEMENTAL IMPACT*	*RESULTANT IMPACT*
HYDRODYNAMICS	• Failure of single gate to rise during closure of the barriers to safeguard lagoon level of +100 cm (P.S.)	LIQUID EXCHANGE BETWEEN SEA AND LAGOON	• Phenomenon with very low frequency of occurence that will produce a negligible change in annual tidal exchange. • Local increase in current velocity downstream of malfunctioning gate will affect very limited area.	NEGLIGIBLE/ NONE	—	NEGLIGIBLE/ NONE	NEGLIGIBLE/ NONE
SOLID TRANSPORT		SOLIDS EXCHANGE BETWEEN SEA AND LAGOON	• Phenomenon with very low frequency of occurence that will produce a negligible change in sediment exchange. • Local erosion effects downstream of malfunctioning element are repairable by filling with additional protection material.	NEGLIGIBLE/ NONE		NEGLIGIBLE/ NONE	
HYDRODYNAMICS	• Sudden opening of all barrier elements at one lagoon inlet	MAX. SIGNIF. WAVE HEIGHT, Hs	• Phenomenon, considered extremely improbable, would cause slow rise in level in the city of Venice at Punta della Salute	NEGLIGIBLE/ NONE		NEGLIGIBLE/ NONE	

Tab. 4.3.56 - Schema riassuntivo dell'impatto sulla sottocomponente Idrodinamica e trasporto solido per la fase di esercizio - condizione di emergenza per lo Scenario B.
Summary of impacts on the Hydrodynamics and solid transport subcomponent for the operation phase - emergency conditions for Scenario B.

SUB-COMPONENT	PERTURBING FACTOR	INDICATOR	ELEMENTAL IMPACT DESCRIPTION	ELEMENTAL IMPACT ASSESSMENT	MITIGA-TION	RESIDUAL ELEMENTAL IMPACT	RESULTANT IMPACT
WATER	DREDGING OF MATERIAL FROM LAGOON BOTTOM	TURBIDITY	Slight increase in turbidity in the areas near excavation. (limited area, low increase in turbidity, reversible)	LOW NEGATIVE	——	LOW NEGATIVE	NEGLIGIBLE/ NONE
		DISSOLVED OXYGEN (freq. of occurrence of hypoxic cond.)	The contents of the resuspended material is not such that it will contribute to the deterioration of water quality	NEGLIGIBLE/ NONE		NEGLIGIBLE/ NONE	
SEDIMENT		ORGANIC C, Zn	Slight improvement in sediment quality due to mixing of existing sediment with pre-industrial era derdged sediment (limited area, modest reduction in contamination).	LOW POSITIVE	——	LOW POSITIVE	
WATER SEDIMENT	PRODUCTION OF DREDGED MATERIAL	——	None as long as only slightly or uncontaminated sediment is reused for lagunal morphological reconstruction	NEGLIGIBLE/ NONE	——	NEGLIGIBLE/ NONE	
WATER SEDIMENT	PRODUCTION OF SOLID & LIQUID WASTE	——	None as along as all wastewater is treated and all other waste is appropriately landfilled	NEGLIGIBLE/ NONE	——	NEGLIGIBLE/ NONE	
WATER SEDIMENT	FILLING	——	None on the basis of the weight and mineralogic characteristics of the stone fill material.	NEGLIGIBLE/ NONE	——	NEGLIGIBLE/ NONE	

Tab. 4.3.6 - Schema riassuntivo degli impatti sulla sottocomponente Qualità delle acque e dei sedimenti per la fase di costruzione.
Summary of the impacts on the Water and sediment quality subcomponent for the construction phase.

SUB-COMPONENT	*SITUATION/ PERTURBING FACTOR*	*INDICATOR*	*ELEMENTAL IMPACT DESCRIPTION*	*ELEMENTAL IMPACT ASSESSMENT*	*MITIGATION*	*RESIDUAL ELEMENTAL IMPACT*	*RESULTANT IMPACT*
WATER	BARRIER SYSTEM AT-REST	TOTAL DISS. INORG. NITROGEN (TDIN)	Possible very localized stagnation of water in in the area behind the artificial island at Lido because of limited reduction in water movement	NEGLIGIBLE/ NONE	——	NEGLIGIBLE/ NONE	NEGLIGIBLE/ NONE
SEDIMENT		—	None, since there is no effect on sediment transport	NEGLIGIBLE/ NONE		NEGLIGIBLE/ NONE	
WATER	BARRIER SYSTEM FUNCTIONING (CUMULATIVE EFFECT)	—	None since there is no significant increase in dissolved contaminant concentration.	NEGLIGIBLE/ NONE		NEGLIGIBLE/ NONE	
SEDIMENT		ORGANIC C	Slight increas in the organic content and its residence times in the sediment of lagoon shallows, mudflats and canals (area of med. extens., slight perm. contam.)	LOW NEGATIVE		LOW NEGATIVE	
WATER	BARRIER SYSTEM FUNCTIONING (SINGLE CLOSURE & MULTIPLE CLOSURES AT BRIEF INTERVALS)	DISSOLVED OXYGEN (freq. of occurrence of hypoxic cond.)	• In the warmer months and in areas with elevated biomass, possible generationof anoxic conditions • Slow down of recovery from distrophic cond. before closure (area of small ext., low freq., reduced duration).	NEGLIGIBLE/ NONE		NEGLIGIBLE/ NONE	
	ARTIFICIALLY-INDUCED HYDRAULIC CIRCULATION IN LAGOON (DIFFERENTIAL OR TOTAL CLOSURES)	DISSOLVED OXYGEN (freq. of occurrence of hypoxic cond.); TDIN	• Recovery of persistent anoxic conditions (differential closures). • Increase in hydraulic exchange particularly in the central Lagoon (differential closures). • Protection from toxic spills inside or outside Lagoon (either differential or complete closure) (moderately extensive area, reduction of contamination in critical moments)	MEDIUM POSITIVE		MEDIUM POSITIVE	
	EMISSION OF SUBSTANCES (GATES AT-REST OR FUNCTIONING)	Zn	Moderate emission of zinc particularly concentrated when gates are raised following long periods at-rest. (slight contam., persist. in extensive areas, mod. contam. episodes in limited areas)	LOW NEGATIVE		LOW NEGATIVE	

Tab. 4.3.7 – Schema riassuntivo degli impatti sulla sottocomponente Qualità delle acque e dei sedimenti per la fase di esercizio all'attuale livello medio mare.

Summary of the impacts on the Water and sediment quality subcomponent for the operation phase at current mean sea level.

SUB-COMPONENT	SITUATION/ PERTURBING FACTOR	INDICATOR	ELEMENTAL IMPACT DESCRIPTION	ELEMENTAL IMPACT ASSESSMENT	MITIGATION	RESIDUAL ELEMENTAL IMPACT	RESULTANT IMPACT
WATER	BARRIER SYSTEM AT-REST	TDIN	Possible very localized stagnation of water in in the area behind the artificial island at Lido because of limited reduction in water movement	NEGLIGIBLE/ NONE	—	NEGLIGIBLE/ NONE	LOW NEGATIVE
SEDIMENT		—	None, since there is no effect on sediment transport	NEGLIGIBLE/ NONE		NEGLIGIBLE/ NONE	
WATER	BARRIER SYSTEM FUNCTIONING (CUMULATIVE EFFECT)	TDIN	• Slight increase in average nutrient concentration, in particular in autumn and winter • Reduction in the nitrogen load from the sea in spring and summer (moderately extensive are, slight prolonged contamination, reversible alteration)	NEGLIGIBLE/ NONE		NEGLIGIBLE/ NONE	
SEDIMENT		ORGANIC C	Slight increas in the organic content and its residence times in the sediment of lagoon shallows, mudflats and channels (mod. extensive area, slight permanent contamination)	LOW NEGATIVE		LOW NEGATIVE	
WATER	BARRIER SYSTEM FUNCTIONING (SINGLE CLOSURE & MULTIPLE CLOSURES AT BRIEF INTERVALS	DISSOLVED OXYGEN (freq. of occurrence of hypoxic cond.)	• Limited increment of frequency of situations conducive to localized hypoxic events with respect to natural conditions. • Slow down of recovery from distrophic cond. prior to closures	MEDIUM-LOW NEGATIVE	* Impact can be progressively reduced by the realization of interventions related to reducion of the nutrient loads from the Drainage Basin and the city of Venice (D4.3) and better managed using data from the monitoring system foreseen for the project realization phase	MEDIUM-LOW NEGATIVE	
	ARTIFICIALLY-INDUCED HYDRAULIC CIRCULATION IN LAGOON (DIFFERENTIAL OR TOTAL CLOSURES)	DISSOLVED OXYGEN (freq. of occurrence of hypoxic cond.); TOTAL DISS. INORG. N (TDIN)	• Recovery of persistent anoxic conditions (diff. closures). • Increase in hydraulic exchange particularly in the central Lagoon (differential closures). • Protection from toxic spills inside or outside Lagoon (either differential or complete closure) (mod. extens. area, reduced contam. in critical moments)	MEDIUM POSITIVE	—	MEDIUM POSITIVE	
	EMISSION OF SUBSTANCES (BARRIERS AT-REST OR FUNCTIONING)	Zn	Moderate emission of zinc particularly concentrated when gates are raised following a long period at-rest. (slight contam., persistent in extensive areas, moderate contamination episodes in limited areas)	LOW NEGATIVE		LOW NEGATIVE	

Tab. 4.3.8 - Schema riassuntivo degli impatti sulla sottocomponente Qualità delle acque e dei sedimenti per la fase di esercizio per lo Scenario B.
Summary of the impacts on the Water and sediment quality subcomponent for the operation phase for Scenario B.

