Rijkswaterstaat
Ministerie van Infrastructuur en Waterstaat

Waterway Guidelines 2020

Water. Wegen. Werken. Rijkswaterstaat.

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Contents

Foreword

Transport by water is important for the Netherlands as a country strong on logistics, and not only from an economic perspective. It is also a sustainable alternative to transport by road. As managers of the country's waterways, we are therefore working to ensure they are modern, reliable and well designed, with sufficient depth, width and headroom that skippers can proceed with even more speed and even more safely.

The 'Waterways Guidelines' make a major contribution to this endeavour. First published in 1990, they contain instructions for the technical design of waterways in transport engineering terms, and their maintenance. The guidelines are updated regularly to incorporate the latest scientific and technical knowledge and insights, and comply with any new legislation.

The most recent version of the guidelines dated from 2017, and was ready for an update. This time, the update has been based on extensive research by Marin and Deltares, which has made it possible to add guidelines for navigation channels in rivers. This is a valuable addition, as designing a navigation channel in a river is a difficult task. Currents, differences in water level, the dynamics of the waterway bottom and the navigation behaviour of vessels is much more complex on rivers than on canals.

This development fulfills a long-held wish of many waterway management authorities and designers. Navigation channels in rivers are not only easier to design now, the new guidelines also offers guidance for many other projects, from building bridges and replacing weirs, to restructuring and enhancing the sustainability of rivers.

Hopefully, these updated guidelines will once more contribute to a safe, efficient and sustainable sector. The revised edition was again compiled in close collaboration with other waterway management authorities. By applying the guidelines uniformly, we can improve the efficiency and consistency of the network of waterways in our country. Ultimately, this will enable us to achieve the goal we all work towards: constant improvements to our waterways that serve the needs of waterway users, the surrounding areas and waterway management authorities to the fullest possible extent.

We hope they prove useful to you!

Michèle Blom
Directeur-General, Rijkswaterstaat

1 Introduction

1.1 History of the guidelines

1.1.1 *Waterway Management Authorities Committee*

On 28 April 1977 the then Director-General of *Rijkswaterstaat*, having consulted the heads of the provincial public works and water management services, established the Waterway Management Authorities Committee (CVB).

The establishment of the Committee was prompted by the Policy Document on Waterways (ref. 1), a draft of which appeared in 1975, quickly followed by the Waterways Structure Plan (ref. 2). The former publication noted that design standards were already available for the larger waterways, but not for the smaller ones. The original goal of the CVB was to draw up guidelines for the design and dimensions of smaller waterways in classes I to III in accordance with the Conférence Européenne des Ministres de Transports (CEMT) classification. It later also set out guidelines for class IV and V waterways and for recreational waterways. The Committee's final report was published in 1996, and officially adopted by G. Blom, then Director-General of *Rijkswaterstaat*.

The CVB was disbanded once it had published its final report. At that point it was decided that *Rijkswaterstaat* would be responsible for updating the guidelines. This task was given to the Centre for Water, Transport and Environment (WVL, formerly known as the Centre for Transport and Navigation and, prior to that, the AVV Transport Research Centre). The Committee was already aware at the time that, thanks to changes in the fleet, particularly an increase in the use of bow propellers, further research was required on a number of matters, and that the Waterway Guidelines would have to be supplemented and corrected. Experts from AVV and *Rijkswaterstaat's* Infrastructure Department (as RWS Centre for Infrastructure was formerly known) performed the research and AVV published the results in a supplement to the Waterway Guidelines that appeared in 1998.

1.1.2 *Waterway Guidelines 2005*

Over a number of years, the Waterway Guidelines convincingly proved their worth as they were used in practice. Nevertheless, new developments occurred, in both regulation and daily practice, that meant the 1996 guidelines needed updating. On 7 December 2000 *Rijkswaterstaat's* former Shipping Consultative Group (*Overleggroep Scheepvaart*) agreed to a proposal to adapt the Waterway Guidelines, and expand on certain points. The project was carried out by an AVV project group and the Infrastructure Department. A focus group consisting of representatives of *Rijkswaterstaat* and the provincial and harbour authorities supported the project group. The final text was submitted to and approved by representatives of the recreational and commercial navigation sectors.
The project began with an informal survey among users of the Guidelines. Their wishes and comments had a decisive influence on the Waterway Guidelines 2005. The structure had changed since the 1996 version, though the original guidelines still formed the core of the document.

1.1.3 *Waterway Guidelines 2011*

The great demand for the Guidelines for Waterways 2005, which soon sold out, meant that a new version had to be published. Users' questions and comments were incorporated into the guidelines and the latest developments and insights were taken into account. These changes did not however substantially change the tenor of the Guidelines, requiring immediate infrastructural changes.

1.1.4 *Waterway Guidelines 2017*

New insights and developments meant the Waterway Guidelines 2011 needed revising. This involved, first and foremost, the integration of the Waterway Guidelines Supplement that had been published in 2013, which includes guidelines for class VI. *Rijskwaterstaat's* development of frameworks for bridges and locks necessitated changes to chapter 7. Finally, research results on the simplification of fenders had become available.
The update addressed many user questions and comments. The changes did not however substantially alter the tenor of the Guidelines, which would have required immediate infrastructural changes.

1.1.5 *Waterway Guidelines 2020*

The publication of this version of the Waterway Guidelines means they no longer apply only to waterways with a longitudinal current not exceeding 0.5 m/s – mainly canals and lakes. Years of research by Marin and Deltares have allowed the Waterway Guidelines to be extended to cover upstream stretches of river (drainage-dominated), downstream stretches (tide-dominated) and rivers that can be dammed. The update also addresses questions and comments from users.
As is customary, the final version was presented to and approved by representatives of commercial and recreational navigation sectors, provincial authorities, and port and harbour management authorities.

1.2 Status of the guidelines

1.2.1 *Framework*

The Guidelines cover the technical design of waterway sections, locks, bridges and harbours for inland navigation from class I to VIc (commercial navigation) and ZM-A to MD (recreational navigation), and provide instructions applicable to the building and renovation of waterways and facilities. All elements and dimensions in figures, tables and text continue to apply in full.

Experience has shown that in many cases, stipulating that the Waterway Guidelines be adhered to in tendering procedures is not enough. They must be accompanied by further specifications applicable to the project at hand. Waterway management authorities must be involved in drafting these specifications.
RWS has basic specifications on things like the design of bridges and fenders at locks, which can be found in the RWS Practical Guide (*Werkwijzer RWS*).

The Waterway Guidelines serve as a framework for *Rijkswaterstaat*. In other words, they are mandatory, and may be deviated from only with the prior approval of the

construction and maintenance process owner. *Rijkswaterstaat* has a process for planned deviation from the Waterway Guidelines, which can be found in the Werkwijzer.
The provincial waterway management authorities have also committed to the Waterway Guidelines, and provide internal accountability in the event of any deviation from the guidelines.

Many of the National Waterways in rivers – specifically the Rhine, Waal, Lek and their direct connections to the sea - are subject to the Mannheim Convention (ref. 83). The Central Commission for the Navigation of the Rhine (CCNR) monitors compliance with the Convention, and promotes inland navigation. In cases where the instructions in the Waterway Guidelines would lead to a different outcome, the requirements of the CCNR concerning works in the waters covered by the Act (ref. 79) take precedence.

1.2.2 Deviation from the guidelines

Uniform application of these Guidelines by all waterway management authorities fosters the safe, smooth handling of shipping traffic. A management authority may however deviate from the Guidelines, provided the alternative solution also guarantees smooth, safe and reliable navigation. It is important that waterway management authorities are able to provide sound arguments to support any deviations from the Guidelines, that they be documented, and that users be adequately informed.

1.2.3 Due care

The greatest possible care has been taken in drawing up the Waterway Guidelines. Draft guidelines, in both the original versions and the current edition, have been co-ordinated with and approved by representatives of the inland navigation and recreational navigation sectors and by waterway managers and other specialists at *Rijkswaterstaat*, provincial authorities and port authorities. The Guidelines can therefore be regarded as technically and nautically sound solutions for smooth, safe, reliable navigation. Design in accordance with the Guidelines will present waterway users with highly predictable situations on the waterways.

1.2.4 Management of the Waterway Guidelines

As indicated in § 1.1.1, responsibility for keeping the Waterway Guidelines up-to-date rests with *Rijkswaterstaat*, more specifically its Centre for Water, Transport and Environment (WVL). Any questions or comments concerning the text should be sent to the *Rijkswaterstaat* WVL Information Desk, at the following email address: informatiepuntwvl@rws.nl.

1.3 Use of the guidelines

1.3.1 Definition of scope

The Waterway Guidelines cover only:
- the technical design in terms of transport engineering; the structural design is beyond the scope of the Guidelines
- waterways in CEMT classes I to VI and recreational waterways
- waterways not primarily intended for sea shipping

The shipping lanes in the North Sea and Wadden Sea are not covered by the Waterway Guidelines.

1.3.2 *Design process*

The design process depicted in figure 1 is based on waterway elements such as waterway sections, locks, bridges and harbours, and is virtually identical to the structure (chapters) of this document. The design process for a waterway or associated engineering works consists of the following stages:

1. Determine the desired CEMT class, taking account of future developments

2. Choose the motor cargo vessel, pushed convoy or coupled unit appropriate to the waterway class (chapter 2). Every waterway class has a single reference motor cargo vessel, pushed convoy and coupled unit. The most stringent requirement or combination of several requirements (length, beam, draught, height etc.) is the reference value for each aspect of the design of the waterway.

3. In the case of new waterways, determine the waterway profile (§ 3.2): the choice of normal, narrow, high-volume or single-lane profile depends on the expected volume of traffic. On existing waterways, the existing profile is standard, insofar as it is larger than the planned design profiles.

4. Define the hydraulic parameters (§ 3.3): it is particularly importance to make the correct choice of reference high and low water level for shipping (MHWS or MLWS).

5. Define the wind conditions (§ 3.4): is the waterway in a coastal or inland zone?

6. Fill in the technical details of:
   - waterway sections (§ 3.5 to § 3.12)
   - locks (chapter 4)
   - bridges (chapter 5)
   - harbours (chapter 6)

7. Specify how facilities are to be operated (hoofdstuk 7).

8. Determine whether and which waterway markings can be found in the 2008 edition of the Shipping Signs Guidelines (*Richtlijnen Scheepvaarttekens*, ref. 22).

9. Include management and maintenance in the design (chapter 8).

For easy reference, a subject index has been included in the appendices. Symbols and definitions of terms are also explained in the appendices. A bibliography summarising literature references and background reports has also been included.

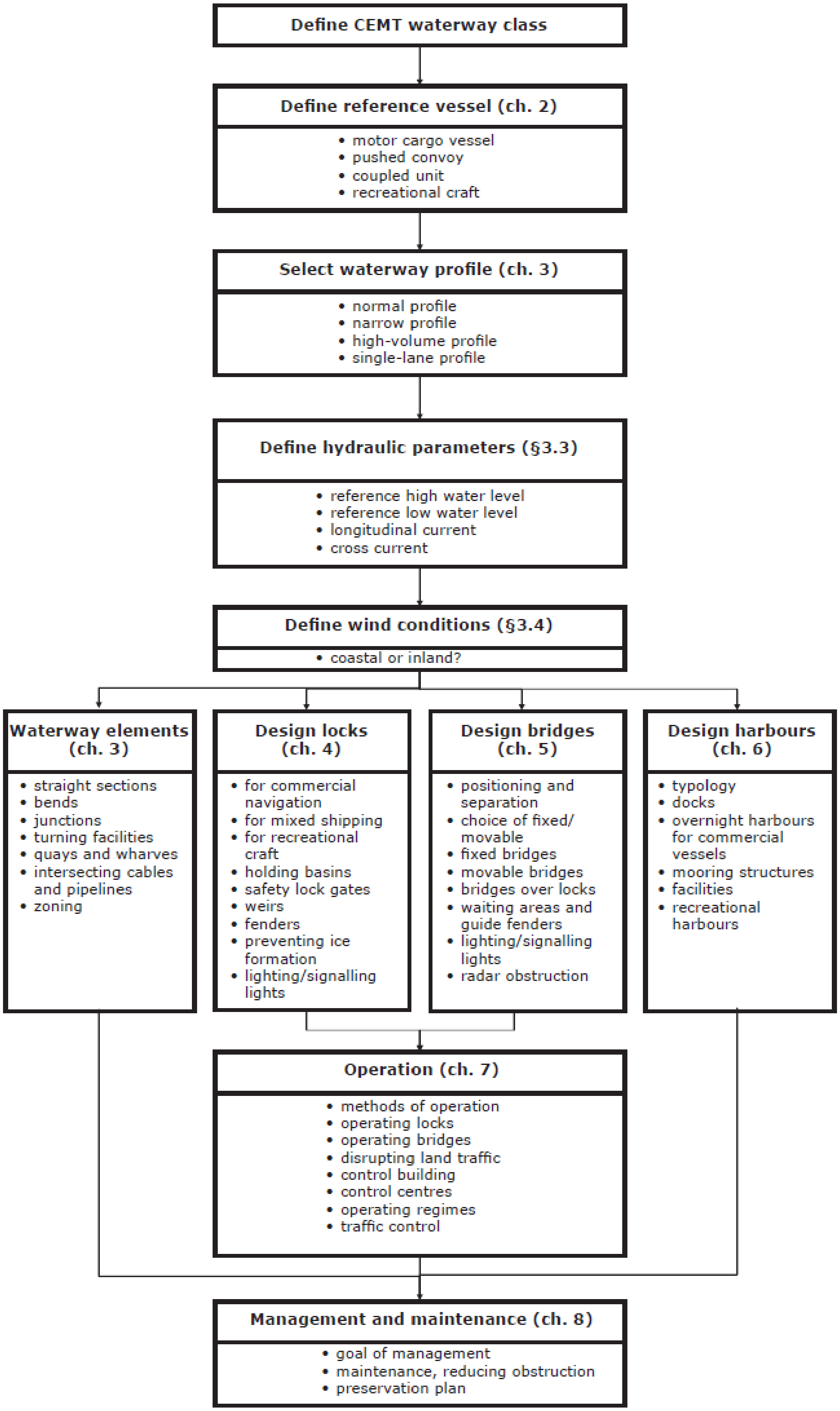

Figure 1: Flow diagram of the Waterway Guidelines design process

2 Reference vessels

2.1 History

2.1.1 *Standardisation*

Europe's rivers have traditionally formed the backbone of its waterway network, connected over the years by canals. The locks in the canals dictated the maximum size of vessel that the waterway could accommodate. International coordination was virtually non-existent in the past, however. In 1879 the French minister of public works, Charles de Freycinet, launched legislation to upgrade and construct 9000 km of canal. The legislation defined the standard vessel dimensions as 38.5 x 5.05 m. As a result, the péniche, which at the time had a cargo capacity of 300 tonnes, was deemed to be the standard vessel on the French canal network. The Dortmund-Ems Canal and Rhine-Herne Canal in Germany, both built in the early 20th century, were so important for shipping in the Rhine basin that vessels with a cargo capacity of 1000 and 1350 tonnes respectively were developed, based on the locks on these two canals. In the Netherlands, the Ringers Commission issued recommendations for the dimensions of the waterways in the west of the country in 1932, and in 1950 the Kloppert Commission produced recommendations for the northern Netherlands (refs. 3 and 4).

2.1.2 *CEMT-classificatie*

It was not until 1954 that the Conférence Européenne des Ministres des Transports (CEMT) accepted an international classification system which divided waterways into five classes, depending on their horizontal dimensions. The system was based on the dimensions of five types of vessel that were common in Western Europe at the time. The class to which a waterway belongs depends on the largest standard vessel it can accommodate. The CEMT recommended that the class IV vessel, the Rhine-Herne Canal type, be used as the standard for waterways of European importance, which is why it was often referred to as the 'Europe vessel'. The CEMT also set out guidelines for the dimensions of canals, bridges and locks on class IV waterways. The first pushed convoy travelled along the Rhine in 1957, and push-towing soon took off. The CEMT responded in 1961 by adding a class VI to its classification. After a time, however, this classification turned out to be inadequate. PIANC, the World Association for Waterborne Transport Infrastructure, took charge of revising the system. A working group specially set up for the purpose produced a report in 1990, and later published a supplement in the form of a study on class Vb waterways (refs. 5 and 6). This prompted the CEMT and the United Nations Economic Commission for Europe (ECE) to produce a uniform new classification, known as CEMT1992 after the year it was adopted (ref. 7). This classification takes account of East European waterways, which generally have slightly smaller dimensions than similar waterways in Western Europe. Table 1 shows only the dimensions relevant to Western Europe (west of the Elbe).