COMPONENT/ SUBCOMPONENT	*SITUATION/ PERTURBING FACTOR*	*INDICATOR*	*ELEMENTAL IMPACT DESCRIPTION*	*ELEMENTAL IMPACT ASSESSMENT*	*MITIGA-TION*	*RESIDUAL ELEMENTAL IMPACT*	*RESULTANT IMPACT*
GEOMORPHOLOGY	——	——	No interference	*no impact*	——	*no impact*	*no impact*
LAND USE AND SOIL COVER	Consumption of resources in lagoon	WEIGHTED PERCENTAGE OF SURFACE LOST OR GAINED	Temporary modification to restore to original conditions upon completion of construction	NEGLIGIBLE/ NONE	——	NEGLIGIBLE/ NONE	LOW NEGATIVE
	Consumption of resources at lagoon inlets		Loss of expanses of water due to submerged or exposed structures and refuge ports	LOW NEGATIVE		LOW NEGATIVE	
			Loss of dry land	LOW NEGATIVE		LOW NEGATIVE	
	Fill material		Loss of submerged land due to the construction of artificial island at Lido and beaches at Chioggia	MEDIUM-LOW NEGATIVE		MEDIUM-LOW NEGATIVE	
	Production of excavated material		Availability of material for the eventual reconstruction of the salt marshes	LOW POSITIVE		LOW POSITIVE	

Tab. 4.3.9 - Schema riassuntivo degli impatti sulla componente Suolo e sottosuolo per la fase di costruzione.

Summary of impacts on the Soil and subsurface component for the construction phase.

SUBCOMPONENT	*SITUATION/ PERTURBING FACTOR*	*INDICATOR*	*IMPACT DESCRIPTION*	*ELEMENTAL IMPACT ASSESSMENT*	*MITIGATION*	*RESIDUAL ELEMENTAL IMPACT*	*RESULTANT IMPACT*
LAND USE AND SOIL COVER	——	——	No interference	*no impact*	——	*no impact*	*no impact*
GEOMORPHOLOGY	LAGOON	SEDIMENT BALANCE	Limited reduction in the net loss of sediments	LOW POSITIVE	——	LOW POSITIVE	NEGLIGIBLE/ NONE
		SEDIMENT DISTRIBUTION	Limited increase in the sedimentation of the channels	NEGLIGIBLE/ NONE		NEGLIGIBLE/ NONE	
			Reduction in erosion of salt marshes due to the reduction in wave height	LOW POSITIVE		LOW POSITIVE	
	LIDO INLET	SEDIMENT BALANCE & DISTRIBUTION	Potential erosive effects of the presence of the artificial island and the new navigatable channel	MEDIUM-LOW NEGATIVE	Localized protection of shallows near S. Erasmo	LOW NEGATIVE	
	MALAMOCCO INLET		Effects resolved by normal maintenance for maintaining channel navigability	NEGLIGIBLE/ NONE	——	NEGLIGIBLE/ NONE	
	CHIOGGIA INLET		Effects resolved by normal maintenance for maintaining channel navigability	NEGLIGIBLE/ NONE		NEGLIGIBLE/ NONE	

Tab. 4.3.10 – Schema riassuntivo degli impatti sulla componente Suolo e sottosuolo per la fase di esercizio all'attuale livello medio mare.

Summary of impacts on the Soil and subsurface component for the operation phase at current mean sea level.

SUBCOMPONENT	***SITUATION/ PERTURBING FACTOR***	***INDICATOR***	***ELEMENTAL IMPACT DESCRIPTION***	***ELEMENTAL IMPACT ASSESSMENT***	***MITIGATION***	***RESIDUAL ELEMENTAL IMPACT***	***RESULTANT IMPACT***
LAND USE AND SOIL COVER	——	—	No interference	no impact	——	no impact	no impact
GEOMORPHOLOGY	LAGOON	SEDIMENT BALANCE	Significant reduction in the net loss of sediments	MEDIUM POSITIVE	——	MEDIUM POSITIVE	NEGLIGIBLE/ NONE
		SEDIMENT DISTRIBUTION	Increase in the sedimentation of the canals	NEGLIGIBLE/ NONE		NEGLIGIBLE/ NONE	
			Reduction in the erosion of the salt marshes	LOW POSITIVE		LOW POSITIVE	
	LIDO INLET	SEDIMENT BALANCE & DISTRIBUTION	Potential erosive effects of the presence of the artificial island and the new navigatable channel	MEDIUM-LOW NEGATIVE	Localized protection of shallows near S. Erasmo	LOW NEGATIVE	
	MALAMOCCO INLET		Effects resolved by normal maintenance for maintaining channel navigability	NEGLIGIBLE/ NONE	—	NEGLIGIBLE/ NONE	
	CHIOGGIA INLET		Effects resolved by normal maintenance for maintaining channel navigability	NEGLIGIBLE/ NONE	—	NEGLIGIBLE/ NONE	

Tab. 4.3.11 - Schema riassuntivo degli impatti sulla componente Suolo e sottosuolo per la fase di esercizio per lo Scenario B.
Summary of impacts on the Soil and subsurface component for the operation phase for Scenario B.

SUBCOMPONENT	SITUATION/ PERTURBING FACTOR	INDICATOR	DESCRIPTION OF ELEMENTAL IMPACT	ELEMENTAL IMPACT ASSESSMENT	MITIGATION	RESIDUAL ELEMENTAL IMPACT	RESULTANT IMPACT
TERRESTRIAL (ONSHORE) VEGETATION and FLORA	Consumption of resources	PHYTOCENOSES	Significant subtraction of psammofile formations of elevated botanic value (Cà Roman)	MEDIUM NEGATIVE	* Attempt to grow the subtracted formations in the zones of land reclaimed elsewhere	MEDIUM NEGATIVE	MEDIUM-LOW NEGATIVE
			Limited subtraction of psammophile formations of elevated botanical value (Lido Alberoni)	MEDIUM-LOW NEGATIVE		MEDIUM-LOW NEGATIVE	
			Limited subtraction of wave-lapped zones without vegetative cover (S. Nicolò, S. Maria del Mare)	NEGLIGIBLE / NONE		NEGLIGIBLE / NONE	
			Elimination of vegetative formations of low botanical value (Bosco S. Felice) or of anthropic derivation (Chioggia e Marghera)	NEGLIGIBLE/ NONE	* Development or improvements in other zones of the Lagoon	NEGLIGIBLE/ NONE	
	Dust and combustible gas emissions		Slight disturbance to the functions of vegetative species	NEGLIGIBLE/ NONE		NEGLIGIBLE/ NONE	
TERRESTRIAL (ONSHORE) FAUNA	Consumption of resources	BIRDLIFE	Elimination of habitat that will not appreciably modify local Little Tern population (Cà Roman)	NEGLIGIBLE/ NONE	—	NEGLIGIBLE/ NONE	
			Elimination of habitat that will not appreciably modify Kentish Plover populations (Cà Roman, S. Nicolo, Alberoni, S. Maria del Mare)	NEGLIGIBLE/ NONE		NEGLIGIBLE/ NONE	
			Elimination of habitat that will not appreciably modify local populations of ample ecological value (Chioggia, Marghera, Bosco S. Felice)	NEGLIGIBLE/ NONE		NEGLIGIBLE/ NONE	
	Noise		Disturbance during the reproductive period of the Little Tern (reduction in population, reversible in the long term) (Cà Roman)	MEDIUM NEGATIVE	Cessation of most critical activities between March & August (Cà Roman)	NEGLIGIBLE/ NONE	
			Disturbance during the reproductive period of the Kentish Plover (reduction in population, reversible in long term) (Cà Roman, S. Nicolo, Alberoni, S. Maria del Mare)	MEDIUM-LOW NEGATIVE		NEGLIGIBLE/ NONE	
			Disturbance to species of ample ecological value (Bosco S. Felice, Chioggia, Marghera)	NEGLIGIBLE/ NONE	—	NEGLIGIBLE/ NONE	
			Disturbance during nonreproductive periods of ornithological population (Bacan)	NEGLIGIBLE/ NONE		NEGLIGIBLE/ NONE	

* Possible interventions aimed at improving the component.

Tab. 4.3.12 - Schema riassuntivo degli impatti sulla sottocomponente Vegetazione, flora e fauna terrestre per la fase di costruzione.
Summary of impacts on the Terrestrial Vegetation, flora and fauna subcomponent for the construction phase.

SUBCOMPONENT	*SITUATION/ PERTURBING FACTOR*	*INDICATOR*	*DESCRIPTION OF ELEMENTAL IMPACT*	*ELEMENTAL IMPACT ASSESSMENT*	*MITIGATION*	*RESIDUAL ELEMENTAL IMPACT*	*RESULTANT IMPACT*
TERRESTRIAL (ONSHORE) VEGETATION AND FLORA	Barrier system functioning for high water (cumulative effect)	PHYTOCENOSES	No appreciable variation in the floristic composition of salt marsh phytocenoses	NEGLIGIBLE/ NONE	—	NEGLIGIBLE/ NONE	NEGLIGIBLE/ NONE
TERRESTRIAL (ONSHORE) FAUNA	—	BIRDLIFE	No interference	*no impact*		*no impact*	

Tab. 4.3.13 – Schema riassuntivo degli impatti sulla sottocomponente Vegetazione, flora e fauna terrestre per la fase di esercizio all'attuale livello del mare.
Summary of impacts on the Terrestrial Vegetation, flora and fauna subcomponent for the operation phase at current mean sea level.

SUBCOMPONENT	*SITUATION/ PERTURBING FACTOR*	*INDICATOR*	*DESCRIPTION OF ELEMENTAL IMPACT*	*ELEMENTAL IMPACT ASSESSMENT*	*MITIGATION*	*RESIDUAL ELEMENTAL IMPACT*	*RESULTANT IMPACT*
TERRESTRIAL (ONSHORE) VEGETATION AND FLORA	Barrier system functioning for high water (cumulative effect)	PHYTOCENOSES	No appreciable variation in the floristic composition of salt marsh phytocenoses	NEGLIGIBLE/ NONE	—	NEGLIGIBLE/ NONE	NEGLIGIBLE/ NONE
TERRESTRIAL (ONSHORE) FAUNA	—	BIRDLIFE	No interference	*no impact*		*no impact*	

Tab. 4.3.14 - Schema riassuntivo degli impatti sulla sottocomponente Vegetazione, flora e fauna terrestre per la fase di esercizio per lo Scenario B.
Summary of impacts on the Terrestrial Vegetation, flora and fauna subcomponent for the operation phase for Scenario B.

SUBCOMPONENT	*SITUATION/ PERTURBING FACTOR*	*INDICATOR*	*DESCRIPTION OF ELEMENTAL IMPACT*	*ELEMENTAL IMPACT ASSESSMENT*	*MITIGATION*	*RESIDUAL ELEMENTAL IMPACT*	*RESULTANT IMPACT*
AQUATIC VEGETATION AND FLORA	Dredging of material from mudline; consump. of resources & filling	MARINE PHANEROGAMS	Areas to be dredged are not currently vegetated with phanerogams	NEGLIGIBLE/ NONE	—	NEGLIGIBLE/ NONE	LOW NEGATIVE
	Generation of turbidity		Slight indications of degradation of the meadows located in deeper shallows.	LOW NEGATIVE		LOW NEGATIVE	
AQUATIC FAUNA	Dredging of material from mudline	BENTHIC COMMUNITY	Removal of diversified benthic community from the area of the lagoon inlets (alteration reversible in long term)	MEDIUM-LOW NEGATIVE	—	MEDIUM-LOW NEGATIVE	
	Consumption of resources and filling		Modification of diversified benthic communities in the lagoon inlet areas which will not cause appreciable variation of the communities	NEGLIGIBLE/ NONE		NEGLIGIBLE/ NONE	
	Generation of turbidity		Insignificant alteration to benthic community in the lagoon inlet area	NEGLIGIBLE/ NONE		NEGLIGIBLE/ NONE	

Tab. 4.3.15 - Schema riassuntivo degli impatti sulla sottocomponente Vegetazione, flora e fauna acquatica per la fase di costruzione.

Summary of impacts on the Aquatic Vegetation, flora and fauna subcomponent for the construction phase.

SUBCOMPONENT	SITUATION/ PERTURBING FACTOR	INDICATOR	DESCRIPTION OF ELEMENTAL IMPACT	ELEMENTAL IMPACT ASSESSMENT	MITIGATION	RESIDUAL ELEMENTAL IMPACT	RESULTANT IMPACT
AQUATIC VEGETATION AND FLORA	Barrier system at rest	ULVA	Insignificant increment in macroalgal development potential between S. Erasmo and the artificial island at Lido	NEGLIGIBLE/ NONE	—	NEGLIGIBLE/ NONE	NEGLIGIBLE/ NONE
	Barrier system functioning - cumulative effect	ULVA	Moderate increment in macroalgal population due to modest decrease in sediment quality	LOW NEGATIVE		LOW NEGATIVE	
	Barrier system functioning - Effect of single closures and repeated closures at brief intervals	ULVA	Absence of significant variation of the macroalgal biomass even at the local level	NEGLIGIBLE / NONE		NEGLIGIBLE / NONE	
		PHANEROGAMS	Verified absence of variation in phanerogam meadows due to degraded water quality	NEGLIGIBLE/ NONE		NEGLIGIBLE/ NONE	
AQUATIC FAUNA	Barrier system at rest	BENTHIC COMMUNITY	Local modification of hydrodynamism (due to the artificial island at Lido) insufficient to provoke appreciable modification of the benthic communities	NEGLIGIBLE/ NONE	—	NEGLIGIBLE/ NONE	
	Barrier system functioning - cumulative effect		Unappreciable modification of the composition of the lagoon communities	NEGLIGIBLE / NONE		NEGLIGIBLE / NONE	
	Barrier system functioning - Effect of single closures and repeated closures at brief intervals		Temporary decrease in biomass insufficient to cause appreciable variation in the structure and diversity of the benthic community	NEGLIGIBLE / NONE		NEGLIGIBLE / NONE	
	Artificially-induced hydraulic circulation in the Lagoon (Differential closures)		Conditions favorable to the development of the diversified benthic community in limited areas	MEDIUM POSITIVE		MEDIUM POSITIVE	
	Release of substances and heated coolant waters into aquatic environment		Unappreciable alteration at a local level	NEGLIGIBLE/ NONE		NEGLIGIBLE/ NONE	

Tab. 4.3.16 - Schema riassuntivo degli impatti sulla sottocomponente Vegetazione, flora e fauna acquatica per la fase di esercizio all'attuale livello del mare.

Summary of impacts on the Aquatic Vegetation, flora and fauna subcomponent for the operation phase at current mean sea level.

SUBCOMPONENT	SITUATION/ PERTURBING FACTOR	INDICATOR	DESCRIPTION OF ELEMENTAL IMPACT	ELEMENTAL IMPACT ASSESSMENT	MITIGATION	RESIDUAL ELEMENTAL IMPACT	RESULTANT IMPACT
AQUATIC VEGETATION AND FLORA	Barrier system at rest	ULVA	Insignificant increment in macroalgal development potential between S. Erasmus and the artificial island at the Lido inlet	NEGLIGIBLE/ NONE	—	NEGLIGIBLE/ NONE	LOW NEGATIVE
	Barrier system functioning - cumulative effect	ULVA	Moderate increment in macroalgal population due to modest decrease in sediment quality	LOW NEGATIVE		LOW NEGATIVE	
	Barrier system functioning - Effect of single closures and repeated closures at brief intervals	ULVA	Absence of significant variation in macroalgal biomass	NEGLIGIBLE/ NONE		NEGLIGIBLE/ NONE	
		PHANEROGAMS	Verified absence of variation in phanerogam meadows due to the temporary degradation in water quality	NEGLIGIBLE/ NONE		NEGLIGIBLE/ NONE	
AQUATIC FAUNA	Barrier system at rest	BENTHIC COMMUNITY	Local reduction in hydrodynamism (due to the artificial island at the Lido inlet) is insufficient to provoke appreciable modification of the benthic community	NEGLIGIBLE/ NONE	—	NEGLIGIBLE/ NONE	
	Barrier system functioning - cumulative effect		Unappreciable modification of the composition of the lagoon communities	NEGLIGIBLE / NONE		NEGLIGIBLE / NONE	
	Barrier system functioning - Effect of single closures and repeated closures at brief intervals		Possible temporary decrease in biomass of the diversified benthic community in limited areas (area B) for the case of multiple closuresat brief intervals, reversible in the long term	MEDIUM-LOW NEGATIVE		MEDIUM-LOW NEGATIVE	
	Artificially-induced hydraulic circulation in the Lagoon (Differential closures)		Conditions favorable to the development of the diversified benthic community in limited areas	MEDIUM POSITIVE		MEDIUM POSITIVE	
	Release of substances and heated coolant waters into aquatic environment		Insignificant variation of the benthic community	NEGLIGIBLE/ NONE		NEGLIGIBLE/ NONE	

Tab. 4.3.17 – Schema riassuntivo degli impatti sulla sottocomponente Vegetazione, flora e fauna acquatica per la fase di esercizio per lo Scenario B.

Summary of impacts on the Aquatic Vegetation, flora and fauna subcomponent for the operation phase for Scenario B.

SUBCOMPONENT	SITUATION/ PERTURBING FACTOR	INDICATOR	DESCRIPTION OF ELEMENTAL IMPACT	ELEMENTAL IMPACT ASSESSMENT	MITIGATION	RESIDUAL ELEMENTAL IMPACT	RESULTANT IMPACT
TERRESTRIAL (ONSHORE) ECOSYSTEMS	Consumption of resources	BIOCENOSES	Significant subtraction of dunal biocenoses of elevated ecologic value a Cà Roman	MEDIUM NEGATIVE	—	MEDIUM NEGATIVE	MEDIUM-LOW NEGATIVE
			Limited subtraction of dunal biocenoses of elevated value (Lido Alberoni)	MEDIUM-LOW NEGATIVE		MEDIUM-LOW NEGATIVE	
			Elimination of biocenoses of low ecologic value (S. Nicolò, S. Maria del Mare, Bosco S. Felice) or of anthropic derivation (Chioggia e Marghera)	NEGLIGIBLE/ NONE		NEGLIGIBLE/ NONE	
AQUATIC ECOSYSTEMS	Dredging of material from mudline and	BIOCENOSES	Removal of biocenoses of moderate ecologic value with reduction in diversification in limited areas near the inlets, alterations reversible in the long term	LOW NEGATIVE	—	LOW NEGATIVE	NEGLIGIBLE/ NONE
	Consumption of resources and filling		None - Irrelevant modification of ecosystems near the lagoon inlets	NEGLIGIBLE / NONE		NEGLIGIBLE / NONE	
	Generation of turbidity		Not appreciable variation of biocenoses of elevated ecologic value and no alteration to the dynamics of the ecosystem near the lagoon inlets	NEGLIGIBLE/ NONE		NEGLIGIBLE/ NONE	

Tab. 4.3.18 - Schema riassuntivo degli impatti sulla componente Ecosistemi per la fase di costruzione.
Summary of impacts on the Ecosystems component for the construction phase.