	Type de voies navigables / Type of Inland waterways	Classe de voies navigables / Classes of navigables waterways	Automoteurs et chalands / Motor vessels and barges — Type de bateaux: caractéristiques générales / Type of vessel: générales characteristics					Convois poussés / Pushed convoys — Type de convoi- Caractéristiques générales / Type of convoy- Générales characteristics					Hauteur minimale sous les ponts / Minimum height under bridges
			Dénomination / Designation	Longueur / Length	Largeur / Beam	Tirant déau / Draught	Tonnage / Tonnage		Longueur / Length	Largeur / Beam	Tirant déau / Draught	Tonnage / Tonnage	
				m	m	m	t		m	m	m	t	m
D'INTERET REGIONAL	OF REGIONAL IMPORTANCE	I	Péniche Barge	38.50	5.05	1.80-2.20	250-400						4.00
		II	Kast-Caminois Campine-Barge	50-55	6.60	2.50	4.00-650						4.00-5.00
		III	Gustav Koenings	67-80	8.20	2.50	650-1000						4.00-5.00
D'INTERET INTERNATIONAL	OF INTERNATIONAL IMPORTANCE	IV	Johan Welker	80-85	9.50	2.50	1000-1500		85	9.50	2.50-2.80	1250-1450	5.25/or 7.00
		Va	Grand bateaux Rhenands/Large Rhine Vessels	95-110	11.40	2.50-2.80	1500-3000		95-110	11.40	2.50-4.50	1600-3000	5.25/or 7.00/or 9.10
		Vb							172-185	11.40	2.50-4.50	3200-6000	
		VIa							95-110	22.80	2.50-4.50	3200-6000	7.10/or 9.10
		VIb		140	15.00	3.90			185-195	22.80	2.50-4.50	6400-12000	7.10/or 9.10
		VIc							270-280 193-200	22.80 33.00-34.20	2.50-4.50 2.50-4.50	9600-18000	9.10
		VII							285 195	33.00 34.20	2.50-4.50	14500-27000	9.10

Tabel 1: CEMT 1992 classification of waterways west of the Elbe (NB: some of these values have been partially adapted for use in the Netherlands, see §2.2)

2.1.3 *Notes on and use of CEMT table*

Several footnotes have been added to the original CEMT table. The waterway class is determined by the horizontal dimensions of the vessels, particularly the beam. The RWS 2010 classification (Table 8) of the inland navigation fleet is also based on these dimensions. The smallest dimensions of the reference vessel in the table are the lower limit for classifying a waterway in a particular standardised class. The largest dimensions of the reference vessel are used as a basis for designing waterways and engineering structures.

The CEMT table does not list the characteristics of coupled units, because such combinations rarely occurred at the time when the table was originally drafted. These Guidelines do however include the dimensions of coupled units (Table 7).

The draught depends above all on the local conditions, and the value listed in the CEMT table is merely indicative. The tonnage given is also indicative. The columns showing draught and tonnage in the CEMT table are not the reference draught of the vessels, and are not therefore the reference for the design of waterways. Reference draughts are described in § 2.2 to § 2.5.

The figure for the minimum headroom under bridges includes a safety margin of 0.30 m between the highest point of the vessel when it is fully loaded and the underside of the bridge. The minimum headroom including safety margin in the current CEMT table is as follows:

- 5.25 m for vessels with 2 layers of containers
- 7.00 m for vessels with 3 layers containers
- 9.10 m for vessels with 4 layers containers

50% of the containers may be empty, or there may be ballast on board. The height above the waterline of the reference vessel, which may be greater, must of course also be taken into account.

Measurements on the Rhine have however shown that the height above the waterline of vessels loaded with containers has increased (ref. 62), largely as a result of the growing proportion of extra high (30 cm) containers, known as 'high cubes' (see also § 2.3.3). A number of cost-benefit analyses (refs. 63 and 80) have shown that a generic heightening of bridges is not under discussion. As a result, the Minister of Infrastructure and Water Management has decided that the headroom will continue to be defined by the current CEMT standards applying to Dutch waterways and that the link with the number of layers of containers introduced in the CEMT '92 classification should be abandoned.
Seaport regions, where tunnels or movable bridges with a minimum headroom of 11.35 m are preferred, constitute an exception to the current CEMT standard heights.

The Minister of Infrastructure and Water Management may also decide to stipulate more headroom on the four promising waterway corridors Western Scheldt - Rhine/Antwerp - Rotterdam, Amsterdam - Rotterdam, Amsterdam – Northern Netherlands and the canalised sections of the Maas route: Weurt - Born (ref. 81).

The minimum headroom for new bridges may not at any rate be less than the headroom of existing or planned bridges in the vicinity, so as not to introduce any further restrictions.

A minimum of class Vb is currently used as the European standard for international routes, with a minimum headroom of 7.0 m for container transport. When existing regional waterways are upgraded or new ones built, the CEMT stipulates that efforts should be geared to achieving at least class Va. Account must be taken of the current dimensions of reference vessels as listed in § 2.2 to § 2.5. There are no class VII waterways (for nine push barges) in the Netherlands.

The following specifications apply to the upgrading of existing and design of new national waterways in the Netherlands:

- suitable for class Va with 3.5 m draught
- minimum headroom of 9.10 m
- normal profile

It has been found that some figures in the CEMT table are obsolete as a result of the scaling up that has occurred in shipping. This prompted *Rijkswaterstaat* to develop its own classification in 2010 (see § 2.2.2) and PIANC to establish the international Working Group 179 in 2015 to produce recommendations for a review of the current CEMT classification.

2.1.4 *Basic Blueprint for Recreational Touring in the Netherlands*

As prosperity grew after 1960, so did recreational navigation. In the summer, some Dutch waterways carry more recreational craft than commercial vessels. The talks on the Waterways Structure Plan were hampered by the lack of a vision for recreational navigation. Recreational touring was seeing particularly strong growth, just at a time when smaller waterways suitable for touring were being closed. It was decided that the national and provincial authorities, industry and interest groups should develop a vision for recreational navigation. This led to the publication, between 1985 and 2013, of several editions of the policy document on recreational touring in the Netherlands. Since 2015 the Basic Recreational Touring Network (BRTN) has been incorporated into the Basic Blueprint for Recreational Touring in the Netherlands 2015-2020 (ref. 8) and into individual provincial ordinances.

The BRTN focuses on recreational touring, i.e. sailing and motor boats with permanent accommodation facilities for overnight stays onboard and trips lasting several days. In practical terms, these are boats from approx. 6 m in length, with an engine. The authors of the BRTN devised a classification for navigation areas linked to standard draughts and heights, as reported in § 2.6.

2.2 Commercial navigation: general

2.2.1 *Determining waterway class and reference vessel*

The design process starts with the definition of the desired CEMT class. There are three types of cargo-carrying commercial vessels: motor cargo vessels, pushed convoys and coupled units. Once the waterway class has been selected, the reference motor cargo vessel, pushed convoy and coupled unit must be defined. The reference vessel is the largest vessel that can smoothly and safely navigate the waterway in question. This vessel determines the dimensions in the technical design of the waterway and the associated engineering structures.

The structural design is determined by the most stringent requirement or combination of requirements associated with the reference motor cargo vessel, pushed convoy or coupled unit, though other vessels might also be used. Possibilities include tugboats, which can cause larger stern waves and is thus the reference for bank protection. The cargo capacity values traditionally listed in the tables cannot be used directly for structural design, as a factor needs to be applied to give total water displacement, which is a higher value.

The choice of reference vessel is based primarily on horizontal dimensions, with the beamas the most important factor. Dutch lock chambers are often longer than a single vessel, so length is not the defining criterion. The draught and height of the ship can be influenced to some extent by the amount of cargo or ballast it is carrying.

Reference vessels have the dimensions listed in table 8, but the waterway management authority may choose a reference vessel with other dimensions if it better represents the traffic on the waterway in question. The management authority's choice determines the waterway's CEMT classification. When a new waterway is built or an existing waterway is upgraded, the largest dimensions of the reference vessel in table 8 form the basis for the design.

In exceptional cases, the waterway management authority can permit vessels larger than the reference vessel access to a waterway. When such vessels are admitted, additional measures or licence conditions must be put in place to guarantee smooth, safe navigation of the waterway. On national waterways an exemption may be granted from the permitted dimensions under article 9.03, paragraph 3 of the inland waterways police regulations (BPR). The framework for this can be found in the *RWS Werkwijzer*.

Besides cargo-carrying motor cargo vessels, pushed convoys and coupled units, vessels without cargo may also use the waterway: passenger ships, charter ships, speedboats, fishing vessels, large cargo transporters etc. Any such unusual ships with anomalous dimensions or features must generally hold a licence to use the waterway.

2.2.2 RWS 2010 classification of the inland navigation fleet

Further analysis (refs. 9 to 11) has shown that the figures in the CEMT table are no longer representative of the current West European inland navigation fleet and do not reflect the scale expansion that has occurred. Vessels have been repeatedly lengthened, so a greater length – and therefore a larger tonnage – is now often associated with a standard beam than indicated in previous versions of the Guidelines. The draught when fully loaded is also often greater than that shown in the CEMT table.

Table 8 shows the Rijkswaterstaat (RWS) 2010 classification for design and construction, incorporating the dimensions of the current fleet. The table is a further specification of the CEMT table, with the current largest motor cargo vessels and coupled units added. The margin for the length of the reference vessel is plus or minus 1 metre, and for the beam it is plus or minus 10 cm. A vessel's CEMT class is primarily defined by the beam and length criterion. The classification based on tonnage is not accurate.

Tables 2 to 7 are in fact a summary of the more detailed RWS 2010 classification (Table 8) for the design and construction of waterways. When new waterways are built or existing ones upgraded, the largest reference vessel in the CEMT class must be taken as the basis. Classes M3, M4, M6, M8, M10 and M11, with smaller dimensions than the reference vessel, represent the lower limit for classification of a waterway in a particular CEMT class, and are used only when existing waterways, locks and bridges are renovated.

2.3 Motor cargo vessels

2.3.1 Reference motor cargo vessels

The characteristics of reference motor cargo vessels for the Dutch waterways are listed in Table 2. These are the average values for reference vessels, i.e. the largest vessels in a certain class, not the average of the entire class. The data shown in Table 2 are partly based on new research into the characteristics and manoeuvring mechanisms of large vessels (refs. 9 and 11). Extended vessels occur mainly in classes III, IV and Va, which is why two sets of measurements are given in the table. In practice, the class VIa motor cargo vessel has dimensions that differ from those envisaged by the CEMT. For the sake of consistency, the 'Rhinemax ship' has been designated as class VIa rather than class VIb.

The reference draught is defined in Table 2 on the following basis: the average maximum draught for the waterway in question is the reference value, i.e. the largest vessel. Some vessels navigate with a smaller draught, since they are by no means always fully laden, due to draught restrictions elsewhere, transport of low-density goods or consignments smaller than the vessel's maximum cargo capacity. The draught criterion applies to the reference vessels in a certain class. The lower-class vessels on the waterway thus experience fewer draught restrictions, if at all. Ships often travel laden on the way to their destination and empty on the return journey. This does not apply to container ships. However, since they also transport empty containers, laden container ships rarely travel at their maximum draught.

Table 2 shows the average total capacity of the main engines and bow propellers of the reference vessels in a particular class. In combination with the draught, they determine the vessel's burden on the fairway bottom and bank protection, in mooring places or the holding basins of locks, for example. When calculating the reference flow rates in the propeller races, the maximum capacity of the vessels using the waterway and the maximum capacity usage in the event of the least favourable combination of engine capacity and depth during the lifetime of the fairway bottom and bank protection should be used, rather than the average maximum capacities in table 2. NB: oceangoing ships on inland waters (Table 12) generally have a greater draught than those given for motor cargo vessels in Table 2.

CEMT class	beam (m)	length (m)	draught (m) laden	empty	height above waterline (m)	cargo capacity (ton)	engine capacity (kW)	bow propeller (kW)
I	5.05	38.5	2.5	1.2	4.25	365	175	100
II	6.6	50 - 55	2.6	1.4	5.25	535 - 615	240 - 300	130
III	8.2	67 - 85	2.7	1.5	5.35	910 - 1250	490 - 640	160 - 210
IV	9.5	80 -105	3.0	1.6	5.55	1370 - 2040	750 - 1070	250
Va	11.4	110 - 135	3.5	1.8	6.40	2900 - 3735	1375 - 1750	435 - 705
VIa	17.0	135	4.0	2.0	8.75	6000	2400	1135

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Table 2: Characteristics of reference motor cargo vessels

2.3.2 *Class characteristics*

The class characteristics refer to all vessels in the class in question, not only the reference vessels, which merely represent the upper limit. The class characteristics of motor cargo vessels are given in Table 3. The height above the waterline is defined in Table 3 as the height that is not exceeded by 90% of empty vessels in a certain class (see also § 5.4.2). Table 3 does not take any account of container loads, which are considered in the following section.

CEMT class	height above waterline 90% (m) empty	laden	average cargo capacity (tonnes)	average engine capacity (kW)
I	4.65	3.35	365	175
II	5.8	4.6	540	250
III	6.3	5.1	935	435
IV	6.7	5.3	1505	690
Va	7.1	5.4	2980	1425
VIa	10.0	8.0	5125	2015

Table 3: Class characteristics of motor cargo vessels

Almost all motor vessels now have a bow propeller or active bow rudder. This applies to over 98% of vessels in classes III to VI. As a result, their manoeuvrability at low speeds has increased considerably. This is important when determining the need for waiting areas at locks and movable bridges, as there is now less need for vessels to moor up because a skipper can keep his vessel moving more easily using the bow propeller. Coupled units and single and double pushed convoys do not always have a propeller on the push barge, though motor cargo vessels used for pushing do.

2.3.3 *Container ships*

Vessels for transporting containers do not generally look any different from vessels that carry conventional loads, except for the fact that most container ships have a vertically movable wheelhouse. A standard container is 8 feet 6 inches, or 8½ feet, high (= 2.60 m) and 8 feet wide (= 2.44 m). However, high cube containers with a height of 9½ feet (= 2.90 m) are becoming more and more common. Recent measurements on the Rhine have shown that the height above the waterline of vessels loaded with containers has consequently increased (ref. 62). These measurements showed that 90% of passing container ships would need headroom of 5.80 m (2 layers of containers), 8.50 m (3 layers) or 11.05 m (4 layers). This, combined with a number of additional cost-benefit analyses, has led to a change of policy concerning the headroom under bridges over national waterways, which can be found in §2.1.3.

Table 4 gives the capacity of several types of vessel expressed in TEU (twenty-foot equivalent units, equal to 6.06 m). Most containers transported by inland vessel measure 40 feet (= 12.20 m) and count as 2 TEU. There are also anomalous sizes, such as 45 feet (= 13.72 m), pallet-wide containers with an external width of 2.50 m.

vessel class or type	container capacity (TEU) beam x height x length
II/III	2 x 2 x 7 = 28
Neokemp*	2 x 3 x 8 = 48
IVa	3 x 3 x 10 = 90
Va	4 x 4 x 13 = 208
Va extended	4 x 4 x 17 = 272
VIa	6 x 4 x 17 = 398
E I – push barge	3 x 3 x 9 = 81
E II – push barge	4 x 4 x 10 = 160

* The Neokemp type vessel was specially designed for small waterways

Table 4: Container capacity of several types of vessel

When placing containers in the hold vessels must take account of the defined headroom, or they must use ballast to reduce their height to the defined value, in so far as the depth of the waterway allows. The correct choice of reference high water level for shipping is essential for determining headroom; see also § 3.3.

Generally speaking, container ships have a vertically movable wheelhouse that can be lowered to below the height of the cargo when passing under bridges. Sometimes, however, a container ship's height above the waterline is greater than the height of the container cargo, and this is thus the reference height for bridges. Vessels laden with containers generally have a smaller draught than indicated in Tables 2, 7 and 8.

2.4 Push towing

2.4.1 Push barges

Although the Europa II type push barge is the most common, there are other standard push barges. The main ones are listed in Table 5. In addition, some 30% of national transportation by push barge is carried out by barges smaller than Europa I. The beam of such barges is generally the same as that of motor vessels in the same class. The draught of an empty barge is approximately 0.6 m, and that of a push boat is 1.8 m.