SUBCOMPONENT	*SITUATION/ PERTURBING FACTOR*	*INDICATOR*	*DESCRIPTION OF ELEMENTAL IMPACT*	*ELEMENTAL IMPACT ASSESSMENT*	*MITIGATION*	*RESIDUAL ELEMENTAL IMPACT*	*RESULTANT IMPACT*
TERRESTRIAL ECOSYSTEMS		BIOCENOSES	No interference	*no impact*		*no impact*	*no impact*
ACQUATIC ECOSYSTEMS	Barrier system at-rest	BIOCENOSES	Irrelevant modification at ecosystem level	NEGLIGIBLE/ NONE	—	NEGLIGIBLE/ NONE	NEGLIGIBLE/ NONE
	Barrier system functioning - cumulative effect		Irrelevant modification at ecosystem level	NEGLIGIBLE/ NONE		NEGLIGIBLE/ NONE	
	Barrier system functioning - Effect of single closures and repeated closures at brief intervals		Possible temporary decrease in biocenoses of moderate ecological value in limited area (area B) associated with closures in the spring /summer period, without appreciable modifications at the ecosystem level	NEGLIGIBLE / NONE		NEGLIGIBLE / NONE	
	Artificially-induced hydraulic circulation in the Lagoon (Differential closures)		Recovery from oxygen deficit of biocenoses of moderate ecologic value in late spring/summer periods in limited areas	LOW POSITIVE		LOW POSITIVE	
	Release of substances and heated coolant waters into aquatic environment		Absence of appreciable modifications of biocenoses sufficient to have repurcussions at the ecosystem level	NEGLIGIBLE/ NONE		NEGLIGIBLE/ NONE	

Tab. 4.3.19 - Schema riassuntivo degli impatti sulla componente Ecosistemi per la fase di esercizio all'attuale livello del mare
Summary of impacts on the Ecosystems component for the operation phase at current mean sea level.

SUBCOMPONENT	*SITUATION/ PERTURBING FACTOR*	*INDICATOR*	*DESCRIPTION OF ELEMENTAL IMPACT*	*ELEMENTAL IMPACT ASSESSMENT*	*MITIGATION*	*RESIDUAL ELEMENTAL IMPACT*	*RESULTANT IMPACT*
TERRESTRIAL ECOSYSTEMS	—	BIOCENOSES	No interference	*no impact*		*no impact*	*no impact*
ACQUATIC ECOSYSTEMS	Barrier system at rest	BIOCENOSES	None. Irrelevant modification at the ecosystem level	NEGLIGIBLE/ NONE	—	NEGLIGIBLE/ NONE	LOW NEGATIVE
	Barrier system functioning - cumulative effect		None. Irrelevant modifications at the ecosystem level	NEGLIGIBLE/ NONE		NEGLIGIBLE/ NONE	
	Barrier system functioning - Effect of single closures and repeated closures close together	BIOCENOSES	Possible temporary decrease in biomass of biocenoses of moderate ecological value associated with closures in the late spring/summer periods, reversible in the long term	LOW NEGATIVE		LOW NEGATIVE	
	Artificially-induced hydraulic circulation in the Lagoon (Differential closures)		Recovery from oxygen deficit of biocenoses of moderate ecologic value in late spring/summer periods in limited areas	LOW POSITIVE		LOW POSITIVE	
	Release of substances and heated coolant waters into aquatic environment		None. Absence of appreciable modification of biocenoses sufficient to have repercussions at the ecosystem level	NEGLIGIBLE/ NONE		NEGLIGIBLE/ NONE	

Tab. 4.3.20 - Schema riassuntivo degli impatti sulla componente Ecosistemi per la fase di esercizio per lo Scenario B.
Summary of impacts on the Ecosystems component for the operation phase for Scenario B.

COMPONENT/ SUBCOMPONENT	*SITUATION/ PERTURBING FACTOR*	*INDICATOR*	*ELEMENTAL IMPACT DESCRIPTION*	*ELEMENTAL IMPACT ASSESSMENT*	*MITIGATION*	*RESIDUAL ELEMENTAL IMPACT*	*RESULTANT IMPACT*
PUBLIC HEALTH	FOSSIL FUEL AND DUST EMISSIONS	VARIATION IN CONCENTRATION: SOx , NOx, CO TOT. SUSP. SOLIDS VOLATILE ORGANICS	Estimate of atmospheric emissions will cause only a modest increase in contaminant concentrations that will not affect human health.	NEGLIGIBLE/ NONE	—	NEGLIGIBLE/ NONE	NEGLIGIBLE/ NONE
	RELEASE OF CONTAMINANTS IN WATER	VARIATION IN CONCENTRATION	Type of substance released (principally inert material) does not have toxic effects on human health	NEGLIGIBLE/ NONE		NEGLIGIBLE/ NONE	
	PRODUCTION OF SOLID & LIQUID WASTE		Type of substances released, and the method of disposal foreseen guarantee the absence of negative effects on human health.	NEGLIGIBLE/ NONE		NEGLIGIBLE/ NONE	
	RESUSPENSION OF VARYINGLY CONTAMINATED SEDIMENTS	VARIATION IN CONCENTRATION : PAH, PCB, DDT, Ag, As, Ba, Hg, Ni, Se, Cyan.ides, Zn	Increase in toxic contaminant concentration in water will not significantly affect public health especially considering the limited exposure period.	NEGLIGIBLE/ NONE		NEGLIGIBLE/ NONE	
	NOISE GENERATION	VARIATION OF CONDITIONS CORRELATABLE WITH HUMAN HEALTH	Levels of noise will not affect public health as long as noisier equipment remains inactive during nighttime hours	LOW NEGATIVE		LOW NEGATIVE	

Tab. 4.3.21 - Schema riassuntivo degli impatti sulla componente Salute pubblica per la fase di costruzione.
Summary of impacts on the Public health component for the construction phase.

COMPONENT/ SUBCOMPONENT	SITUATION/ PERTURBING FACTOR	INDICATOR	ELEMENTAL IMPACT DESCRIPTION	ELEMENTAL IMPACT ASSESSMENT	MITIGA-TION	RESIDUAL ELEMENTAL IMPACT	RESULTANT IMPACT
PUBLIC HEALTH	CHLORINATION OF WATER WITHIN GATE ELEMENT	VARIATION IN WATER CONCENTRATION OF CHLORINE	Chlorine concentrations estimated as negligible with negligible effects on public health	NEGLIGIBLE/ NONE	—	NEGLIGIBLE/ NONE	MEDIUM POSITIVE
	RELEASE OF ZINC FROM CATHODE PROTECTION SYSTEM	VARIATION IN WATER CONCENTRATION OF Zn	Although the Zn concentration is significant , it leads to a level that remains one tenth of acceptable levels (USEPA, 1994).	NEGLIGIBLE/ NONE		NEGLIGIBLE/ NONE	
	RELEASE OF TOXIC SUBSTANCES IN WATER DURING THE PAINTING PHASE	VARIATION IN WATER CONCENTRATION OF TOXIC SUBSTANCES	Exterior coat of paint used on barriers is nontoxic and permits only limited release of substances..	NEGLIGIBLE/ NONE		NEGLIGIBLE/ NONE	
	CONTACT WITH CHEMICAL AND MICROBIOLOGICAL CONTAMINANTS DURING FLOODING	VARIATION IN CONDITIONS CORRELATABLE WITH PUBLIC HEALTH	Elimination of water levels exceeding +100 cm P.d.S. will substantially reduce health risks associated with contact with unhealthy water or inhalation of its volatile substances.	MEDIUM POSITIVE		MEDIUM POSITIVE	

Tab. 4.3.22 - Schema riassuntivo degli impatti sulla componente Salute pubblica per la fase di esercizio.
Summary of impacts on the Public health component for the operation phase.

COMPONENT/ SUBCOMPONEN	SITUATION/ PERTURBING FACTOR	INDICATOR	DESCRIPTION OF ELEMENTAL IMPACT	ELEMENTAL IMPACT ASSESSMENT	MITIGA-TION	RESIDUAL ELEMENTAL IMPACT	RESULTANT IMPACT
LANDSCAPE	Modification of landscape	Modification at local level	Lido lagoon inlet (med. sensitivity, moderate modification)	MEDIUM NEGATIVE	—	MEDIUM NEGATIVE	MEDIUM-LOW NEGATIVE
			Malamocco lagoon inlet (low sensit., modest modification)	LOW NEGATIVE		LOW NEGATIVE	
			Chioggia lagoon inlet (med. sensit., major modification)	MEDIUM-HIGH NEGATIVE		MEDIUM-HIGH NEGATIVE	
			Logistical base at Porto Marghera (low sensit., modest modification)	LOW NEGATIVE		LOW NEGATIVE	
			Logistical base at Chioggia (low sensit., moderate modification)	MEDIUM-LOW NEGATIVE		MEDIUM-LOW NEGATIVE	
			Storage area at Canale Spignon (med. sensitivity, moderate modification)	MEDIUM NEGATIVE		MEDIUM NEGATIVE	
		Lagoon landscape system	Southern central lagoon (med. sensitivity, modest modification)	NEGATIVE		MEDIUM-LOW NEGATIVE	

Tab. 4.3.23 - Schema riassuntivo degli impatti sulla componente Paesaggio per la fase di costruzione.
Summary of impacts on the Landscape component for the construction phase.

COMPONENT/ SUBCOMPONENT	SITUATION/ PERTURBING FACTOR	INDICATOR		DESCRIPTION OF ELEMENTAL IMPACT	ELEMENTAL IMPACT ASSESSMENT	MITIGA-TION	RESIDUAL ELEMENTAL IMPACT	RESULTANT IMPACT
LANDSCAPE	Modification of landscape	Modification at local level	Lido	Punta Sabbioni (med. sensitivity, moderate modification)	MEDIUM NEGATIVE	* For the artificial island and the vast area of P. Sabbione, specific designs for the requalification of the landscape could be identified, possibly through an international competition, given that the area serves as a new Lagoon entrance and the presence of new land surface.	MEDIUM NEGATIVE	NEGLIGIBLE/ NONE
				Punta Sabbioni coast (med. sensit., modest modification)	MEDIUM-LOW NEGATIVE		MEDIUM-LOW NEGATIVE	
				Lido of S.Erasmo (med. sensitivity, modest modification.)	MEDIUM-LOW NEGATIVE		MEDIUM-LOW NEGATIVE	
				Forte di S.Andrea (med. sensitivity, modest modification)	MEDIUM-LOW NEGATIVE		MEDIUM-LOW NEGATIVE	
				modification)	LOW NEGATIVE		LOW NEGATIVE	
				modification)	MEDIUM-LOW NEGATIVE		MEDIUM-LOW NEGATIVE	
				External enclave of inlet (low sens., modest modification)	LOW NEGATIVE		LOW NEGATIVE	
				Internal enclave of inlet (med. sensit., major modification)	MEDIUM-HIGH NEGATIVE		MEDIUM-HIGH NEGATIVE	
			Malamocco	Punta Alberoni (med. sensit., moderate modification)	MEDIUM NEGATIVE		MEDIUM NEGATIVE	
				Punta Alberoni coast (med. sensit., modestmodification)	MEDIUM-LOW NEGATIVE		MEDIUM-LOW NEGATIVE	
				Urban area of Punta Alberoni (low sens., no modification)	NEGLIGIBLE / NONE		NEGLIGIBLE / NONE	
				Punta e Forte S.Pietro (med. sensit., modest modification)	MEDIUM-LOW NEGATIVE		MEDIUM-LOW NEGATIVE	
				Lagoon territory behind the Murazzi (seawalls) (low sens., no modification)	NEGLIGIBLE / NONE		NEGLIGIBLE / NONE	
				Lagoon inlet channel (low sensit., moderate modification)	MEDIUM-LOW NEGATIVE		MEDIUM-LOW NEGATIVE	
				Lagoon (low sensit. moderate modification)	MEDIUM-LOW NEGATIVE		MEDIUM-LOW NEGATIVE	
			Chioggia	Ca' Roman (med. sensit., major modification)	MEDIUM-HIGH NEGATIVE		MEDIUM-HIGH NEGATIVE	
				Chioggia center (med. sensit., modest mod.)	MEDIUM-LOW NEGATIVE		MEDIUM-LOW NEGATIVE	
				Sottomarina center (low sensit., no modification)	NEGLIGIBLE / NONE		NEGLIGIBLE / NONE	
				Sottomarina coast (low sensit., moderate modification)	MEDIUM-LOW NEGATIVE		MEDIUM-LOW NEGATIVE	
				modification)	MEDIUM NEGATIVE		MEDIUM NEGATIVE	
				Lagoon inlet channel (low sensit., moderate modification)	MEDIUM-LOW NEGATIVE		MEDIUM-LOW NEGATIVE	
				Lagoon (sens. medium, modest modification)	MEDIUM-LOW NEGATIVE		MEDIUM-LOW NEGATIVE	
		Lagoon landscape system	System	Historical center: monuments (high sensitivity, positive modification)	MEDIUM POSITIVE		MEDIUM POSITIVE	
				Mainland (low sensitivity, no modification)	NEGLIGIBLE / NONE		NEGLIGIBLE / NONE	
				Open lagoon (medium sensitivity, positive modification)	MEDIUM POSITIVE		MEDIUM POSITIVE	
				Fish farms (medium sensitivity, no modification)	NEGLIGIBLE / NONE		NEGLIGIBLE / NONE	
				Coastal zones (medium sensibility, positive modification)	MEDIUM POSITIVE		MEDIUM POSITIVE	

Tab. 4.3.24 - Schema riassuntivo degli impatti sulla componente Paesaggio per la fase di esercizio all'attuale livello medio mare

Summary of impacts on the Landscape component for the operation phase at current mean sea level.

COMPONENT/ SUBCOMPONENT	SITUATION/ PERTURBING FACTOR	INDICATOR	DESCRIPTION OF ELEMENTAL IMPACT		ELEMENTAL IMPACT ASSESSMENT	MITIGA-TION	RESIDUAL ELEMENTAL IMPACT	RESULTANT IMPACT
LANDSCAPE	Modification of landscape	Modification at local level	Lido	Punta Sabbioni (med. sensitivity, moderate modification)	MEDIUM NEGATIVE		MEDIUM NEGATIVE	MEDIUM POSITIVE
				Punta Sabbioni coast (med. sensit., modest modification)	MEDIUM-LOW NEGATIVE	* For the artificial	MEDIUM-LOW NEGATIVE	
				Lido of S.Erasmo (med. sensitivity, modest modification.)	MEDIUM-LOW NEGATIVE	island and the	MEDIUM-LOW NEGATIVE	
				Forte di S.Andrea (med. sensitivity, modest modification)	MEDIUM-LOW NEGATIVE	vast area of P.	MEDIUM-LOW NEGATIVE	
				modification)	LOW NEGATIVE	Sabbione, specific	LOW NEGATIVE	
				modification)	MEDIUM-LOW NEGATIVE	designs for the	MEDIUM-LOW NEGATIVE	
				External enclave of inlet (low sens., modest modification)	LOW NEGATIVE	requalification of	LOW NEGATIVE	
				Internal enclave of inlet (med. sensit., major modification)	MEDIUM-HIGH NEGATIVE	the landscape	MEDIUM-HIGH NEGATIVE	
			Malamocco	Punta Alberoni (med. sensit., moderate modification)	MEDIUM NEGATIVE	could be identified,	MEDIUM NEGATIVE	
				Punta Alberoni coast (med. sensit., modestmodification)	MEDIUM-LOW NEGATIVE	possibly through	MEDIUM-LOW NEGATIVE	
				Urban area of Punta Alberoni (low sens., no modification)	NEGLIGIBLE / NONE	an international	NEGLIGIBLE / NONE	
				Punta e Forte S.Pietro (med. sensit., modest modification)	MEDIUM-LOW NEGATIVE	competition,	MEDIUM-LOW NEGATIVE	
				Lagoon territory behind the Murazzi (seawalls) (low sens., no modification)	NEGLIGIBLE / NONE	given that the area serves as a new	NEGLIGIBLE / NONE	
				Lagoon inlet channel (low sensit., moderate modification)	MEDIUM-LOW NEGATIVE	Lagoon entrance	MEDIUM-LOW NEGATIVE	
				Lagoon (low sensit. moderate modification)	MEDIUM-LOW NEGATIVE	and the presence	MEDIUM-LOW NEGATIVE	
			Chioggia	Ca' Roman (med. sensit., major modification)	MEDIUM-HIGH NEGATIVE	of new land	MEDIUM-HIGH NEGATIVE	
				Chioggia center (med. sensit., modest mod.)	MEDIUM-LOW NEGATIVE	surface.	MEDIUM-LOW NEGATIVE	
				Sottomarina center (low sensit., no modification)	NEGLIGIBLE / NONE		NEGLIGIBLE / NONE	
				Sottomarina coast (low sensit., moderate modification)	MEDIUM-LOW NEGATIVE		MEDIUM-LOW NEGATIVE	
				modification)	MEDIUM NEGATIVE		MEDIUM NEGATIVE	
				Lagoon inlet channel (low sensit., moderate modification)	MEDIUM-LOW NEGATIVE		MEDIUM-LOW NEGATIVE	
				Lagoon (sens. medium, modest modification)	MEDIUM-LOW NEGATIVE		MEDIUM-LOW NEGATIVE	
		Lagoon landscape system	System	Historical center: monuments (high sensitivity, positive modification)	HIGH POSITIVE		HIGH POSITIVE	
				Mainland (low sensitivity, no modification)	NEGLIGIBLE / NONE		NEGLIGIBLE / NONE	
				Open lagoon (medium sensitivity, positive modification)	MEDIUM POSITIVE		MEDIUM POSITIVE	
				Fish farms (medium sensitivity, no modification)	NEGLIGIBLE / NONE		NEGLIGIBLE / NONE	
				Coastal zones (medium sensibility, positive modification)	MEDIUM POSITIVE		MEDIUM POSITIVE	

Tab. 4.3.25 - Schema riassuntivo degli impatti sulla componente Paesaggio per la fase di esercizio per lo Scenario B
Summary of impacts on the Landscape component for the operation phase for Scenario B

4.4 Resultant impacts

The resultant impacts were assessed on the basis of the residual elemental impacts for each of the phases and scenarios described in section 4.2. The resultant impacts describe the level of the effects of the Project on the various environmental components (Table 4.4.1). While the elemental impacts induced by the construction and operation phases of the mobile gate project have been calculated and presented considering the individual environmental components in order to better emphasise the impacts on each component concerned, the resultant impacts are discussed together with reference to each phase of the Project in order to emphasise the effects of the Project on the environment as a whole.

4.4.1 Construction phase

After implementing the mitigation measures to contain the concentrations of dust in the short term, there is an overall *low negative* impact on the ATMOSPHERE due to the temporary increase, albeit within legal limits, in the emissions of combustible gases from motorvehicle (Table 4.3.1).