CEMT class	type of push barge	beam (m)	length (m)	draught when laden (m)	cargo capacity (tonnes)
IV	Europa I	9.5	70.0	3.0	1450
Va	Europa II	11.4	76.5	3.5	2450
Va	Europa IIa	11.4	76.5	4.0	2780
Va	Europa IIa extended	11.4	90.0	4.0	3220

Table 5: Characteristics of reference push barges

2.4.2 Pushed convoys

The combination of a push boat and a number of push barges is known as a push convoy. The analysis referred to above (ref. 9) indicated that a number of combinations of push barges and push boats occur fairly commonly (Table 6). For the method of determining reference dimensions, see § 2.2.

No standard dimensions can be given for push boats, because many small push boats are in fact converted tugs. In connection with the maximum length of a push convoy permitted on the Rhine, the heaviest type of push boat is approx. 40 m in length and approx. 15 m wide. Such push boats have a propulsion power of up to 4000 kW, while small push boats generally have no more than 1500 kW.

CEMT class	type of pushed convoy	beam (m)	length (m)	draught when laden (m)	cargo capacity (tonnes)
I	1 barge in front	5.2	55	1.9	≤ 400
II	1 barge in front	6.6	60 – 70	2.6	401-600
III	1 barge in front	8.2	85	2.7	601-1250
IV	1 barge in front Europa I type	9.5	85 – 105	3.0	1251-1800
Va	1 barge in front Europa II type	11.4	95 – 135	3.5 - 4.0	1801-3950
Vb	2 Europa II barges long formation	11.4	170 – 190	3.5 - 4.0	3951-7050
VIa	2 Europa II barges wide formation	22.8	95 – 145	3.5 - 4.0	3951-7050
VIb	4 Europa II barges	22.8	185 – 195	3.5 - 4.0	7051-12000
VIc	6 Europa II barges long formation	22.8	270	3.5 - 4.0	12001-18000
VIc	6 Europa II barges wide formation	34.2	195	3. 5 - 4.0	12001-18000

Table 6: Characteristics of reference pushed convoys

2.5 Coupled units

In the inland navigation sector and in these Guidelines, a coupled unit is deemed to exist if a motor cargo vessel has another vessel or push barge attached in front or alongside. The inland waterways police regulations (BPR) refer to this as a coupled combination. The barge generally has the same beam as the vessel pushing it. So a class IV vessel will be coupled with a Europa I barge, and a class Va vessel with a Europa II barge.

Coupled units are not included in the CEMT classification, but they are now so widely used that reference dimensions have been drawn up for the Waterway Guidelines. A number of characteristic dimensions are listed in Table 7. See § 2.2 for details of the method of defining reference dimensions.

CEMT class	type of coupled unit	beam (m)	length (m)	draught when laden (m)	cargo capacity (tonnes)
I	2 péniches, long	5.05	80	2.5	≤ 900
I	2 péniches, wide	10.1	38.5	2.5	≤ 900
IVb	1 Europa I type barge in front	9.5	170 – 185	3.0	901 - 3350
Vb	1 Europa II type barge in front	11.4	170 – 190	3.5 - 4.0	3351 - 7250
VIa	1 Europa II type barge alongside	22.8	95 – 110	3.5 - 4.0	3351- 7250
VIb	3 Europa II barges	22.8	185	3.5 - 4.0	≥ 7250

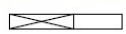
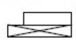
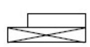
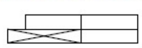
Table 7: Characteristics of reference coupled units

CEMT Class	Motor vessels							Pushed convoys (Barge				
	RWS Class	Characteristics of reference vessel**				Classification		RWS Class	Characteristics of reference pushed convoy**			
		Designation	Beam	Length	Draught (laden)	Cargo capacity	Beam and length		Combination	Beam	Length	Draught (laden)
			m	m	m	t	m			m	m	m
0	M0	Other				1-250	B<= 5.00 of L<= 38.00					
I	M1	Péniche	5.05	38.5	2.5	251-400	B= 5.01-5.10 and L>=38.01	BO1		5.2	55	1.9
II	M2	Kempenaar	6.6	50-55	2.6	401-650	B=5.11-6.70 and L>=38.01	BO2		6.6	60-70	2.6
III	M3	Hagenaar	7.2	55-70	2.6	651-800	B=6.71-7.30 and L>=38.01	BO3		7.5	80	2.6
	M4	Dortmund Eems (L < = 74 m)	8.2	67-73	2.7	801-1050	B=7.31-8.30 and L=38.01-74.00	BO4		8.2	85	2.7
	M5	Ext. Dortmund Eems (L > 74 m)	8.2	80-85	2.7	1051-1250	B=7.31-8.30 and L>=74.01					
IVa	M6	Rhine-Herne Vessel (L <= 86 m)	9.5	80-85	2.9	1251-1750	B=8.31-9.60 and L=38.01-86.00	BI	Europa I pushed convoy	9.5	85-105	3.0
	M7	Ext. Rhine-Herne (L > 86 m)	9.5	105	3.0	1751-2050	B=8.31-9.60 and L>=86.01					
IVb												
Va	M8	Large Rhine Vessel (L <=111 m)	11.4	110	3.5	2051-3300	B= 9.61-11.50 and L=38.01- 111.00	BII-1	Europa II pushed convoy	11.4	95-110	3.5
	M9	Extended Large Rhine Vessel (L >111 m)	11.4	135	3.5	3301-4000	B= 9.61-11.50 and L>= 111.01	BIIa-1	Europa IIa pushed convoy	11.4	92-110	4.0
								BIIL-1	Europa II long	11.4	125-135	4.0
Vb								BII-2l	2-barge pushed convoy long	11.4	170-190	3.5-4.0
VIa	M10	**Ref. vessel 13.5 * 110 m**	**13.50**	**110**	**4.0**	**4001-4300**	**B=11.51-14.30 and L=38.01- 111.00**	BII-2b	2-barge pushed convoy wide	22.8	95-145	3.5-4.0
	M11	**Ref. vessel 14.2 * 135 m**	**14.20**	**135**	**4.0**	**4301-5600**	**B=11.51-14.30 and L>= 111.01**					
	M12	Rhinemax Vessel	17.0	135	4.0	>= 5601	B>= 14.31 and L>= 38.01					
VIb								BII-4	4-barge pushed convoy (incl. 3-barge long)	22.8	185-195	3.5-4.0
VIc								BII-6l	6-barge pushed convoy long (incl 5-barge long)	22.8	270	3.5-4.0
VIc								BII-6b	6-barge pushed convoy wide (incl. 5-barge wide)	34.2	195	3.5-4.0

* In classes I, IV, V and higher the headroom has been adjusted for 2, 3 and 4 layers of containers respectively (headroom at MHWS)

** The characteristics of the reference vessels have a margin of error of ± 1 metre in the length, and ± 10 cm in the beam.

Tabel 8: Classification of inland navigation fleet, Rijkswaterstaat 2010

es)		Coupled units (Convoys)							Headroom *
Classification		RWS Class	Characteristics of reference coupled unit**				Classification		incl. 30 cm spare headroom
Cargo capacity	Beam and length		Combination	Beam	Length	Draught (laden)	Cargo capacity	Beam and length	
t	m			m	m	m	t	m	m
0-400	B<=5.20 and L= all	C1l	2 péniches long	5.05	77-80	2.5	<= 900	B<= 5.1 and L=all	5.25*
		C1b	2 péniches wide 	10.1	38.5	2.5	<= 900	B=9.61-12.60 and L<= 80.00	5.25*
401-600	B=5.21-6.70 and L=all								6.1
601-800	B=6.71-7.60 and L=all								6.4
801-1250	B=7.61-8.40 and L=all								6.6
									6.4
1251-1800	B=8.41-9.60 and L=all								7.0*
									7.0*
		C2l	Class IV + Europa I long 	9.5	170-185	3.0	901-3350	B=5.11-9.60 and L=all	7.0*
1801-2450	B=9.61-15.10 and L<=111.00								9.1*
2451-3200	B=9.61-15.10 and L<=111.00								9.1*
3201-3950	B=9.61-15.10 and L=111.01-146.00								9.1*
3951-7050	B=9.61-15.10 and L>=146.01	C3l	Class Va + Europa II long 	11.4	170-190	3.5-4.0	3351-7250	B=9.61-12.60 and L>=80.01	9.1*
3951-7050	B=15.11-24.00 and L<=146.00	C2b	Class IV + Europa I wide 	19.0	85-105	3.0	901-3350	B=12.61-19.10 and L<=136.00	7.0* only for class IV coupled unit
		C3b	Class Va +Europa II wide 	22.8	95-110	3.5-4.0	3351-7250	B>19.10 and L<=136	9.1*
7051-12000 (7051-9000)	B=15.11-24.00 and L=146.01-200	C4	Class Va + 3 Europa II 	22.8	185	3.5-4.0	>=7251	B>12.60 and L>=136.01	9.1*
12001-18000 (12001-15000)	B=15.11-24.00 and L>=200.01								9.1*
12001-18000 (12001-15000)	B>=24.01 and L=all								9.1*

NB: 1: A reference vessel is a vessel whose dimensions determine the dimensions of the waterway and the engineering structures on or in it.
2: New waterways and enlarged waterways are based on the largest reference vessel within a CEMT class.
3. Classes M3, M4, M6, M8, M10 and M11 may be used only for the renovation of existing waterways, locks and bridges.
4: The smallest dimensions of a reference vessel represent the lower threshold for categorising a waterway in a particular standardised class.

2.6 Recreational navigation

2.6.1 Dimensions according to BRTN

The purpose of the Basic Blueprint for Recreational Touring in the Netherlands (ref. 8) is to bring some consistency to the Dutch recreational touring network. Draught and height are the main parameters determining whether the network is accessible for recreational craft. The following waterway classes are indicated in the BRTN:

- connective waterways: connect the major navigation areas (A)
- access waterways: provide access to individual navigation areas (B, C and D)

B, C and D (Table 9) indicate various gradations. In each class, a distinction is drawn between waterways that are accessible to sailing and motor boats (with the addition of the letters ZM), and waterways that are accessible only to motor boats or to sailing boats with their mast lowered (with the addition of the letter M).

Table 9 shows the bridge height including a safety margin, also known as the spare headroom, for M routes. The vast majority of boats (80 to 90%) fall among the values given in Table 9.

Since the average dimensions of the recreational fleet are increasing, the standard dimensions in the table should be regarded as an absolute minimum. The 4.5 m beam value does however reflect the increased dimensions, and this value should be used as the basis for designing new waterways or upgrading existing ones. Where waterways can accommodate larger dimensions than the reference dimensions listed, this capacity should be preserved.

ZM route		length	beam	draught	mast height
connective waterway	A	15.0	4.25 - 4.5	2.1	30.0
access waterway	B	15.0	4.25 - 4.5	1.9	30.0
access waterway with restrictions	C*			1.7	30.0**
	D				-

* CZM only in Friesland

** 15.0 m is sufficient if a route with > 30.0 m is available within a short distance

M route		length	beam	draught	boat height	bridge height
connective waterway	A	15.0	4.25 - 4.5	1.50	3.40	3.75
access waterway	B	15.0	4.25 - 4.5	1.50	2.75	3.00
	C	14.0	4.25	1.40	2.75	3.00
	D	12.0	3.75	1.10	2.40	2.60

Table 9: Reference vessel dimensions (m) for Z and M routes, according to the BRTN, plus length and beam measurement

2.6.2 *European standards*

The United Nations Economic Commission for Europe has drawn up recommended dimensions for a European network of waterways for recreational navigation (ref. 12). These values are shown in Table 10. The sailing boat (RD) category is not found on most inland waterways.

type of craft	cate-gory	length	beam	draught	bridge height
open boat	RA	5.5	2.0	0.50	2.00
cabin cruiser	RB	9.5	3.0	1.00	3.25
motor yacht	RC	15.0	4.0	1.50	4.00
sailing boat	RD	15.0	4.0	2.10	30.00

Table 10: Reference vessel dimensions (m) according to ECE

2.6.3 *Charter navigation*

Charter navigation is taken to mean navigation by commercial historical, generally sailing vessels that are rented out to sail with paying passengers, with or without a professional crew. The commonly used name ‘brown fleet’ refers to the brown sails used in the past. Charter navigation should be regarded as professional navigation for leisure purposes, rather than recreational navigation.

Charter navigation occurs mainly in large navigation areas such as the Wadden Sea, IJsselmeer lake and the Delta area. In Table 11, class BVA is the reference class for large vessels on open waters. Class BVB represents charter vessels with the exception of the largest ships, and is the reference for sheltered waters.

The beam shown in table 11 is the size of the hull including the leeboards. For the leeboards of sailing boats, 0.25 m has been added either side of the hull, or 0.5 m in total.

class	length	beam incl. leeboards	draught	mast height
BVA	35.0	7.0	1.4	30.0
BVB	25.0	6.0	1.2	30.0

Table 11: Reference dimensions (m) of charter vessels

Further differentiation can be introduced on the basis of the original dimensions permitted in certain regions, such as the Frisian standard (31.5 x 5.4), the Drenthe standard (27 x 5.2) and the Veenvaart standard (28 x 4.8).

2.6.4 *Small-scale water sports*

Small-scale water sports tend to take place on lakes or in the immediate vicinity of a marina. Other forms of water-based recreation also tend to take place on waterways suitable for small-scale water sports, including rowing, windsurfing, paddleboarding, fishing, and skating in the winter. The user requirements for such sports should be taken into account when the dimensions of small waterways are defined.

The Water Sports Council presented a policy vision in 2001 (ref. 13) describing not boat dimensions but desired and minimum measurements for waterways and bridges. These can be found in sections 3.6.4 and 5.5.3 respectively.

2.6.5 *VHF radio and mobile phones*

Recreational craft often use VHF radio and mobile phones to contact bridge and lock operators, and various bankside authorities. Mobile phones cannot always be used in large navigation areas because they often cannot receive a signal. Furthermore, recreational vessels are increasingly being equipped with Inland AIS devices. The devices must be an approved type, as stipulated in article 4.07, paragraph 5 of the inland waterways police regulations (BPR).

2.7 Oceangoing vessels on inland waters

Oceangoing vessels have always used inland waterways. As oceangoing vessels grew larger, a special category of small coastal vessels arose, able to travel inland despite restrictions on height and draught. Such vessels are known as sea-river vessels, fluvio-maritime vessels, short sea shipping, etc.

Oceangoing vessels have a larger beam and draught than inland navigation vessels of the same length. They come in a remarkable range of sizes. A PIANC working group has attempted to bring some order to the category, based on an analysis of the European and Russian fleet, and consistent with the CEMT table (ref. 14). The result is shown in Table 12.

class	length	beam	draught	headroom*
R/S 1	90	13.0	3.5/4.5	7.0/9.1
R/S 2	135	16.0	3.5/4.5	9.1
R/S 3	135	22.8	4.5	9.1

* headroom including 30 cm safety margin; other headroom specifications may apply in certain cases, see §2.1.3.

Table 12: Reference dimensions (m) of sea-river vessels

Class R/S 1 is based on existing waterways. Class R/S 2 is based on developments likely to happen in the short term, and class R/S 3 anticipates future developments.

The proportion of sea-river vessels in the traffic on inland waterways is generally so small that the waterway management authority will base its choice of reference vessel on inland vessels. Sea-river vessels are then regarded as normal inland navigation vessels because they are similar in terms of their dimensions, manoeuvrability and equipment. However, it is advisable to take account of sea-river vessels on certain routes, particularly as regards draught, because the ability for sea-river ships to carry cargoes of sufficient size has a strong bearing on the profitability of navigating inland waters.

3 Waterway elements

3.1 Networks

3.1.1 Corridor and network approach

Waterways form part of a network. The dimensions and the level of service offered must be coordinated with those of the adjacent waterways. To ensure the waterway is used efficiently, and to guarantee a certain speed on a route, a corridor and network approach must be taken, whereby waterway management authorities look further than their own area, to the benefit of waterway users. In this context, a corridor can be defined as a cluster of waterways connecting two economic and/or water sports centres.

3.1.2 Nota Mobiliteit

The 1975 Policy Document on Waterways was followed up in 1988 by the Second Transport Structure Plan, which in turn was superseded in 2004 by the Policy Document on Mobility (ref. 15). This last policy document distinguishes four types of waterway: trunk routes, key waterways, other main waterways and other waterways. The trunk routes connect the important transport hubs of Rotterdam and Amsterdam with the international hinterland, particularly Germany and Belgium. The key waterways connect key economic areas in the Netherlands with the trunk routes. Trunk route and key waterway status depends on the quantity of goods transported on the waterway: trunk routes and main waterways transport at least five million tonnes of goods or 25,000 TEU a year (Figure 2).

The Policy Document on Mobility states that the aspiration for trunk routes is that they should be suitable for class VIb vessels and four-layer container transport. Main waterways should be able to accommodate at least class Va and four-layer container transport. And other main waterways should aim to take at least class IV and three-layer container transport. The Policy Document does not stipulate targets for any other waterways. In response to the Policy Document, a 'policy letter' (ref. 16) announced measures to boost inland navigation, including the construction of a future-ready network of waterways and harbours. A future-ready waterway has the normal profile set out in these Guidelines and a CEMT class based on future cargo transport.

3.1.3 National Policy Strategy for Infrastructure and Spatial Planning

In 2012 the Policy Document on Mobility was superseded by the National Policy Strategy for Infrastructure and Spatial Planning (SVIR), which introduced a change to policy on mobility and spatial planning. Central government now leaves more decisions to the decentralised authorities, limiting itself to issues affecting more than one province, and cross-border issues, such as the main waterways network. Appendix 6 to the SVIR still contains the essential elements of the Policy Document on Mobility, such as the categorisation of waterways into trunk routes, main waterways and other waterways for policy purposes. The SVIR also stipulates that the authorities may use the opportunities afforded by infrastructure with a nautical safety profile. It also formalises central government's aim of maximum separation of commercial and recreational navigation. Where possible, designs should reflect this.

Rijkswaterstaat adopted a manual for this purpose in 2016, which can be found on 'Werkwijzer RWS'.

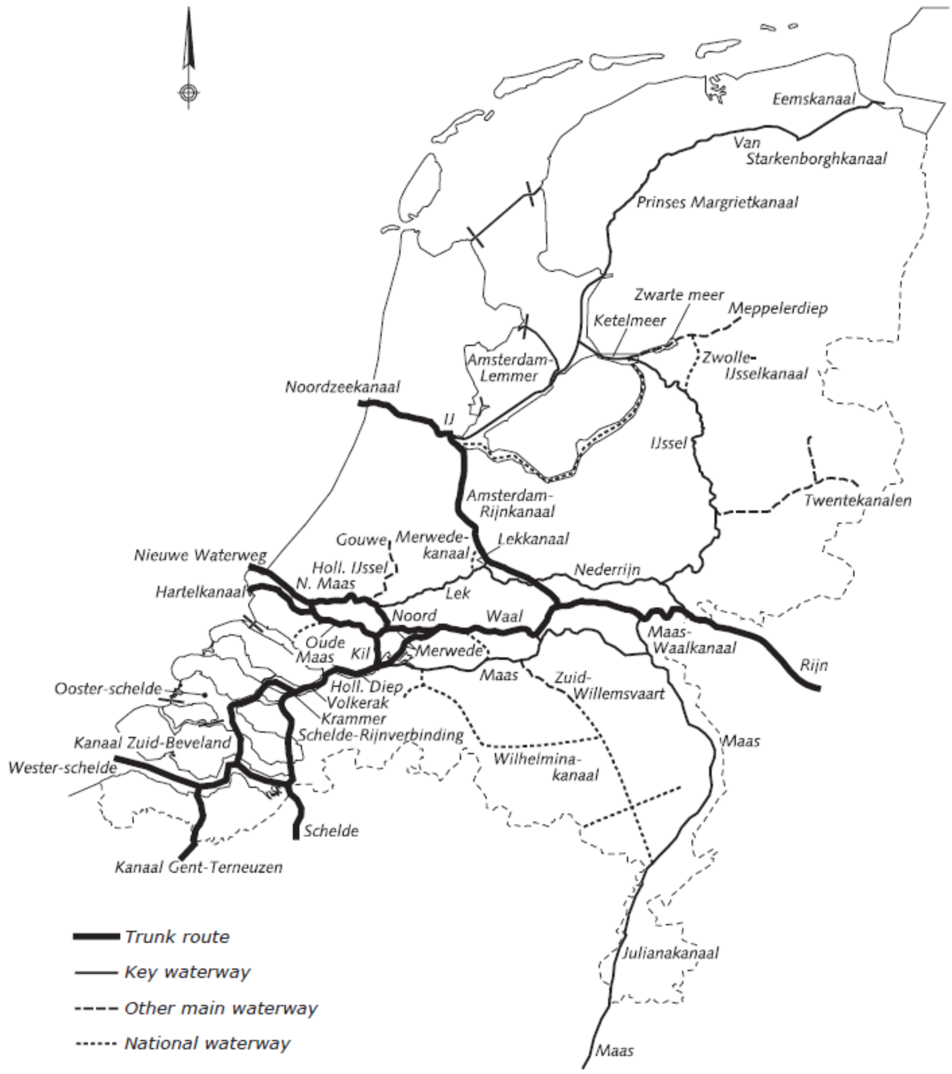


Figure 2: Trunk routes and main waterways according to the National Policy Strategy for Infrastructure and Spatial Planning, 2012

3.1.4 *European networks*

Both the European Union and the United Nations Economic Commission for Europe (ECE) have defined a European waterway network. They largely overlap, at least within the territory of the EU. The ECE network, which also covers Eastern Europe (including Russia west of the Urals), has been defined in a database known as the Blue Book. The EU network was announced on 29 October 1993. The EU Council of Ministers decided that the network should at least meet the requirements of CEMT class IV, and in the event of modernisation and modification, class Va/Vb. The network can be regarded as indicative, and the member states have not undertaken any financial commitments in this regard. Nevertheless, they are expected to develop initiatives to resolve ten bottlenecks and gaps in the network.

In July 1997 the Ministry of Transport, Public Works and Water Management signed the European Agreement on Main Inland Waterways of International Importance (AGN; ref. 17). The AGN is a binding international agreement under which waterways must at least be kept up to the standard of their specified class. The AGN covers virtually the entire Dutch waterway network. The agreement also includes a minimum requirement for European waterways, i.e. at least class IV and, after upgrading, class Vb. Annex III of the AGN mentions several technical and operational characteristics of European waterways. These have been incorporated into the present Waterway Guidelines.

3.1.5 BRTN

The main objective of the Basic Blueprint for Recreational Touring in the Netherlands 2015-2020 (ref. 8) is to preserve and further develop the network of navigable waters in the Netherlands to create a single attractive, differentiated and consistent recreational touring network. For the sake of consistency, height and depth measurements have been determined and desirable operating hours for bridges and locks specified. The BRTN provides the basis for a classification of recreational waterways (Table 9) consisting of four categories for motorboats (M-routes) and three categories for both sailing boats and motorboats (ZM-routes). The BRTN has been included in the European network of recreational waterways (ref. 18).

3.1.6 Changes to waterway status and CEMT class

A change of status (trunk route, main waterway, other waterway) is a policy decision that must be taken by the Minister or State Secretary. Change of status proposals must be submitted to the Directorate-General for Mobility and Transport (DGB). In the event of plans to change the status of national waterways, the director-general of *Rijkswaterstaat* submits a proposal to his counterpart at DGB. If the plans concern non-national waterways, the management authority submits the proposal directly to DGB. DGB informs *Rijkswaterstaat* and other stakeholders of the Minister or State Secretary's decision. The altered status of the waterway in question is recorded by DGB in the next edition of or amendment to a document with national policy strategy status and indicated on a map.

To alter the CEMT class of a national waterway, the director-general of *Rijkswaterstaat* submits a proposal to his counterpart at DGB. If the plans involve a non-national waterway, the proposal goes directly to DGB, which assesses whether the waterway in question complies with the Waterway Guidelines for the award of the higher class. DGB communicates the ECE's decision to Rijkswaterstaat and other stakeholders so that it can be included in legislation, almanacs, maps and databases. If the waterway in question appears in the Blue Book, DBG will ask the ECE to adopt the new CEMT class there.

In the event a temporary change in dimensions associated with a certain CEMT class, such as restrictions on draught because of a backlog in dredging operations, for example, or a narrowing of a waterway, a traffic order must be issued in accordance with the usual procedures. The competent authority is responsible for this, as referred to in the Shipping Traffic Act.

3.2 Waterway profiles

3.2.1 Profiles for commercial navigation

The cross-section of the waterway must have dimensions that guarantee smooth, safe navigation. The necessary width dimensions of the waterways have traditionally been based on the 'theory of shipping lanes'. The Waterway Guidelines generally apply to waterways up to CEMT class VI and were initially developed for two-lane traffic, i.e. one reference vessel travelling in each direction in the same waterway section, with the exception of the single-lane profile, of course. In cases where there more than two lanes of traffic, the required extra width (known as the high-volume increment) must be determined by performing a simulation. The premium will depend on the volume of traffic expected on the waterway in question, combined with the type of vessels in the fleet and the dimensions of the reference vessel. There are four types of profile for commercial navigation:

- high-volume profile (multiple lanes)
- normal profile for two-lane traffic
- narrow profile for two-lane traffic
- single-lane profile

The normal or high-volume profile is the standard for new waterways. A narrower profile may be selected if there are convincing arguments for doing so, such as low annual traffic volume. The single-lane profile is intended for exceptional cases, such as a traffic volume of no more than a few passing vessels a day.

On existing waterways, the existing profile is the basis for design, provided it is bigger than the above-mentioned standard profiles. However, existing waterways will not always comply with the design profiles, either as a result of the fact that many were built before these Guidelines were issued, or as a result of incompatibility with other functions, which might be established by further investigation.

3.2.2 High-volume profile for commercial navigation

If the volume of traffic is expected to exceed 30,000 commercial vessel movements a year, the high-volume profile is applicable. Such high volumes of traffic occur mainly on CEMT class VI waterways. This profile is the result of a normal profile plus the high-volume increment, which can be found in Table 21.

3.2.3 Normal profile for commercial navigation

On waterways with a maximum traffic volume of 15,000 to 30,000 commercial vessels a year, the following level of traffic handling should be possible:

- two laden reference vessels travelling in opposite directions should be able to pass each other with little or no need to reduce speed
- one laden reference vessel should be able to carefully overtake another (in other words, with a slight reduction in speed)
- a laden reference vessel should be able to pass an unladen reference vessel travelling in the opposite direction in a strong side wind

3.2.4 *Narrow profile for commercial navigation*

Where the volume of passing traffic is 5,000 to 15,000 vessels a year, it is acceptable for a narrower profile to be used on part of the waterway, i.e. no longer than five kilometres, with traffic control services if necessary. The permitted draught in the narrow profile should be equal to the reference draught of the normal profile in the adjacent waterway sections.

If it is decided that a section should be executed using a narrow profile, hard boundaries in the form of bridge piers, abutments etc. should be dimensioned such that they do not hamper the future upgrading of the waterway to a normal profile.

The narrow profile should be regarded as a technical minimum that is only just acceptable for waterways where it is possible that two reference vessels travelling in opposite directions will meet. It may be applied to an entire waterway only when very low traffic volumes are expected, i.e. fewer than 5000 passing commercial vessels a year. A narrow profile is also acceptable on sections with no through traffic. The following reference level of traffic handling has been defined for narrow profiles:

- reduction in speed required when two laden reference vessels travelling in opposite directions meet
- incidental overtaking of laden reference vessels by unladen reference vessels, whereby the laden vessel must sharply reduce its speed
- reduction in speed when laden reference vessels meet unladen reference vessels travelling in the opposite direction in a strong side wind

An overtaking manoeuvre by two laden reference vessels need not be regarded as a design requirement for the narrow profile because generally speaking:

- the volume of traffic on waterways that are narrow along their entire length is relatively low (almost always lower than one vessel per hour in each direction)
- the differences in speed between laden reference vessels are small in a narrow profile

3.2.5 *Single-lane profile for commercial navigation*

In exceptional cases a profile may be applied over a short section of waterway that does not allow two reference vessels to pass each other. The section in question must be no longer than two kilometres, and the volume of traffic low, i.e. no more than 5000 passing vessels a year. Reference vessels will be able to navigate sections with this single-lane profile (also incorrectly referred to as a one-way profile) only if they travel at a restricted speed. Two reference vessels will not be able to pass each other, so some form of traffic control or passing places will be needed. It is usually possible for small vessels and commercial and recreational navigation to pass each other in a single-lane profile. This can be taken into account in the traffic control regime. The single-lane profile is not suitable for main waterways.

Such profiles are generally used in areas where little space is available, such as urban connectors. In such areas, the impact of the wind depends on the buildings along the waterway (gusts of wind between buildings). The low speed means the width increment for side winds increases. However, this all depends to a great extent on local circumstances.

The dimensions for the single-lane profile given in these Guidelines apply only to short, perhaps temporary sections of waterway that are not subject to side winds. In other cases, the required profile dimensions must be further investigated.

3.2.6 *Profiles for recreational navigation*

Recreational navigation does not include a single-lane profile. Busy waterways have a 'high-volume profile'. Three different profiles can therefore be distinguished, depending on the volume of traffic:

- high-volume profile
- normal profile
- narrow profile

If the expected traffic volume exceeds 50,000 passing vessels a year, the high-volume profile will also be inadequate, and further investigation will be required.

3.2.7 *High-volume profile for recreational navigation*

The high-volume profile is applicable when the volume of traffic is between 30,000 and 50,000 passing recreational craft a year. If the number of passing vessels exceeds 50,000 a year, further investigation of the dimensions of the cross-section will be required.

3.2.8 *Normal profile for recreational navigation*

The normal profile is the nautically optimum cross-section for the waterway, which can smoothly and safely handle up to 30,000 passing recreational craft a year. This is the minimum standard that must be adopted for new waterways.

3.2.9 *Narrow profile for recreational navigation*

The narrow profile is the nautical minimum standard for two-lane recreational navigation. It is used on waterways with a traffic volume of fewer than 5000 passing recreational craft per year.

Provided there are no objections in other respects, such as protection of the banks, the narrow profile may also be used on waterways with around 10,000 passing vessels a year, for short stretches and difficult passages in urban areas, for example, where there are insurmountable obstacles to widening the waterway.

3.2.10 *Profile for mixed shipping*

Waterway sections that carry mixed shipping – and this applies to virtually all waterways – should adhere to the design rules applying to waterway sections with only commercial navigation. In the design of a waterway with a trapezoidal cross-section, two-lane traffic tailored to reference commercial vessels may be assumed, up to a traffic volume of some 30,000 passing commercial vessels combined with some 30,000 passing recreational craft per year.

In practice, commercial vessels navigate along the axis of the waterway, while recreational craft remain close to the banks, where the waterway is too shallow for commercial navigation. This is an efficient use of the space available, all the more so since the peak months for recreational navigation, July and August, do not coincide with the busiest period for commercial navigation. This type of use is not possible in a waterway bordered by vertical sheet piling, where extra width is required for recreational navigation. When there is a high volume of recreational traffic, these ‘cycle paths’ have insufficient capacity, forcing recreational craft to use the ‘highway’ for commercial vessels. If the volumes of commercial and recreational traffic are both expected to exceed 30,000 movements a year, further investigation will be required.

3.2.11 *Choice of profile: summary*

The relationship between choice of profile and volume of traffic is summarised in Table 13.

vessels/year commercial	description	choice of waterway profile
> 50,000	very busy	high-volume profile
30,000 – 50,000	busy	high-volume profile
15,000 - 30,000	normal	normal profile for two-lane traffic
5,000 - 15,000	quiet	normal profile, narrow profile on short sections
< 5,000	Very quiet	narrow profile for two-lane traffic, single-lane profile in exceptional cases

vessels/year recreational	description	choice of waterway profile
> 50,000	very busy	further investigation required
30,000 – 50,000	busy	high-volume profile
5,000 – 30,000	normal	normal profile for two-lane traffic
< 5,000	quiet	narrow profile for two-lane traffic

Table 13: Relationship between appropriate waterway profile and traffic volume

3.3 Hydraulic parameters

3.3.1 *Reference water levels for shipping*

Variations in water level and longitudinal and cross currents can occur in both rivers and canals. These have implications for the dimensions of the waterway. It is very important to choose the correct reference high and low water levels for shipping, relative to the headroom and the depth and width of the waterway, taking account of possible future developments like subsidence or raised water levels. The reference water levels for shipping may differ from those that apply to river management and flood protection.