A *negligible/none* impact is assessed for the HYDRAULIC ENVIRONMENT subcomponent for the hydrodynamics and solid transport subcomponent, wherein limited variation in the volume of liquids exchanged between the sea and the Lagoon, in the velocity through the inlets and in the concentration of sediment in suspension are experienced. The same lack of resultant impact is assessed for the water and sediment quality subcomponent. The *low negative* elemental impact on the latter subcomponent due to the removal of material from the sea floor is compensated by the *low positive* elemental impact related to the modest local reduction in sediment contamination. All the other perturbing factors do not generate any impact on this component (Tables 4.3.3 and 4.3.6).

The resultant impact for the SOIL AND SUBSURFACE component can be defined as a *low negative* impact with the *medium-low* negative elemental impact due mainly to the loss of submerged Lagoon floor for the construction of the artificial island, being balanced by the *low positive* elemental impact associated with the greater availability of material for the reconstruction of the salt marshes (Table 4.3.9).

Terrestrial VEGETATION, FLORA AND FAUNA is subject to an overall *medium-low* resultant impact in that, although the majority of the elemental impacts are *negligible/none*, particular importance has been attributed to the removal of the vegetation of high botanical value in the areas of Cà Roman and Lido Alberoni (Table 4.3.12). For the aquatic VEGETATION, FLORA AND FAUNA, the resultant impact is a *low negative* in consideration of the effects of some relevance on the benthic communities and on the marine phanerogams that will persist over a rather long time (Table 4.3.15).

The TERRESTRIAL ECOSYSTEMS are affected by a *medium-low negative* impact in that the effects of the project, although on a local level, have repercussions on biotic communities that are generally of considerable biological value. AQUATIC ECOSYSTEMS, on the other hand, will experience a resultant impact can be considered as *negligible/none*, because the only appreciable effect, due to the removal of the biotic communities of fairly high ecological value, affects only limited areas in some parts of the Lagoon inlets (Table 4.3.18).

The resultant impact on PUBLIC HEALTH can also be considered *negligible/none*, because the only perturbing factor that could generate a significant effect, i.e. the noise level, is mitigated by avoiding the performance of the noisier activities during the night (Table 4.3.21).

Finally, the LANDSCAPE is affected by a *medium-low negative* resultant impact because of the interactions on the entire Lagoon due to the construction work and principally from the widespread increase in the traffic and activities (Table 4.3.23).

4.4.2 Operation phase at current mean sea level

The resultant impact on the ATMOSPHERE, and consequently on the quality of the air, is *negligible/none* (Table 4.3.2).

For the HYDRAULIC ENVIRONMENT, on the other hand, there is a *low positive* resultant impact on the hydrodynamics and solid transport subcomponent taking into account the three different operational situations: gate the system at-rest, emergency conditions and the barrier raised to counter a high water event (Table 4.3.4a, b and c). The quality of the water and sediment subcomponent experiences a *negligible/none* resultant impact, considering the various scenarios configured and their associated indicators (Table 4.3.7).

The resultant impact on the SOIL AND SUBSURFACE component during operation, relevant only to the geomorphologic aspects, is assessed as *negligible/none* impact (Table 4.3.10).

Terrestrial and aquatic VEGETATION AND FLORA as well as aquatic FAUNA are affected by a *negligible/none* resultant impact. There is no interference with the terrestrial fauna during the operation phase (Tables 4.3.13 and 4.3.16).

No interference was detected for the ECOSYSTEMS, whereas the resultant impact on the Aquatic ECOSYSTEMS is assessed as *negligible/none* (Table 4.3.19).

The resultant impact on PUBLIC HEALTH is *medium positive* as a result of preventing contact with the contaminants in the water during high water episodes (Table 4.3.22).

Finally, with reference to the discussion none regarding the construction phase, the resultant impact on the LANDSCAPE can be estimated as *negligible/none* considering that the positive effect of safeguarding the heritage of the Venetian Lagoon landscape balances out the individual local negative residual impacts (Table 4.3.24).

4.4.3 Operation phase with respect to the working life of the project (100 years)

Scenario A

Comparison of the results of the impact relative to the operation phase at current mean sea level with those relative to the operation phase under Scenario B supports the contention that the Scenario A situation does not require an analysis specifically dedicated to its situation. Instead, given the very small increase in mean sea level as discussed in section 4.2, the resultant impacts assessed for the current sea level are also applicable to Scenario A.

Scenario B

Concerning the ATMOSPHERE, there is no reason to modify the results of the analyses performed in the absence of any eustatic phenomena, so the resulting impact remains *negligible/none*.

As far as the HYDRAULIC ENVIRONMENT is concerned, the resultant impact on the hydrodynamics and solid transport increases with respect that assessed for operation at current sea level, from *low positive* to a *medium positive*. This enhancement is due to the capacity of the barrier system to prevent the more frequent high water flooding events in excess of +100 cm (Punta della Salute datum), with consequent benefits for the buildings and infrastructures abutting the Lagoon. There is also a significant reduction in the net loss of Lagoon sediment because of the lower annual volume of fluid exchanged between the sea and the Lagoon (Table 4.3.5a and b).
The resultant impact on the water and sediment quality has been assessed as *low negative* as opposed to the *negligible/none* value relative to current sea level, due both to the slight increase in the concentration of contaminants in the Lagoon and to the greater likelihood of single or repeated closures in the warmer months possibly creating conditions that would facilitate oxygen deficiency phenomena (Table 4.3.8).

The SOIL AND SUBSURFACE, again exclusively relating to the geomorphology, is subject to a *negligible/none* resultant impact in that the effects due to the presence of the island and of the new navigable canal at the Lido inlet are balanced by the likelihood of a reduction in the erosion of the salt marshes and by the possible reduction in the net loss of sediment from the Lagoon (Table 4.3.11).

The resultant impact on the terrestrial VEGETATION is *negligible/none,* whereas the terrestrial fauna remain unaffected by the changes expected from this scenario (Table 4.3.14). Aquatic VEGETATION, FLORA AND FAUNA, on the other hand, is expected to experience a *low negative* impact mainly associated with the increased risk of hypoxic phenomena due to the increase in the number of gate closures (Table 4.3.17).

No interference has been determined for the terrestrial ECOSYSTEMS and thus no impact has been assessed. The resultant *low negative* impact for the Aquatic ECOSYSTEMS takes into account the possible effects of repeated closures in the late spring and summer accompanied by slower recovery from situations of stress (Table 4.3.20).

In terms of PUBLIC HEALTH, no changes have been envisaged with respect to the situation at today's sea level and, hence, the *medium positive* impact remains unchanged.

Also for the LANDSCAPE component, there are no tangible differences with respect to the situation at current mean sea level and this, a *low positive* resultant impact is assessed for Scenario B.

Scenario C

As previously mentioned, the conclusions relating to Scenario A and Scenario B are applicable to Scenario C for the majority of the working life of the mobile gates. In the event that is decided to proceed with further action interventions to integrate with the present configuration of the project, the following typical situations can be considered:

a) the number of closures foreseen in Scenario B remains the same

In the event that the height of the local *insulae* defences of the inhabited centres is increased and/or other interventions are realised that are designed to maintain unchanged the number of gate closures predicted for Scenario B, the situation will not differ greatly from the conclusions described for Scenario B. In fact, the variations will only concern those environmental components directly affected by the increased mean water levels in the Lagoon.

Higher levels in the Lagoon will promote a tendency for increased wave motion that could induce greater sediment resuspension in the shallows. This could lead to an increase in the net loss of sediment to the sea because of the increased liquid exchange between the sea and the lagoon. The increase in the volume of water in the Lagoon will also tend to improve water quality, thanks to a greater dilution of the pollutants introduced, with positive effects on the aquatic ecosystems.

Higher water levels will also cause a further reduction in the surface area of the salt marshes and mudflats, with a loss of characteristic habitat for the associated plant and animal life.

No significant variation is expected for the Atmosphere, Public health and Landscape components.

b) increase in the number of gate closures with respect to scenario B.

If, on the other hand, the number of closures is assumed to increase in comparison to the situation in Scenario B, then in order to avoid penalising port activities, the construction of at least one shipping lock could be suggested, the technical compatibility of which with the present project configuration has already been verified. It is currently impossible, however, to formulate Lagoon navigational scenarios over the course of the next century.

Another effect of the increase in the number of closures would be a reduction in the liquid exchange between the sea and the Lagoon. This could lead, on the one hand, to a reduction in the net loss of sediment to the sea and, on the other, to a tendency for the quality of the environment to deteriorate.

An improvement in the general environmental conditions of the lagoon system could be predicted, since all the measures already planned for containing the contaminant load from the drainage basin, arresting the deterioration of the Lagoon and restoring its morphology could be expected to have taken become effective by this future time.

The decision to plan for more frequent gate closures consequently depends on the actual ability to control the pollution load and the improvements to environmental quality that will exist at that time.

COMPONENT/ SUBCOMPONENT		*RESULTANT IMPACT ASSESSMENT*		
		CONSTRUCTION PHASE	*OPERATION PHASE*	
			CURRENT MEAN SEA LEVEL	*SCENARIO B**
ATMOSPHERE		LOW NEGATIVE	NEGLIGIBLE/ NONE	NEGLIGIBLE/ NONE
HYDRAULIC ENVIRONMENT	HYDRODYNAMICS AND SOLID TRANSPORT	NEGLIGIBLE/ NONE	LOW POSITIVE	MEDIUM POSITIVE
	WATER & SEDIMENT QUALITY	NEGLIGIBLE/ NONE	NEGLIGIBLE/ NONE	LOW NEGATIVE
SOIL AND SUBSURFACE	LAND USE	LOW NEGATIVE		
	GEOMORPHOLOGY		NEGLIGIBLE/ NONE	NEGLIGIBLE/ NONE
VEGETATION, FLORA E FAUNA	TERRESTRIAL VEGETATION, FLORA E FAUNA	MEDIUM-LOW NEGATIVE	NEGLIGIBLE/ NONE	NEGLIGIBLE/ NONE
	AQUATIC VEGETATION, FLORA E FAUNA	LOW NEGATIVE	NEGLIGIBLE/ NONE	LOW NEGATIVE
ECOSYSTEMS	TERRESTRIAL ECOSYSTEMS	MEDIUM-LOW NEGATIVE		
	AQUATIC ECOSYSTEMS	NEGLIGIBLE/ NONE	NEGLIGIBLE/ NONE	LOW NEGATIVE
PUBLIC HEALTH		NEGLIGIBLE/ NONE	MEDIUM POSITIVE	MEDIUM POSITIVE
LANDSCAPE		MEDIUM-LOW NEGATIVE	NEGLIGIBLE/ NONE	LOW POSITIVE

NOTE: * The situations for Scenarios A and C are described in paragraph D6.2.3.1.