The concepts of reference high and lower water levels for shipping (MHWS and MLWS) are of particular importance for the design of the waterway. These are the levels between which the full functionality of the waterway is available to shipping. Higher or lower water levels may give rise to restrictions on headroom and waterway profile. The severity and duration of the restrictions that might occur when the water level falls outside the two reference levels must be considered when determining the reference water levels for a waterway. Water level fluctuations in waterways occur as a result of differences in discharge, tides, seasonal variations, wind setup, translation waves etc. Water level variations also apply in canals with a so-called fixed canal water level.

In many cases the water level is not a natural phenomenon, but the result of deliberate management. On waterways with locks and/or weirs, short-term but frequent changes in water level can occur as a result of translation waves propagated by sluicing, lockage or manipulations with weirs. These changes can involve several tens of centimetres and must be reflected in the vertical dimensions of waterway elements. Hydrological testing made be necessary to determine the extent of variation in the water level.

At locks situated in rivers or tidal waters, a distinction must be made between the following when determining the reference water level:

- lock elements that might impact accessibility, such as the sill depth and headroom
- other, less critical elements, such as the height of the lock plateau, and fenders

In the former case, the water level that is exceeded or not exceeded 1% of the time should be used. The level exceeded or not exceeded 10% of the time may be used for the second category. The difference between 1% and 10% can amount to several metres on Dutch rivers (ref. 26).

The reference water levels, both high and low, are set by the water management authority and laid down in its management plan. They serve, among other things, as a datum plane for water depth and headroom..

3.3.2 *Reference high water wevel for shipping*

For commercial navigation, the reference high water level (MHWS) is one of the following values:

- on canals and in the event of short-term water level variations: the water level that is exceeded 1% of the time, measured over the past ten years
- in the event of long-term water level variations, for example in rivers: the water level that has been exceeded only once for a consecutive period of 24 hours in the past ten years

The reason for this distinction lies in the fact that long-term obstruction due to high water levels causes more hindrance than a few short-term obstructions. A value that is exceeded 2% of the time during the summer period (1 April to 1 October) should be used for recreational navigation.

Since the Netherlands, unlike Germany, seldom experiences obstruction due to high water levels, the MHWS defined for the Rhine and its distributaries in the Netherlands is equal to the water level applying to a discharge of 16,000 m^3/s at Lobith, which gives an exceedance probability considerably lower than 1%. In February 1999 the minister adopted an official policy line on the introduction of restrictions or closures to shipping in the event of extremely high water levels (ref. 19). It does not stipulate any fixed levels, instead advocating a tailored response. The Rhine and its distributaries must also, incidentally, comply with the requirements of the Central Commission for the Navigation of the Rhine (CCNR).

In tidal waters a water level associated with a low storm surge occurring once every two years, information on which can obtained from the Water Helpdesk, at www.helpdeskwater.nl, should be used. High water levels in tidal areas are of considerably shorter duration than high water levels in upstream stretches of rivers, and the same applies to any obstructions associated with them.

To summarise, the reference high water levels for shipping have always been defined differently in different regions; Table 14 gives an overview:

Waterway	Reference high water level for shipping (MHWS)
Mannheim Convention waters (Lobith – Woudrichem or Krimpen)	water level that occurs when the discharge at Lobith is 16,000 m^3/s
Gelderse IJssel	water level that occurs when the discharge at Lobith is 16,000 m^3/s
Tidal rivers	highest water level that is reached once every two years.
Maas	water level exceeded for 24 hours once in the last 10 years
Canals	water level exceeded 1% of the time, measured over the last 10 years

Table 14: Reference high water levels for shipping

It is also important to consider climate change on waterways that are affected, by determining the future MHWS on the basis of KNMI'14 climate scenario G (ref. 82).

3.3.3 *Reference low water level for shipping*

For commercial navigation, the reference low water level (MLWS) is one of the following values:

- on canals and in the event of short-term water level variations: the water level that is not exceeded 1% of the time, measured over the past ten years
- in the event of long-term water level variations, for example in rivers: the water level that has not been exceeded only once for a consecutive period of 24 hours in the past ten years

The reason for this distinction lies in the fact that long-term obstruction due to low water levels causes more hindrance than a few short-term obstructions. A value that is not exceeded 2% of the time during the sailing/crusing season (1 April to 1 October) should be used for recreational navigation.

On the Rhine distributaries, the minimum water level is determined relative to the agreed low river level (OLR). This is linked to the agreed low river discharge (OLA), a rate of discharge that is not exceeded on 20 days on which the temperature is above zero, and thus occurs approximately 5% of the time.

The Lowest Astronomical Tide (LAT) has applied internationally as the reference low water level in sea ports subject to tidal influences and in sea access channels since 2007. This is the minimum low water level forecast in the current hydrological conditions, or the lowest water level predictable. The value of the LAT can be obtained from the Water Helpdesk, via www.helpdeskwater.nl. The LAT replaces the Lowest Low Water Spring (LLWS), and may be several centimetres or even tens of centimetres lower.

In the downriver area, a datum plane referred to as the agreed low water level (OLW) is used instead of the OLR, defined as the smooth transition from OLR to the sea. The OLW can also be obtained from the Water Helpdesk, via www.helpdeskwater.nl.

In addition, the median water level (MW) is used in the transitional zone between the upstream and downstream stretches of rivers. This is a reference level that is exceeded or not exceeded by 50% of tides.

To summarise, the reference low water levels for shipping have always been defined differently in different regions; Table 15 gives an overview::

Waterway	Reference low water level for shipping (MLWS)
Mannheim Convention waters (Lobith – Woudrichem or Krimpen)	OLR
Gelderse IJssel	OLR
Tidal rivers	OLW
Maas	MLW (water level at lowered flood gates)
Canals	water level not exceeded 1% of the time, measured over the last 10 years

Table 15: Reference low water levels for shipping

3.3.4 *Longitudinal current*

Having been extended to cover rivers, the Guidelines are now intended for waterways with a longitudinal current up to 2.5 m/s. The flow rate is the depth-averaged rate in the axis of the waterway. Compared with canals, where under previous editions of these Guidelines a longitudinal current of no more than 0.5 m/s over the cross-section is permissible, currents in rivers are complex. Sediment transportation in rivers means that the cross-section of the summer river bed adapts to the current with a slight delay. Spiral currents occur on river bends with a deep outer curve. Formations on the summer river bed increase the turbulence of the current. In many sections of river the fairway is marked by groynes in the summer river bed. The current around groynes can include a turbulent series of eddies. When river meadows are flooded, water can flow from the summer river bed to the river meadow, and from a river meadow to the summer river bed with fairway. At low discharge rates, too, water can flow out of a section between groynes, as a result of the suction caused when passing vessels lower the water level. Shipping can then be exposed to a cross current at both high and low discharges. Vessels travelling downstream generally need more path width on bends where there is longitudinal current, while vessels travelling upstream need less (ref. 68). These effects of complex currents are reflected in the Guidelines in an increment in the width of the waterway for each navigation lane, depending on the flow rate (see §3.5.8). If the longitudinal current exceeds 0.5 m/s then more investigation is needed for commercial navigation. This recommendation applies to bends and to straight sections, canals and rivers.

For recreational navigation, flow rates of 0.8 m/s are acceptable at narrowed sections of canals, provided there is at least 50 m of straight waterway upstream and downstream of the narrowed section.

At lift locks, water may need to be sluiced either occasionally or regularly for water management purposes. The culverts must be designed in such a way that lifting can reasonably continue while sluicing is in progress.

3.3.5 *Cross current*

A number of cross current situations can be distinguished. In the case of through traffic, this includes:

- outlet, intake or pump at a lock
- pumps, intakes and discharge sluices
- spiral current on a bend
- junction with a river
- discharge of stream or side channel

In the event that sluices or intakes cause problematic cross currents, skippers can be alerted by the sluicing sign (ref. 22) intended for this purpose.

Cross current problems at a junction with a river or at a sluice by a lift lock are situation-dependent and cannot be used as reference values for waterway sections. In such cases, further investigation is needed. Different maximum permissible cross currents apply to commercial navigation and recreational navigation.

3.3.6 *Cross current for commercial navigation*

The maximum permissible cross current flow vc on a waterway depends on the ratio of the vessel length L to the width of the outflow Wu. The absolute size of cross current discharge Q is also important.

Cross current is permissible in canals and rivers with a longitudinal current below 0.5 m/s if $Q \leq 50$ m^3/s en $v_c \leq 0.3$ m/s. In narrow cross current fields (where $W_u <$ apprixomately 0.2.L) a higher cross current flow rate may be permitted:

$v_c = (1.5 - 6.W_u/L)$ m/s

v_c has been calculated at the bank as an average over the entire water depth. If $Q >$ 50 m^3/s or $W_u > 0.5.L$ Figures 3 and 4 can be used to determine whether cross current is permitted, or further investigation is required, in which case the following criteria apply:

- increase in path width less than ½.B (B = ship's beam) above the path width that the vessel requires without cross current
- rudder angle max. 20º, except for brief outliers

A vessel smaller than the standard vessel for the class to which the waterway belongs may be used as reference for determining the permissible cross current. In the case of narrow cross current fields where v_c> 0.3 m/s the permissibility of the cross current flow rate must be tested using the lengths of all types of vessels that use the waterway.

The representative cross current speed at the groyne line has an important bearing on the maximum permissible cross current on waterways with a longitudinal current speed of more than 0.5 m/s (rivers). The River Management Assessment Framework (ref. 69) can be used as a basis for determining and presenting the representative depth-averaged cross current speed and the representative cross current discharge.

If the representative cross current discharge $Q \leq 50$ m³/s, the maximum permissible representative cross current speed is 0.3 m/s at the groyne line. If the representative cross current discharge $Q > 50$ m³/s the maximum permissible representative cross current speed is 0.15 m/s at the groyne line. This criteria applies subject to the condition that the wind increment was applied when the required waterway width for the waterway profile in the river. If not, or if the wind increment is smaller than 0.5B, an increment of 0.5B must be applied to the waterway width, and the wind increment need not be applied (ref. 75).

If the representative cross current speed already exceeds the standards mentioned in the existing situation, any intervention in the river may not cause any increase in the cross current.

If the above cross current criteria are not met on rivers with a longitudinal current rate of more than 0.5 m/s (see also Figures 3 and 4), further investigations will be required.

Additional research and/or measures will also be needed if the cross current situation is complicated by additional factors that require the skipper's attention. It is therefore important to consider local factors, and to assess whether certain factors might be mutually reinforcing. Examples include:

- Cross current combined with a bend in the waterway
- Cross current near the entrance to a holding basin
- Cross current close to a passage under a bridge

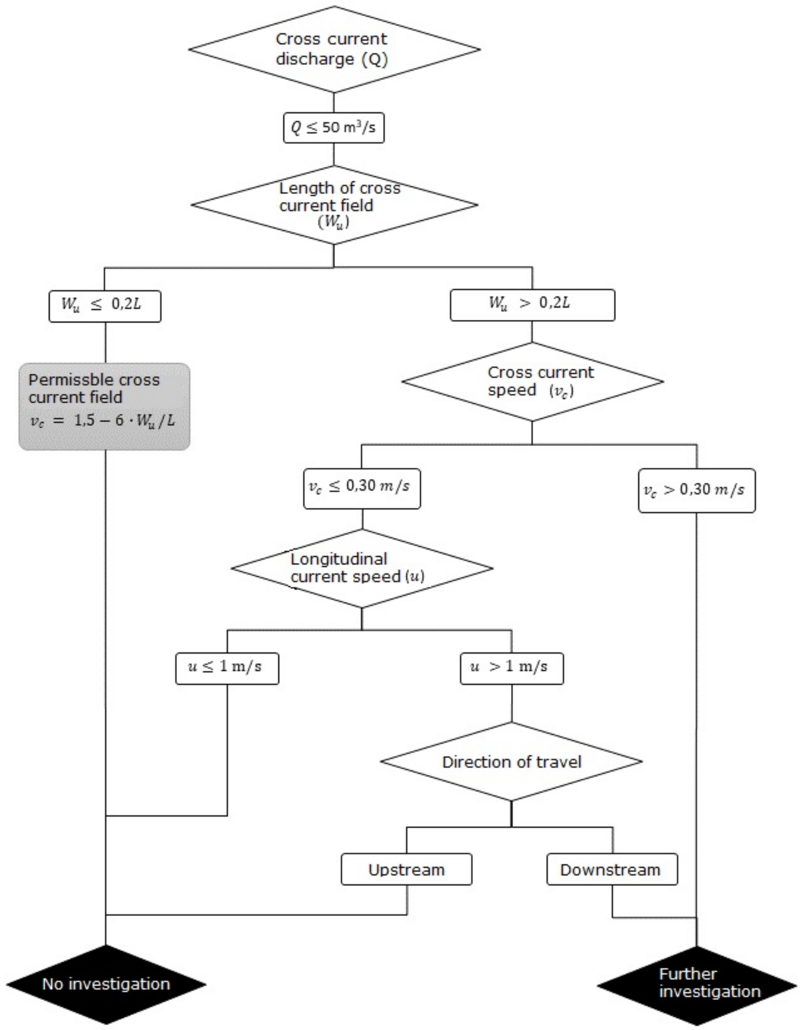


Figure 3: Flow diagram for Q ≤ 50 m^3/s

Q: cross current discharge (m^3/s)
W_u: length of cross current field (m)
vc: cross current speed (m/s)
u: longitudinal current rate (m/s)

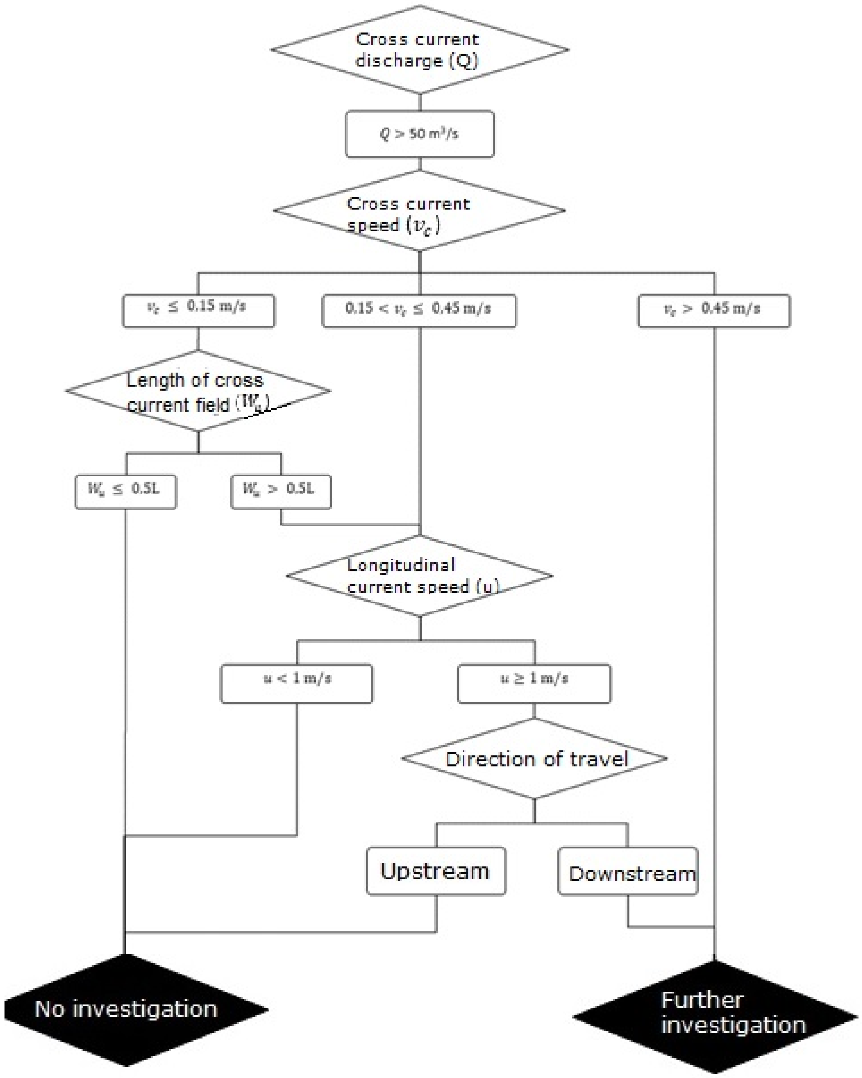


Figure 4: flow diagram for Q > 50 m^3/s

Q: cross current discharge (m^3/s)
W_u: length of cross current field (m)
vc: cross current speed (m/s)
u: longitudinal current rate (m/s)

3.3.7 *Cross current for recreational navigation*

The short length of a recreational craft means it can be knocked significantly off course when it enters a cross current field. Cross currents are permissible if vc≤ 0,3 m/s and the cross current field is no longer than 0.5.L. A cross current up to 1 m/s is permissible before openings, such as pipes, where the diameter of the outlet A < 0,2 m2:

v_c=(1 – 3.5.A) m/s

Though a slight exceedance of the values need not necessarily immediately prompt in-depth investigation, the problem will require some attention. In such cases, warning signs may be posted. In the event of a major exceedance, further investigation will be needed.

3.3.8 *Water abstraction*

Water abstraction from a waterway produces less disruption of the currents, and therefore less obstruction, than drainage flow, so at a discharge of up to 50 m^3/s values 1.5 times higher can be used for v_c, provided the flow is evenly distributed over the inflow.

3.3.9 *Wave reflection*

Ships' waves are reflected on waterways with vertical bank protection, particularly sheet piling. This creates waves that are particularly disruptive for recreational craft, and can lead to unpleasant or even dangerous situations. On busy recreational routes, therefore, a wave-reducing, wildlife-friendly bank would be the first choice (see also § 3.5.11).

3.4 Wind problems

3.4.1 *Extra width*

High vessels, such as empty vessels and container ships, are susceptible to side winds. To prevent vessels fromdriftingaground, they must steer into the wind at a drift angle or crab angle. This means they require extra width, depending on the shape of the vessel, its speed and the wind speed. If the side wind is constant, the vessel will sail at a constant crab angle. The wind will usually vary, however, in both speed and direction. Gusts of wind make the maximum drift angle greater than the angle of equilibrium.

This has been reflected in a width increment shown in Tables 16, 18, 19 and 20 in § 3.5, distinguishing between the waterway's location in a coastal or inland zone, and its orientation, as illustrated in Figure 5. The wind increment must be applied to both straight sections and bends.

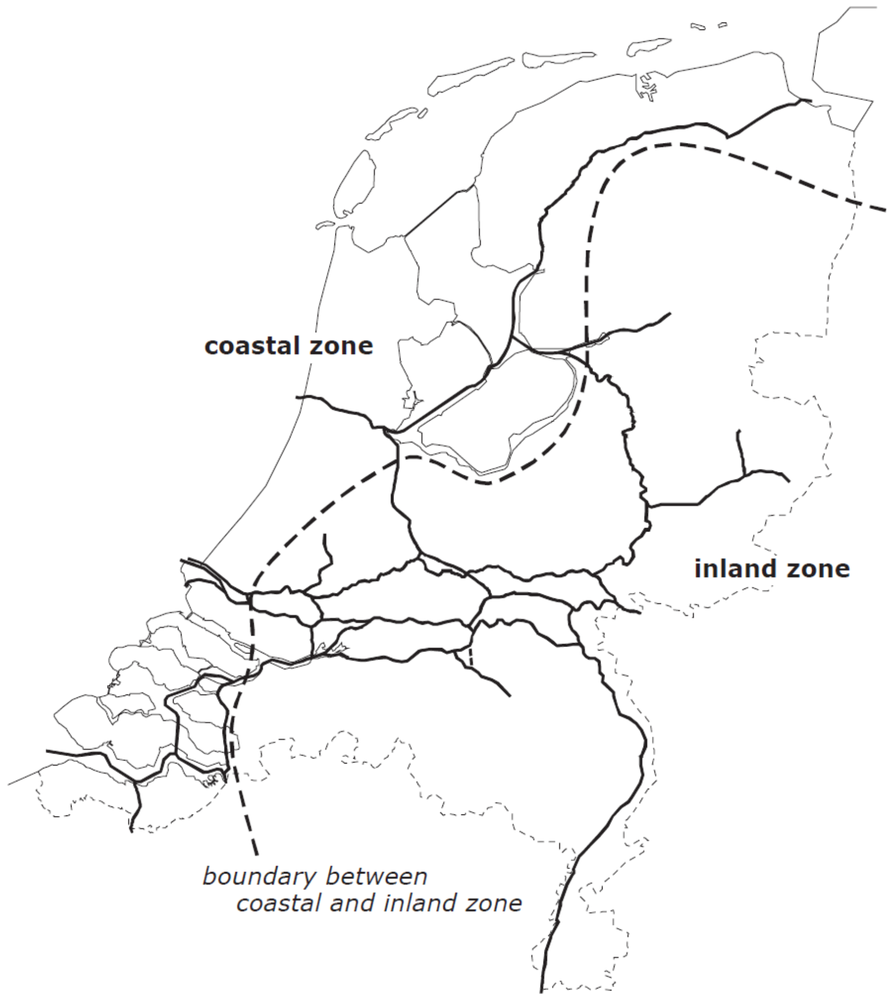


Figure 5: Coastal zone and inland zone

3.4.2 *At locks and bridges*

The previous chapter indicated that almost all commercial vessels have a bow propeller with sufficient power to compensate for wind problems. Skippers also anticipate wind effects at engineering structures as they steer their vessel. It is nevertheless important to ensure that the transitions in exposure to side winds are gradual when planning the areas around locks and bridges.

3.4.3 *Near tall buildings*

High buildings close to the waterway can lead to unpredictable irregularities in wind fields that can be extremely problematic for inland navigation vessels (particularly empty ones) and cause dangerous situations on the waterway. Before issuing permits for such buildings to be constructed, the design should be tested to establish whether it will cause wind problems for shipping.

3.4.4 *Recreational navigation*

Wind problems must be prevented as far as possible on ZM routes for recreational navigation. Problems are caused mainly by fluctuations in wind strength as a result of sudden lulls in the wind, abrupt transitions and wind effects around high buildings.

The design of connections with harbours, ancillary canals etc. that joint the waterway should be effected with great care, with a view to possible wind problems. It is desirable that measures be taken to ameliorate wind problems as a result of abrupt transitions by planting vegetation, for example.

Objects (contiguous vegetation and buildings) along the bank can cause lulls in the wind. The indication for ZM routes used by sailing boats is that the ratio of the object's distance from the waterway to the object height should be more than a factor 7 greater relative to the reference water level for long, closed objects, and more than a factor 5 for small, narrow obstacles.

3.5 Straight sections of waterway for commercial navigation

In combination with section 3.11, which refers to intersecting cables and pipelines, this section defines the minimum waterway profile. It may be more appropriate to make the waterway wider and/or deeper in connection with high water discharge or the creation of natural banks.

3.5.1 Waterway depth in canals

With a normal profile, the depth of the waterway (D) must be at least a factor 1.4 times the draught of the reference ship when laden and immobile (T), relative to MLWS. Where the waterway has a narrow or single-lane profile, the factor 1.3 applies. This depth must be present at all times. This means that the maintenance or dredging depth must be greater than or equal to the waterway depth stipulated here, depending on the expected level of siltation and the frequency of dredging. This is explored in more detail in § 8.3.2.

The deepest draught of reference vessels, and thus the depth of waterways, has increased by several tens of centimetres over the past few decades. When new waterways are built and existing ones deepened, the highest value in Table 18 should be used. No rights may be derived from the table, and a waterway management authority may choose to adopt a different depth. The basis for the design of the waterway depth is the draught of the reference ship when fully laden. The cost-benefit ratio has been found to be most favourable in this situation, facilitating efficient cargo transport.

3.5.2 Waterway depth in rivers

In the Rhine distributaries, at OLR a minimum fairway depth of 2.8 m (Mannheim Convention waters: the river Waal to Tiel, Bovenrijn, Nederrijn/Lek to Arnhem) or 2.5 m (Gelderse IJssel to Wijhe) is guaranteed, and will be maintained by dredging if necessary.
Rijkswaterstaat also strives to maintain keel clearance by optimising the design such that sand accumulation in the fairway as a result of interventions in the river be kept to a minimum, as laid down in the River Management Assessment Framework (see also §8.3.3).

In the transitional zones of the Waal (Tiel-Gorinchem) and IJssel (Wijhe-Kampen), the water level is determined by the river discharge and tidal water level or lake water level. In the Waal a minimum water depth of 2.80 (at OLR) to 4.5 m (at OLW) is guaranteed in this transitional zone. In the IJssel (Wijhe-Kampen) a water depth of

2.5m (at OLR) to 3.50 (at MLWS) is guaranteed in this transitional zone. This is set out in the River Management Assessment Framework.

In the dammed part of the Maas the fairway is maintained at a depth of 4.90 m. This is based on the principle of 1.4 times the draught of the reference vessel, assuming a maximum permitted draught of 3.5 m.

In downstream stretches of the rivers, a minimum water depth at OLW of 1.1 times the maximum draught is standard. Though the keel clearance is then small (10%), the underwater cross-section of the fairway is relatively large, and the tidal effect results in daily variations in water level. Averaged over a tide cycle, the keel clearance is several dozen percentage points greater.

3.5.3 *Theory of shipping lanes*

The width of a waterway is based on the theory of shipping lanes (Figure 6). This assumes that the navigable width of the waterway is the sum of a number of lanes, namely:

- a number of navigation lanes, generally one-way, to be regarded as the 'envelope' surrounding the path widths of all vessels that use the waterway
- one or more safety lanes between the navigation lanes, whose width depends on the vessels expected to pass or overtake each other
- two bank lanes, the safe distance that the skipper must leave between his navigation lane and the toe of the bank.

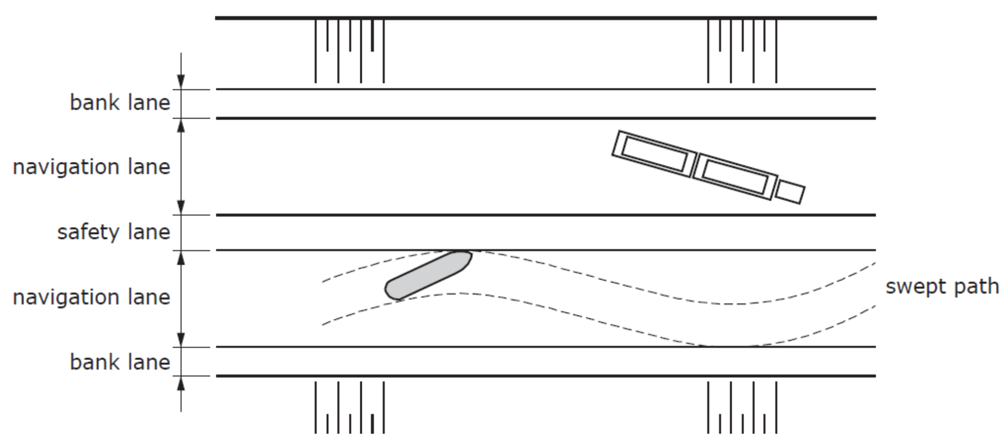


Figure 6: Principle of shipping lanes

The widths of the different lanes have been determined on the basis of practical observations and simulations and incorporated into the guideline for waterway width. The width of the lanes is not specified separately.

3.5.4 *Waterway width for commercial navigation*

The waterway width for commercial navigation is specified at three levels (Figure 8):

- the minimum waterway depth required (Wd) on the waterway bottom
- in the keel plane of a laden vessel (Wt)
- in the keel plane of an unladen vessel, in connection with the extra width that an unladen vessel may need in the event of side winds

More or less any cross-section may be constructed around this minimum waterway profile based on these fixed points, subject to the following conditions:

- the underwater slope must be gradual, with no sudden changes in profile
- the waterway profile encompassing the fixed points must be as symmetrical as possible in the local conditions

With a normal or narrow profile the width Wd in the plane of the waterway bottom must be at least twice the beam B of the reference vessel. Where there is a single-lane profile, the width must at least equal the beam of the reference vessel.

The width Wt in the keel plane of the laden reference vessel must be at least 4, 3 or 2 times the width of the reference vessel in the normal profile, narrow profile and single-lane profile respectively. See also Table 16.

In the high-volume profile W_d and W_t depend on the expected volume and the average cargo capacity.

Profile	W_d	W_t
high-volume	*	*
normal	2.B	4.B
narrow	2.B	3.B
single-lane	B	2.B

*depending on volume and cargo capacity

Table 16: Width of waterway bottom in relation to beam of reference vessel

The minimum waterway profile for commercial navigation in rivers is presented as a rectangular cross-section with a navigable width W and navigable depth D (ref. 87; see Figure 7). The width W is equal to the width W_t for canals plus increments for side winds or longitudinal current (see sections 3.5.5 and 3.5.8).

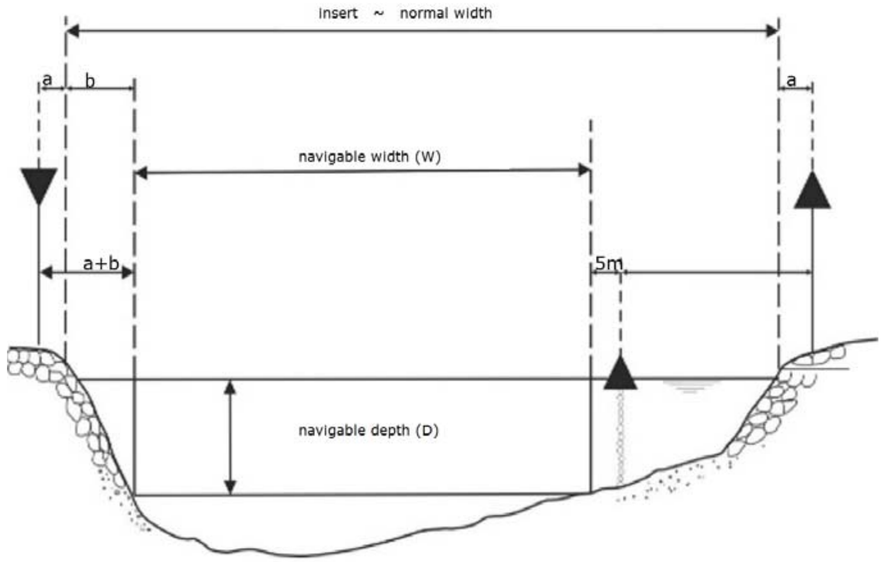


Figure 7: Definition of the fairway in a river

Navigation beacons and/or marker beacons are used to mark the fairway. The distance between the marker beacons and the edge of the fairway (a+b) consists of the distance to the insert (a) and the distance from the insert to the fairway (b). The distance from the marker beacon to the edge of the fairway is given in Table 17.

Location	a+b
Boven-Rijn, Waal	30 m
Pannerden Canal, Neder-Rijn, Lek	20 m – 25 m
IJssel	25 m
Maas	15 m

Table 17: Transverse distances to fairway

If shallows are marked with buoys, the distance between marking and fairway is 5 m.

3.5.5 *Side wind increment*

The beam of the reference vessel in the keel plane must be equal to the beam of the laden vessel in the keel plane plus an increment Dw for side winds, as shown in Figure 8. The profile of the free space is therefore symmetrical. For a normal profile, the side wind increment is approximately 0.05.L (L = length of reference vessel) in the inland zone and approximately 0.10.L in the coastal zone. The side wind increment for the narrow profile is approximately 0.07.L in the inland zone and approximately 0.14.L in the coastal zone. For a single-lane profile the side wind increment must be determined on a case-by-case basis. There is no prescribed method for this.