(shaded box) No impact.

Tab. 4.4.1 - Sintesi della stima degli impatti risultanti dell'opera sulle componenti e sottocomponenti prese in esame.

Summary of the resultant impacts assessed for the project for the components and subcomponents studied.

4.5 Cumulative impacts

This section examines the potential interactions between the Project at the inlets and the proposed wide area measures in order to identify any amplification or compensation of the corresponding impacts once measures have been put into effect. It is worth mentioning that the effects associated with all the wide are measures have already been considered in the assessment of the impacts on water quality and soil and subsurface induced by the Project for the various scenarios analysed.

The indirect positive impact of the wide area interventions on the ATMOSPHERE due to the better quality of the water will be slightly, though temporarily, reduced by the *low negative* impact expected during the construction phase.

The positive impact on the HYDRODYNAMICS AND SOLID TRANSPORT (relative to the net loss of sediment from the Lagoon) after the realisation of the Project will be amplified by the positive impact of the reconstruction of the mudflats and shallows. Moreover, the positive impact of the reduced wave motion will be amplified in that both the wide area measures and the presence of the Project produce such positive effects.

As for the QUALITY OF THE WATER AND SEDIMENT, there are no negative aspects associated with combining the Project and the various wide area measures planned. Instead, the wide area measures have a positive effect on the impacts of the Project in that all the interventions implemented to remediate the pollution of the Lagoon and the drainage basin will also improve the environmental state of the area in which the Project is to be inserted. The general reduction in the trophic levels and the progressive decline in the macro-algae will render the environment less sensitive to the principal negative effects of the Project, especially in Scenario B. The expected reduction in the levels of pollution has already been taken into account in calculating the impact for the scenarios predicting eustatic sea level rises.

The objectives of the wide area measures have also been taken into account in the evaluation of the impact on the SOIL AND SUBSURFACE component, both during the construction of the works (concerning land use) and after the installation of the mobile barrier system (concerning geomorphology). In particular, the impacts relating to further sedimentation in the channels are compensated by the interventions to restore the

Lagoon's morphology, whereas the positive impact of the lower net loss of sediment to the sea is amplified.

The negative impact induced by the Project on the VEGETATION FLORA AND FAUNA, both at today's sea level and in Scenario B, will be reduced by the improved water quality produced by the wide area measures aimed at the arrest of the degradation of the Lagoon environment.

For the ECOSYSTEMS, as well, the objectives of the wide area interventions contribute towards reducing the negative impact temporarily induced by the Project in Scenario B. The positive impact of the defensive interventions on the coastlines, however, will suffer from the impact of the Project during the construction phase (in terms of fragmentation and interference with the naturalness of the ecosystems in the vicinity of the job sites).

The positive impact of the Project on PUBLIC HEALTH, associated with prevention of the population's exposure to contaminated water, will be amplified by the wide area measures for improving water quality. On the other hand, there are no interactions between the negative impact relating to the temporary generation of noise during the construction of the gates and any effects of the wide area interventions.

Finally, the positive impact of the Project on the LANDSCAPE component relative to the protection of the historical urban centres from flooding is far greater in terms of efficacy than the estimated impact of the wide area measures.

5. THE ECONOMIC SYSTEM: EFFECTS AND INTERFERENCES

This section deals with the identification, analysis and evaluation of how the mobile gate Project interferes with the various sectors of the Venetian economic system, formulating considerations, for some production sectors, on the correlated long-term effects. The evaluation of the effects of the Project includes those that could somehow influence the development trajectories of the present economic system in Venice and, more in general, in the Lagoon, where the direct and indirect effects of the Project are concentrated. Specifically, the sectors of the Venetian economic system that were considered included:

- fishing and aquaculture;
- port activities;
- the productive system.

Finally, referring to section 2.4.1 (the "zero option"), an estimate is presented of the overall economic value of the mobile gate Project (capitalising the values of the short- and long-term costs that will be avoided) and of their net benefit on the hundred-year time scale.

5.1 Economic interference of the mobile gate Project on fishing and aquacultural activities

The economic effects and the possible interferences were evaluated with respect to the fishing activities outside and inside the Lagoon (aquaculture) and at the fish farms. The analysis of the impacts on the hydraulic environment and on the aquatic fauna revealed that none of the phases of the Project involve with significant alterations of the Lagoon water in or around the inlets. Consequently, both during the construction and in subsequent operation phases, the interference of the Project on fishing activities at the fish farms and inside and outside the Lagoon (intended as the procurement of aquatic organisms) was considered negligible.

5.2 Economic interferences of the mobile gate Project on port activities

An analysis was conducted on the potential economic interferences on the most relevant aspects of the ports' activities originating from the presence of the mobile gates at the inlets, i.e.

- industrial and commercial traffic;
- passenger traffic;
- fishing fleet traffic;
- pleasure boat activities.

The economic interferences affecting naval traffic were analysed considering both current mean sea level and rises in mean sea level of 10 cm and 20 cm.

The estimate of the number of hours of delay caused to the commercial shipping by the closure of the gates (which must be added to the waiting times that ships already must support because of the particular conditions for accessing the docking areas inside the Lagoon) took into account:

- the frequency and duration of the tidal events reaching levels in excess of +100 cm with reference to the Punta della Salute datum;
- gate element manoeuvre time (i.e. for raising and lowering the gates);
- waiting times at anchor or at the wharf (for the outbound ships) due to a high water alert.

It is also important to bear in mind that, in addition to the delays caused by gate closures motivated by high water levels that actually exceed the established threshold for safeguarding Venice, there will also be further delays due to:

- false alarms;
- routine testing and maintenance;
- extraordinary testing and maintenance.

The principal direct effects, associated with the raising of the barriers, were analysed on the basis of the "ship's cycle", using mathematical simulations to establish the mean additional waiting time accumulated by the ships because of the gate closures.

The "ship's cycle" includes the waiting times at the wharf and inbound and outbound sailing times, the time it takes for docking operations (including hold-ups), and the waiting times at the docks after completing the loading or unloading operations.

The analysis showed that:

- the additional waiting time is not a function of the annual number of closures and is not significantly affected by changes in the volume of traffic;
- the proportion of ships affected by the closures increases virtually linearly with the number of high water events and is only scarcely influenced by the volume of traffic.

- The consequences for commercial traffic

The results of simulations on the number of ships and on the overall value of the losses due to shipping delays have shown that, for the present situation, the operation of the mobile barrier system at the inlets has negligible effects on the ports' activities in the Lagoon, both at Venice and at Chioggia (Table 5.2.1).

As for the cargo traffic, the barrier closures would affect an overall 3.6% of the vessels (for both ports, Venice and Chioggia), despite having conservatively considered in the analysis, a larger amount of traffic than is currently handled by the port of Chioggia. The overall economic burden is estimated at 893 million lire per year.

	Rise in mean sea level (cm)		
	+0	+10	+20
Overall number of ships affected by actual closures, maintenance work and false alarms.	155	295	631
Percentage of total number of vessels in transit	3.6%	6.9%	14.7%
Total number of hours of delay	1,625	2,428	4,298
Total resulting cost (in millions of lire a year)	893	1,333	2,357

Table 5.2.1- *Ports of Venice and Chioggia - Evaluation of the overall effects of the mobile barriers on the cargo traffic*

In addition, both the proportion of the ships affected by the operation of the mobile gates and the consequent annual economic burden tend to increase considerably with a rise in the reference sea level, though they still remain within acceptable values. In the event of a 20 cm rise in mean sea level, the overall proportion of ships affected by the closure of the gates would increase to 14.7%, with a consequent economic burden estimated at 2,357 million lire per year, a figure that is still fairly limited with respect to the total amount of cargo traffic through the two ports involved.

Finally, the creation of a "lighted trail" (*sentiero luminoso*) (to enable shipping to access the port in the fog and at night), which reduces the "ship's cycle", will benefit the activities of the ports by an estimated value of 1,123 million lire per year (for present conditions). Thus, operation of the mobile gates at today's sea level would have no negative bearing on the economic health of the ports. A rise in sea level would be accompanied by residual damage estimated at about 209 and 1,234 million lire per year, respectively, for a 10 cm and a 20 cm increase in mean sea level.

- Consequences for the fishing fleet, passenger traffic and pleasure boat activities

The analysis has shown that the economic effects of the barrier system on fishing fleet, passenger and pleasure craft traffic would be virtually negligible, because the Project provides for the presence of special locks for the smaller shipping vessels at each of the Lagoon inlets.

5.3 Evaluation of the effects of the Project on the productive system

An analysis of the repercussions of activation of the investment in the mobile gates Project on the productive system as a whole was performed for construction and operation phases (including maintenance), distinguishing between the direct effects of the investment on the productive system (local and remote) and the indirect effects as summarised in the following diagram.

Project phase ⇨ **Type of effect** ⇩	***Construction phase***	***Operation and maintenance phase***	**Total effect**
***Direct* effect**	Direct effect of construction phase	Direct effect of operation phase	Sum of the *direct* effects of construction and operation phases
***Indirect* effect**	Indirect effect the construction phase	Indirect effect of operation phase	Sum of the *indirect* effects of construction and operation phases
Total effect	Total effect of *construction phase*	Total effect of *operation phase*	Comprehensive sum of the effects on the economic system

The potential effects generated by the Project on the economic system were evaluated on the basis of a series of representative indicators - i.e. turnover, added value, employment, imports - expressed with reference to the 1992 financial year.

- Effects generated by the construction phase of the Project at the inlets

The economic effects of stimulating demand during the construction of the Project are as follows:

- there are diverse comprehensive effects; in fact, while the direct activated effects (initial activation) coincide with the value of the overall investment (3,700 billion lire), the combined direct and indirect effects (or comprehensive activation) prove greater in consideration of the amplifying effect of "sectorial interdependence" (rising to about 6,585 billion lire);
- the overall (direct and indirect) effect on the different variables considered can be summed up in a growth in activity levels worth about 6,585 billion lire, in a growth in the added value of the system of 3,156 billion lire and in an increase in the level of employment involving about 56,754 people;
- sectorial effects of the redistribution of the added value are characterised in various ways; in fact, with regard to the different levels of added value on the turnover, the sectors that would benefit most from the effect of the investment are represented by:

credit and insurance, businesses services, leasing and rentals, non-metalliferous minerals, and metal products;

- the overall annual effect of the Project, assuming a duration of 10 years of the production phase and with an even distribution of the construction activities over the entire time span of this phase of the Project , can be quantified as follows:
  - production: 658 billion lire per year;
  - added value: 316 billion lire per year;
  - employment: 5,675 posts.

- Analysis of the effects generated by the operation phase of the Project at the inlets

The effects of operating the mobile gates at the inlets are clearly more limited, though - being permanent, they are characterised by a far longer period of interaction which can be assumed to last the predicted working life of the Project (i.e. a hundred years).
The demand for productive input associated with the operation of the Project and its maintenance is estimated at a comprehensive value of 21.5 billion lire per year.
The overall effect of the Project evaluated on an annual basis, assuming a hundred-year duration of the operation and maintenance of the system, can be quantified as follows:

- production: 36 billion lire a year
- added value: 17 billion lire a year
- employment: 277 posts

5.4 Net value of the benefits of the mobile gates Project at the Lagoon inlets

The overall evaluation of the economic worth of the Project at the inlets is presented in the following table (Table 5.4.1), which identifies the individual (short- and long-term) cost components and the specific locations of these costs (where feasible). The comprehensive economic values quantified for the costs avoided as a result of the Project and the *insulae* intervention, as well as for the economic interference on the port activities, have been homogenised to enable their comparison. The overall value was thus determined as follows:

- short-term costs: capitalisation of the annual costs on a 100-year time span (the working life of the Project) at a real rate of 5%;

- long-term costs: for the case of damage that recurs after a given number of years, the method used was identical to the previous case. For damage that is not repetitive, the cost was capitalised on the time span of its occurrence, again at a real rate of 5%;
- the interferences, originally defined on an annual basis, the value was established by means of capitalisation of the losses (i.e. greater costs) suffered on a 100-year time horizon at a real rate of 5%.

As illustrated in the table, the overall value of the avoided costs, capitalised according to the previously mentioned indications, was considerable, even for the assumption of the mean sea level remaining more or less the same as today. With a rise in mean sea level, on the other hand, the value of these avoided costs tends to increase rapidly.

Costs avoided in the short term*	Scenarios			
	Present situation	10 cm rise in mean sea level	20 cm rise in mean sea level	30 cm rise in mean sea level
VENICE	670.6	1,596.8	4,021.6	9,388.3
OTHER TOWNS AND VILLAGES	184.5	607.3	1053.5	2,285.6
TOTAL COSTS AVOIDED IN THE SHORT TERM (in billions of lire)	**855.1**	**2,204.1**	**5,075.1**	**11,673.9**

*(average of hypotheses I and II Chapter C3.1.3)

Costs avoided in the long term*	Scenarios			
	Present situation	10 cm rise in mean sea level	20 cm rise in mean sea level	30 cm rise in mean sea level
Lagoon banks	615.0	892.8	1,190.4	1,845.1
Morphology (loss of sediment)	79.4	91.3	105.2	113.1
Drainage basin	3.8	30.8	486.1	98.5
Banks (after flooding)	331.3	331.3	58.8	542.6
Buildings affected by wave motion	45.0	45.0	45.0	45.0
Capillary Rise	1,771.0	1,780.6	1,849.0	1,898.7
Sewer lines and septic tanks	267.1	414.4	494.0	556.0
TOTAL COSTS AVOIDED IN THE LONG TERM (**) (in billions of lire)	**3,112.6**	**3,586.2**	**4,228.5**	**5,099.0**
COMPREHENSIVE TOTAL (in billions of lire)	**3,967.7**	**5,790.3**	**9,303.6**	**16,772.9**
ECONOMIC INTERFERENCES (port activities)	**-17.7**	**-26.7**	**-46.8**	==
NET BENEFIT	**3,950.0**	**5,763.6**	**9,256.8**	==

Table 5.4.1 *Overall estimate of the economic value of the mobile barrier (in billions of lire)*

(**) Difference between long-term costs for the current situation and residual costs with the presence of the insulae and mobile gates at the inlets. (See Par. C3.1.4 - sec. C).

6. MONITORING

During both construction and operation phases a monitoring system will be implemented to verify and confirm the predicted levels of impact and to identify any unforeseen types of impact for which the necessary corrective measures can be undertaken. The monitoring system will also aid in improving the general understanding of the Lagoon system and, in particular, the validity predictive tools available (such as mathematical models). For example, the monitoring system will include use of the mathematical models already applied during the Project design phase in order to study the hydrodynamics, water quality, morphology of the Lagoon as well as navigation therein.

The data emerging from the monitoring operations will enable continual updating of the mathematical models, better adapting them to the cause-effect relationships of phenomena taking place in the Lagoon, and further verification of the Project design parameters (particularly in its more advanced stages) and of the environmental parameters.

For each geographical area involved, the parameters that were deemed important to monitor during the construction and operation phase of the Project are listed below.

Construction phase

	GEOGRAPHICAL AREA INVOLVED			
PARAMETERS	**Inlets**	**Lagoon**	**Inhabited Centers**	**Notes**
Water quality	x	x		Hydrocarbon content
Turbidity	x	x		Concentration
Current	x			Speed and direction
Wave motion	x			Wave height and period
Wind	x			Speed and direction
Tide	x			Levels and times
Submerged Lagoon floor	x	x		Erosion/sedimentation
Maritime traffic	x	x		
Fishing traffic	x			

Some of the above-mentioned parameters that most affect the environment are water quality, turbidity, currents, wave motion, wind and the survey of the Lagoon bed.

Water quality

Certain activities involved in construction (the use of mechanical and self-propelled vehicles) must be monitored since they may give rise to the spillage of pollutants (hydrocarbons). Monitoring will serve to identify any causes and origins of contamination and to design appropriate corrective measures. The data collected can be evaluated with the dispersive mathematical model to help interpret eventual accidental spillage episodes.

Turbidity

The dredging and filling activities could increase the amount of fine material in suspension and consequently increase the turbidity of the water. The purpose of monitoring is to identify any increase in turbidity in the bodies of water near the inlets. Furthermore, the data will be input into the dispersive model for use in planning the reconstruction of the corresponding deposits.

Data on *Current* and *Wave motion* may be useful in evaluating the direction in which any spillage and turbidity tend to disperse, while monitoring the *Wind* speed and direction will provide further information for controlling spillage through the use of specific models (the mathematical dispersive model and a hydrodynamic model).

Finally, data on the submerged Lagoon floor, such as depths, will be used for following up any erosion or sedimentation caused by the construction activities and will therefore be used in direct evaluations and in analyses using models of equilibrium calibrated for the Lagoon inlets.

Operation phase

PARAMETERS	Drainage basin	Lagoon Inlets	Adriatic sea	Extended geographical area
	GEOGRAPHICAL AREA INVOLVED			
Tide at inlets		x		
Tide in Lagoon		x		
Rain	x	x		
High water prediction		x	x	x
Current at inlets		x		
Wave motion		x	x	
Water quality	x	x	x	
Cargo and passenger traffic		x	x	
Fishing traffic		x	x	

Among the above parameters, those necessary for identifying the moments in which the gates are to be closed are the prediction of a high water episodes and the water levels (tide) at the inlets and in the Lagoon. The other parameters serve the alternative purposes of ascertaining that there is no hindrance to the closure (as in the case of monitoring the maritime traffic), of regulating the procedures for raising and lowering the gates, and of controlling the effects of gate closure. The monitoring data relating most directly to the operation of the gates will be stored in a database and interpreted using analytical procedures and mathematical models for evaluating the effects of the closures and the future trend of the Lagoon system.

For *Water quality*, in particular, continuous measurements will be taken of the chemico-physical parameters (dissolved oxygen, pH, temperature, etc.) and chemico-biological factors (e.g., nitrogen compounds, phosphates, chlorophyll-a, density of macro-algal coverage), and of the physico-chemical and biological conditions of the sediment. The chemico-biological parameters, in particular, will be used to study macro-algal growth mechanisms. The dispersive model will be used for evaluating the influence of the Lagoon hydrodynamics and the ecological model will evidence the effects of chemical and biological processes.