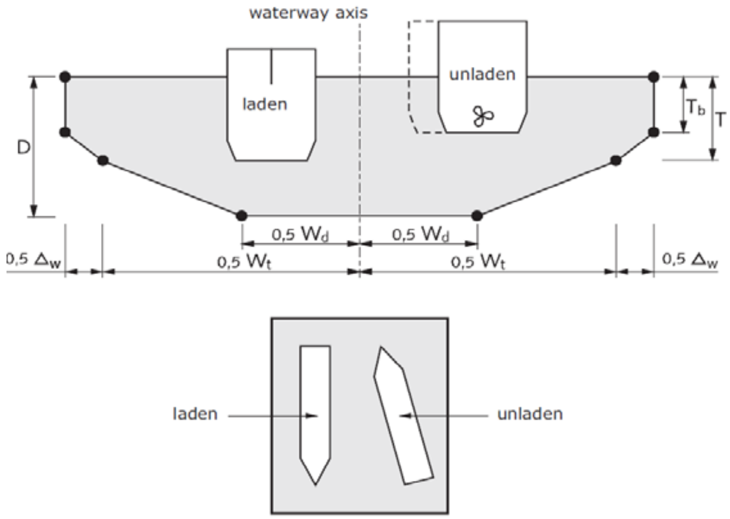


Figure 8: Minimum waterway profile on straight sections of waterway

Laden vessels do not suffer from side wind problems, so no side wind increment is taken into account for laden vessels. Some types of vessel, such as container ships, also catch a lot of wind inland (Figure 5). However, they generally have enough manoeuvrability to compensate for side winds. It had been assumed since the CVB 1999 guidelines that class V vessels have a bow propeller with at least 200 kW capacity. Meanwhile, however, capacities are now substantially greater (see Table 2).

On waterways that are sheltered over their entire length because they are sunken, or lined with hard physical structures or contiguous vegetation, a smaller side wind increment, or no increment at all, will be sufficient. In such cases, the appropriate side wind increment will need to be determined through further investigation. Further investigation is also required when the single-lane profile is used. A side wind increment should be applied to bends (§3.7) if it is also applied to the width of the adjacent straight sections.

The first figure in the depth column in Table 18 is based on the maximum draught according to the CVB 1996 guidelines. Nowadays, inland navigation vessels often have a slightly deeper draught. When new waterways are built or existing ones upgraded, the waterway management authority should select the second value.

class	minimum waterway profile (m)				
	depth	width		side wind increment Δ_W	
	D[1]	W_t	W_d	inland zone	coastal zone
normal profile					
I	3.1 - 3.5	20.4	10.2	2	4
II	3.5 - 3.6	26.4	13.2	3	6
III	3.5 - 3.8	32.8	16.4	4	8
IV	3.9 - 4.2	38.0	19.0	5	11
Va	4.9	45.6	22.8	7	14
Vb	5.6	45.6	22.8	9	18
VIa/M12[2]	5.6	68.0	34.0	7	14
VIa/BII-2b	5.6	91.2	45.6	6	14
VIb	5.6	91.2	45.6	9	19
VIc	5.6	91.2	45.6	13	27
narrow profile[3]					
I	2.9 - 3.3	15.3	10.2	3	5
II	3.3 - 3.4	19.8	13.2	4	7
III	3.3 - 3.5	24.6	16.4	5	10
IV	3.6 - 3.9	28.5	19.0	7	15
Va	4.6	34.2	22.8	9	19
Vb	5.2	34.2	22.8	12	24
single-lane profile[3]					
I	2.9 - 3.3	10.2	5.1	to be determined	to be determined
II	3.3 - 3.4	13.2	6.6		
III	3.3 - 3.5	16.4	8.2		
IV	3.6 - 3.9	19.0	9.5		
Va	4.6	22.8	11.4		
Vb	5.2	22.8	11.4		

[1]gegarandeerde nautische diepte excl. margin for maintenance

[2] top values for motor vessel, bottom values for pushed convoy or coupled unit (wide formation)

[3] class VI must at least comply with the normal profile

Table 18: Minimum waterway profile for straight waterway sections

The waterway depth is based on the draught of the class Va vessel – 3.5 m according to Table 2 – because the majority of vessels on class Va waterways are motor cargo vessels or Europa II barges with a maximum draught of 3.5 m. The reference vessel for a class Vb, VIa or VIb waterway is a pushed convoy or coupled unit with Europa IIa barges with a reference draught of 4.0 m.

The waterway profile must also comply with the minimum dimensions in Figure 8 in the vicinity of engineering structures (aqueducts, safety locks, bridges etc.). The design of engineering structures on existing waterways should be based on the existing waterway width.

	narrow profile (*)		normal profile (*)	
	cargo capacity with Vb ≤ 5%	cargo capacity with Vb ≥ 25%	cargo capacity with Vb ≤ 5%	cargo capacity with Vb ≥ 25%
increment in inland zone (m) waterway orientation =				
0°	0	0	0	5 (0)
30°	0	0	0	0
60°	0	0	0	0
90°	0	0	0	5
120°	0	9	0	15 (5)
150°	0	9	0	15 (5)
increment in coastal zone (m) waterway orientation =				
0°	0	17 (7)	0	46 (31)
30°	0	7 (0)	0	16
60°	0	0	0	6
90°	0	0	0	16 (6)
120°	0	17 (7)	0	31 (26)
150°	0	32 (17)	0	46 (31)
(*) The value in parentheses is the increment that must be used if a ban on empty two-barge pushed convoys applies when the wind is stronger than the reference wind force (2% exceedance probability); in the coastal zone this is 13.5 m/s, in the inland zone 10.5 m/s. Where no value is indicated, such a rule has no impact on the width of the waterway.				

Table 19: Extra wind increment for class Vb (m)

3.5.6 *Extra wind increment for classes Vb, VIb and VIc*

An extra wind increment is required for class Vb, VIb and VIc waterways if the proportion of the said vessels in the total cargo capacity exceeds 5%. If strong growth is expected in the proportion of Vb, Vib or VIc vessels or in the average cargo capacity, and the orientation of the waterway relative to the wind direction is unfavourable, this width increment applies over and above the values listed in Table 18.

Table 19 gives two values, associated with a proportion of class Vb vessels in total cargo capacity of 5% and 25% respectively. Values may be interpolated between these percentages. The assumption is that two-barge pushed convoys on canals always travel in long formation, even if the barges are empty. Table 19 indicates the waterway orientation relative to north. The values in Table 20 should be applied in an identical manner to class VIb and VIc vessels.

	normal profile (*)	
	cargo capacity with VIb and VIc ≤ 5%	cargo capacity with VIb and VIc ≥ 25%
increment in inland zone (m) waterway orientation =		
0º	0	28
30º	0	14
60º	0	0
90º	0	14
120º	0	28
150º	0	31
increment in coastal zone (m) waterway orientation =		
0º	0	28
30º	0	10
60º	0	0
90º	0	10
120º	0	28
150º	0	31
(*) Class VIb must at least comply with the normal profile		

Table 20: Extra wind increment for classes VIb and VIc (m)

3.5.7 *High-volume increment (class VI)*

Class VI waterways carry a volume in excess of 30,000 vessels a year. In this case, the dimensions for two-lane traffic (Table 18) are insufficient, and a high-volume increment must be applied. The same applies if the average cargo capacity exceeds 1950 tonnes. The appropriate high-volume increments can be found in Table 21; interlying values should be interpolated.

annual no. of passing vessels	average cargo capacity [tonnes]						
	1950	2150	2350	2550	2750	2950	3150
30,000	0	0	3	9	18	29	44
60,000	16	16	19	25	34	45	59
90,000	32	32	35	41	49	61	75
120,000	48	48	51	57	65	77	91
150,000	64	64	67	73	81	93	107

Table 21: High-volume increment for class VIa and VIb waterways (m)

The increment applies to canals in terms both of the width of the bottom (W_d) and the width at the draught of a laden (W_t) or unladen reference vessel. For rivers, the increment applies to the navigable width (W; see Figure 7).

No high-volume increment is required at an average cargo capacity < 1950 tonnes. In the event of more than 150,000 vessels a year and/or an average cargo capacity of more than 3150 tonnes, further investigation will be required.

3.5.8 *Current increment*

Longitudinal current on the waterway leads to a greater path width (see also §3.3.4), particularly when a vessel is travelling downstream, and on bends. In the event of a longitudinal current of more than 0.5 m/s and less than 2.5 m/s (rivers) a current increment of 0.1B accordingly applies to the required waterway width at reference flow rates of 0.5 m/s to 1 m/s, and an increment of 0.2B for reference flow rates greater than 1 m/s. The increment must be applied to each navigation lane. Where flow rates exceed 2.5 m/s, further investigation will be required.

CEMT class of laden vessel	Longitudinal current less than 0.5 m/s	Longitudinal current between 0.5 m/s and 1.0 m/s	1.0 m/s < longitudinal current < 2.5 m/s
I		0.5	1.0
II		0.7	1.3
III		0.8	1.6
IV	no increment	0.9	1.9
Va		1.1	2.3
Vb		1.1	2.3
VIa (M12)		1.7	3.4
VI		2.3	4.6

Table 22: Current increment per navigation lane (m)

3.5.9 *Crossing*

To distinguish it from a normal straight section, a crossing is defined as a short straight section connecting two bends in opposite directions in a meandering river or estuary, where the axis of the fairway transitions from one bank to the other.

If there is traffic crossing the waterway between two bends in opposite directions in order to benefit from the current and/or the available water depth on the bends, extra path width (Δb) will be needed for the shift to the other bank, and possible crossing by oncoming traffic. The extra path width (Δb) is approximately proportional to:

- the ratio of the reference longitudinal current to the navigation speed through the water;
- the ratio of the width of the fairway to the length of the crossing or the length of waterway needed in order to cross;
- the ratio between the crossing manoeuvre to the other bank and the width of the fairway.

The extra width required (Δb) for a single navigation lane is 0.072L where L is the length of the reference vessel (ref. 77). The increment Δb for two-way traffic is 0.144L.

The increment is not applied if it is smaller than the bend increment of the adjacent bends, or the progression in the bend increment in the transition from bend to straight section (see § 3.7.3).

3.5.10 *Fairways in lakes*

In canals, width and depth are linked by the requirement that the underwater cross-section must be large enough, given the travelling speed and the bank effect. The profile of fairways in lakes is much more generously proportioned, so the rules for width and depth are independent. The main differences in the parameters for canals and for fairways in lakes are:

- higher wind speed
- more difficult orientation on basis of fairway marking
- wind-generated waves causing horizontal and vertical ship movements
- buoyage inaccuracies

High winds, and other local causes, can produce currents in lakes. However, their influence is deemed to be less important than other factors. The influence of wind set-up and lowering of the water level by wind must be considered when determining the reference water level for commercial shipping (§ 3.3). Wind-generated waves can cause a ship to pitch and roll, momentarily increasing the draught.

The following rules apply to the relationship between fairway depth D and the draught of the reference vessel T (excluding water level raising or lowering as a result of wind effects):

- narrow profile, wind-generated waves < 0.5 m: D/T = 1.2
- narrow profile, wind-generated waves > 0.5 m: D/T = 1.3
- normal profile, wind-generated waves < 0.5 m: D/T = 1.4
- normal profile, wind-generated waves > 0.5: D/T = 1.4

waterway class	classes I to Va				Class Vb, VIa en VIb			
profile	narrow		normal		narrow*		normal	
zone	inland	coast	inland	coast	inland	coast	inland	coast
increment for wind-generated waves	-	15	-	15	-	20	-	20
increment for visual orientation	10	10	20	20	10	10	20	20
increment for buoyage inaccuracies	30	30	30	30	30	30	30	30

* Vb only

Table 23: Width increments (m) for fairways in lakes

The increments for fairway width in a fairway through a lake marked with buoys are shown in Table 23. These must be incorporated into the water bottom plane (Wd) of the fairway.

In large bodies of water (Wadden Sea, IJsselmeer lake, Delta area) it is recommended that, where possible at little extra cost, a width of at least 150 m be applied from class IV upwards. Fairways for commercial vessels wider than 250 m are advised against, to prevent crossing traffic from having to spend too long in the fairway. The extra increments for bends and side winds when there is a lot of class Vb, VIa and VIb traffic as applicable to canals (Tables 19, 20 and 28) also apply to lakes.

The transition from the waterway bottom width in the canal section to that of the fairway should be 1:20 and should occur in part (e.g. half) in the canal itself (Figure 9).

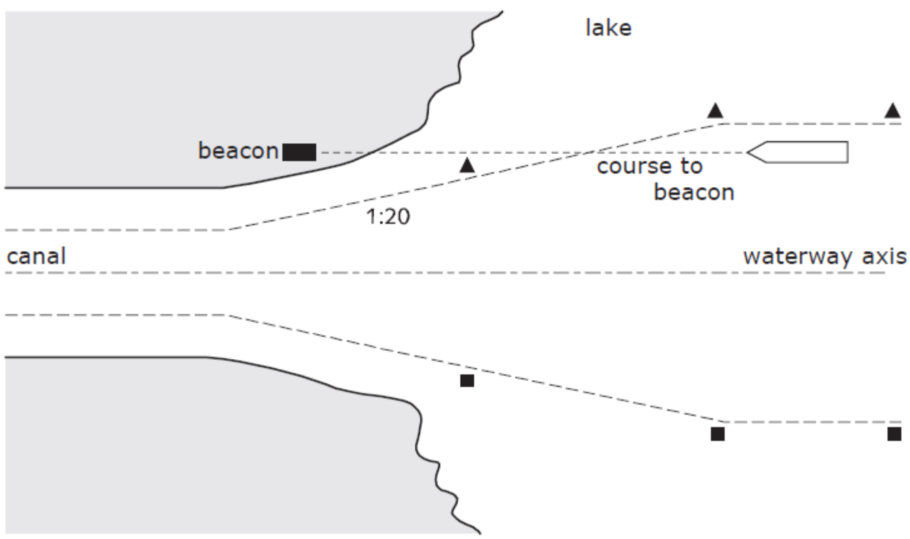


Figure 9: Connection between fairway through lake and canal

3.5.11 *Wildlife-friendly banks*

Sheet piling sunk immediately along the edge of the minimum waterway profile creates a channel that takes up a minimum of space. This profile is not popular among waterway users, however, because it causes wave reflection, and it is not wildlife-friendly.

Problematic wave reflection can be avoided by creating wildlife-friendly banks (ref. 20). The drawback of such banks is that they take up more space than vertical banks. The government is replacing sheet piling by wildlife-friendly banks only in order to restore the national ecological network or where there is a known problem with wildlife drowning. The wildlife-friendly bank may not cause sedimentation in the fairway.

Figure 10 is an illustration of a wildlife-friendly bank. The dots indicate the minimum waterway profile required. It must be clear to waterway users what type of bank protection is present and where the edge of the waterway profile is. The slope protection must therefore continue above the waterline. No launching apron may be laid at the foot of vertical sheet piling, suggesting unlimited navigable depth. Any underwater obstacles must be marked with beacons or signs.

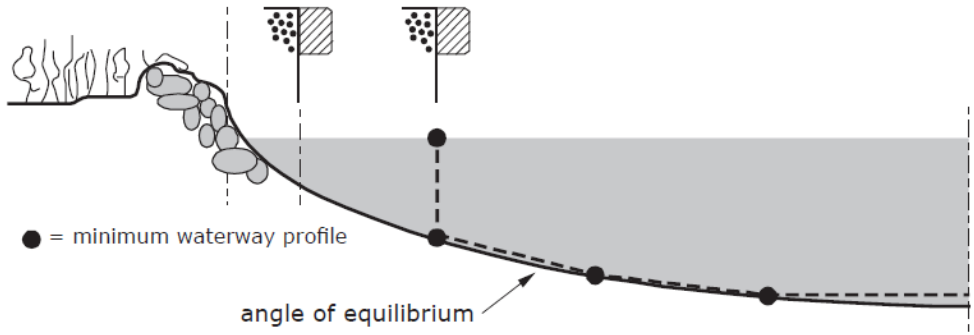


Figure 10: Waterway profile and wildlife-friendly bank

3.5.12 *Wildlife escape*

Animals will attempt to cross any canal transecting their habitat and forming a barrier. They are unable to climb out of waterways lined with sheet piling, however, and will therefore drown.

The best solution for wildlife is a contiguous wildlife-friendly bank. Where this is not possible, wildlife escapes can be created, places where the sheet piling is lowered and a 1:4 to 1:2 slope extends to at least 0.50 m below the waterline. Wildlife escapes must be created on opposite sides of the waterway; they may be positioned no more than 100 m apart, measured along the waterway (ref. 21). This also gives animals in danger of drowning an opportunity to climb onto dry land.

A plank with cross-laths provides an adequate escape for water fowl.

3.6 Straight sections of waterway for recreational navigation

In practice, the Netherlands’ waterways are often used for a combination of commercial and recreational navigation. In such cases, commercial navigation defines the standard for the dimensions of the waterway. The rules set out in this section apply where a waterway is used exclusively for recreational navigation.

3.6.1 *Waterway profile*

The water depth for recreational waterways is calculated differently from that for commercial waterways. A slightly smaller keel clearance is taken into account: 1.2.T for the normal profile and 1.1.T for the narrow profile. Navigation routes through lakes have an extra 0.30 m depth for waves and changes in water level due to the wind. The navigable width (see Figure 7) is given at a waterway depth equal to the reference draught plus keel clearance. The dimensions are more generous than those for commercial vessels. The navigable width for M and ZM routes for recreational navigation is 6.B for the normal profile and 4.B for the narrow profile, including an increment for side winds. This choice was based on the fact that recreational sailors have less experience, and on the lower directional stability of recreational craft compared to commercial vessels (Table 24). Where there is a combination of a (Z)M class and a BV class, the enveloping cross-section must be selected.

When there is a traffic volume of 30,000 to 50,000 passing recreational craft a year, a high-volume profile may be used. In other words: the navigable width will be equal to the width of the normal M or ZM profile, plus a high-volume increment Di and 5 m in width for every 10,000 movements above a volume of 30,000 movements a year. This width does not take account of tacking yachts. An increment of 0.3 m is added to the depth.

boat class	high-volume profile		normal profile		narrow profile	
	waterway depth	navigable width	waterway depth	navigable width	waterway depth	navigable width
ZM-A	2.8	25.0 + Δ_i	2.5	25.0	2.3	17.0
ZM-B	2.6	25.0 + Δ_i	2.3	25.0	2.1	17.0
M-A	2.2	25.0 + Δ_i	1.9	25.0	1.8	17.0
M-B	2.1	25.0 + Δ_i	1.8	25.0	1.7	17.0
M-C	2.0	24.0 + Δ_i	1.7	24.0	1.6	16.0
M-D	1.7	22.0 + Δ_i	1.4	22.0	1.3	15.0
BV-A	2.2	29.0 + Δ_i	1.9	29.0	1.8	24.0
BV-B	2.0	24.0 + Δ_i	1.7	24.0	1.5	20.0

Δ_i = high-volume increment

Table 24: Dimensions (m) of straight waterway sections for recreational navigation

3.6.2 *Tacking yachts*

On longer stretches, at least 30 m of waterway width is required to allow smaller yachts up to approx. 6 m long to tack. Over shorter stretches, approx. 20 m is acceptable. Larger sailing boats on longer stretches need at least 80 m, and over shorter stretches at least 50 m.

3.6.3 *Charter navigation*

The desired profile dimensions for charter navigation are in line with those for commercial navigation, because the vessels and the skills of the skippers are similar. The width of the normal and narrow profiles is 4.B and 3.B respectively, with a side wind increment of ½.B and ¾.B. respectively.

3.6.4 *Small-scale water sports*

The Water Sports Council presented a policy vision in 2001 (ref. 13) setting out desired and minimum waterway dimensions for small-scale water sports. In the context of these Guidelines, they can be regarded as the normal and narrow profile. The latter is acceptable only over short distances.

Table 25 lists width and depth dimensions for the waterway. The width excludes any reed beds. Rowing boat dimensions are based on the wherry, which is used for touring. Small-scale water sports benefit from wave-reducing banks, such as sloping and wildlife-friendly versions (see §3.5.11).

width of waterway	normal	narrow
canoeing and weed cutters	4,0	2,0
recreational angling	5,0	2,5
skating	6,0	2,5
rowing[1]	10,0[1]	2,5[1]
windsurfing	10,0	10,0
depth of waterway	normal	narrow
canoeing, rowing[2] and skating	1,0[2]	0,5[2]
windsurfing	1,0	0,8
weed cutters	1,2	0,8
recreational angling	1,5	1,0

1. These values apply to rowing tours; for training purposes and small races, the rowing association KNRB uses 50 and 20 m for normal and narrow respectively. The length of waterway without obstacles must be 2500 and 200 m respectivelty for normal and narrow for these purposes (ref. 85).
2. These values apply to rowing tours; for training purposes and small races, the rowing association KNRB uses 50 and 20 m for normal and narrow respectively.Table 25:

Table 25: Waterway dimensions (in m) for small-scale water sports

3.7 Bends

The radius of a bend in the waterway must be large enough for both commercial vessels and recreational craft in view of restrictions to:

- the rudder angle needed to take the bend
- the reduction in speed (loss of momentum) in the bend
- any course corrections required
- loss of visibility

3.7.1 Minimum bend radius for commercial vessels

In this connection, the following minimum bend radiuses R apply to the axis of the waterway (L = length of reference vessel):

- normal profile: R = 6.L
- narrow profile: R = 4.L

A minimum bend radius is not relevant to the single-lane profile, because such a profile is used only over short distances.

3.7.2 Width increment

Since vessels take up more width due to their crab angle on a bend, a greater waterway width is required on bends to ensure smooth, safe navigation. The path width in a bend depends on several factors, such as:

- the bend radius;
- the current;
- the wind;

- the direction of travel (upstream or downstream);
- the water depth;
- whether the vessel is laden.

If the bow angle ß is greater than 30º, the following increment applies to the waterway width in the keel plane of a laden vessel:

$\Delta B1 = C_1.L^2/R$

In the keel plane of an empty ship, the width increment is:

$\Delta_{B1} + \Delta_{B2} = (C_1 + C_2).L^2/R$

The factors C_1 and C_2 for a water depth-draught ratio of 1.4 are shown in Table 26 for a laden vessel, and in Table 27 for an empty vessel; the values apply to a speed of travel through the water of 13 km/h and a current at the top end of the range for the appropriate class. In the case of a vessel travelling upstream or in a situation without longitudinal current, the value in the first column applies. The last two columns can be used for vessels travelling downstream. Intervening values for longitudinal current can be determined by linear extrapolation.

CEMT class	upstream or longitudinal current $\leq$ 0.5 m/s	downstream and longitudinal current is 1.0 m/s	downstream and longitudinal current is 2.0 m/s
I	0.30	0.35	0.45
II	0.30	0.35	0.45
III	0.25	0.30	0.40
IV	0.25	0.30	0.35
Va	0.25	0.30	0.35
Vb	0.25	0.30	0.35
VIa	0.30	0.35	0.40
VIb	0.30	0.35	0.40
VIc	0.25	0.30	0.35

Table 26: Value of the factor C_1 for bend widening for laden vessels

CEMT class	upstream or no longitudinal current	downstream and longitudinal current is 1.0 m/s	downstream and longitudinal current is 2.0 m/s
I	0.45	0.65	0.95
II	0.40	0.60	0.80
III	0.35	0.50	0.65
IV	0.35	0.45	0.60
Va	0.35	0.45	0.60
Vb	0.30	0.40	0.50
VIa	0.45	0.60	0.80
VIb	0.45	0.60	0.85
VIc	0.35	0.45	0.60

Table 27: Value of the factor C_1 for bend widening for empty vessels

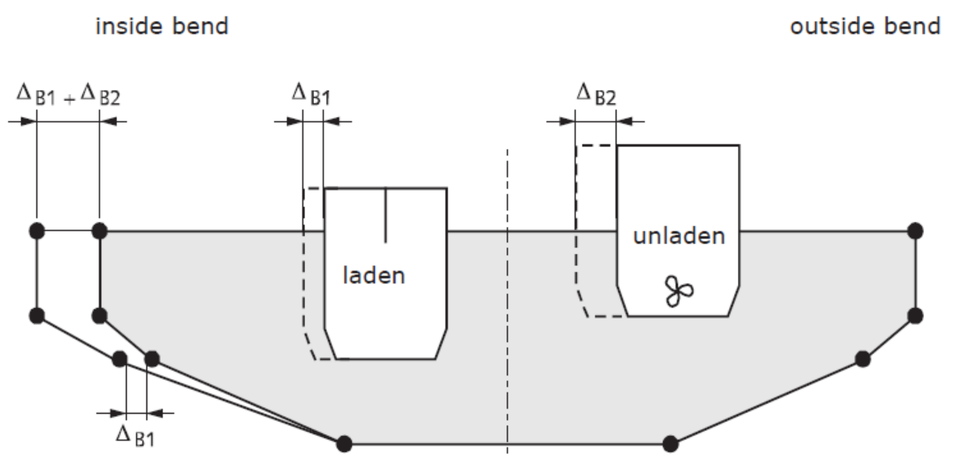


Figure 11: Bend widening in inside bend

One laden and one empty reference vessel passing in opposite directions is regarded as the reference situation for both the narrow and the normal profile. The ability to overhaul on a bend is not regarded as a requirement. It is however important to consider the direction of travel of the majority of laden or unladen vessels, as the factors to be applied for upstream and downstream travel differ (Tables 26 and 27).

The bend widening is calculated for each navigation lane and applied in the keel plane of the vessel in question. The widening for the laden vessel (ΔB1) and the empty vessel (ΔB2) from Table 28 are added in the keel plane of the empty vessel (Figure 11).

The side wind increment (§ 3.5) – if applied to the adjacent straight sections – should also continue into the bend.

CEMT	vessel length	Δ_{B1} for laden vessel (m)		
class	L	4.L	6.L	8.L
I	39	3.0	2.0	1.5
II	55	4.0	3.0	2.0
III	85	5.5	3.5	2.5
IV	105	6.5	4.5	3.5
Va	135	8.5	5.5	4.0
Vb	185	11.5	7.5	6.0
VIa	145	-*	7.5	5.5
VIb	185	-*	9.5	7.0
VIc	270	-*	11.5	8.5

CEMT	vessel length	Δ_{B2} for empty vessel (m)		
class	L	4.L	6.L	8.L
I	39	4.5	3.0	2.0
II	55	5.5	3.5	3.0
III	85	7.5	5.0	3.5
IV	105	9.0	6.0	4.5
Va	135	12.0	8.0	6.0
Vb	185	14.0	9.5	7.0
VIa	145	-*	11.0	8.0
VIb	185	-*	14.0	10.5
VIc	270	-*	16.0	12.0

L = length of reference vessel

*: class VI has a minimum normal profile (6L)

Table 28: Bend widening ΔB (m) for three bend radiuses (4.L, 6.L en 8.L) and longitudinal current less than 0.5 m/s

A bend widening of less than 0.5.B need not be applied in a trapezoidal cross-section.

When the bow angle ß < 30º the width increment may be multiplied by a factor ß/30. These increments apply at the level of the keel plane of the reference vessel. When the bow angle is small (ß < 20º) the difference in configuration between a small radius with a widened bend or a bend radius R = 10.L without bend widening is so small that in these cases, R > 10.L will be chosen in so far as possible given the local circumstances.

A computational model (ref. 71) is available on request from *Rijkswaterstaat* WVL (see § 1.2.4) for determining the factors C_1 and C_2 in situations other than those given in Tables 26 and 27. In the model the factors C_1 and C_2 depend on the local water depth, the properties of the vessel (reference length, beam and draught), the speed of travel through the water and the current speed (relative to the direction of travel). This allows the local water depth beneath the vessel to be taken into account, so a distinction can be made between a deep outside bend and shallow inside bend when calculating the extra path width required.

If the bend radius is smaller (R<4L) additional investigation using manoeuvre simulation models will be needed.

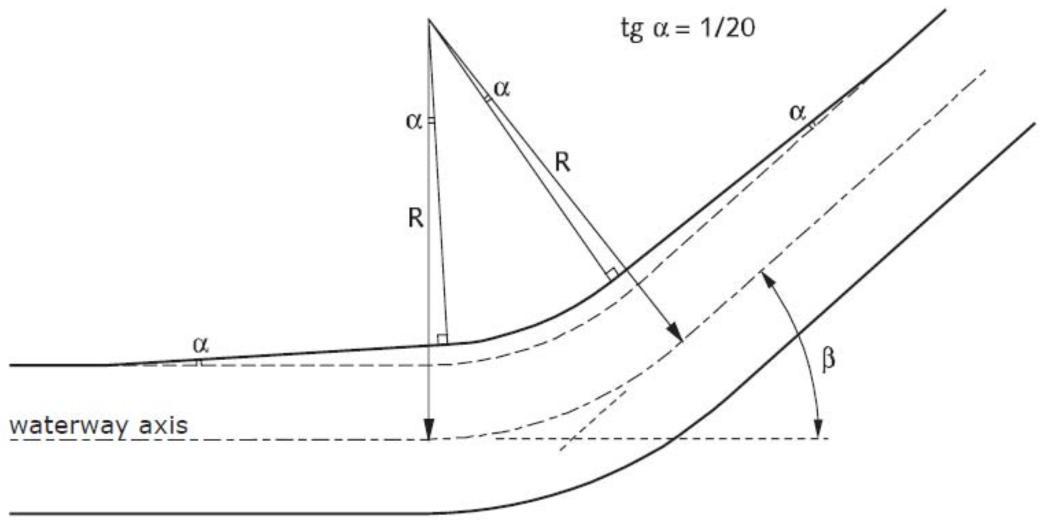


Figure 12: Transition from straight section to bend

3.7.3 *Shape of bend*

For the sake of visibility and nautical comfort, bends are widened on the inside (Figure 12). If necessary in view of the position of the bend, it may be widened on two sides (half the required width on the inside and the outside) or on the outside. The transition between the width of the straight sectionand the width in the bend should be gradual, at 1:20 relative to the axis of the waterway, tangential to the bow.

There must be a straight section of waterway with a length of 1.5.L before and after the bend. Bends near connections to ancillary harbours and at junctions are subject to less stringent requirements than bends in through waterways; see § 3.8.

3.7.4 *Unimpeded line of sight*

A class I to Va and VIa vessel travelling along the axis of the fairway should have an unimpeded view of oncoming traffic in the axis of the fairway with a maximum of 600 m unimpeded line of sight over a distance of 5.L (L = length of reference vessel), in order to allow a controlled stop manoeuvre to be performed. Classes Vb, VIb and VIc require an unimpeded view over a distance of at least 3.L, to enable a controlled evasive manoeuvre to be performed.

The line of sight is measured from the position of the skipper, based on the assumption that both skippers will respond as soon as they see the other vessel and that they are capable of taking timely action. There may not be any buildings or obstructive vegetation between the line of sight and the waterway. The plane that must be kept free of obstruction may not be any higher than 2.5 m above the average water level.

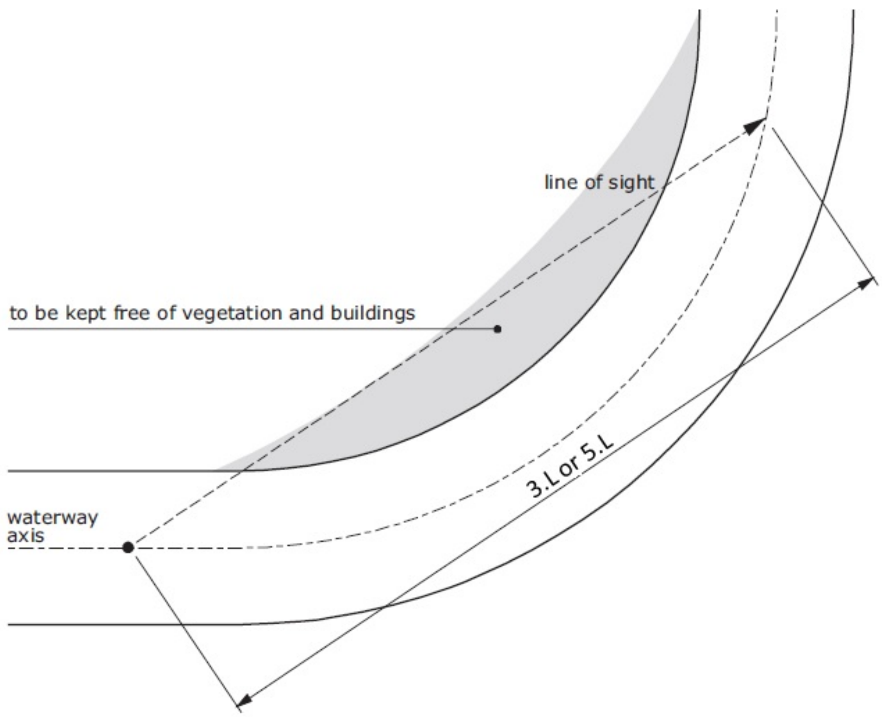


Figure 13: Line of sight on a bend

3.7.5 *Recreational navigation only*

In principle, the rules for commercial navigation apply to waterways that carry only recreational craft, with the addition of the following:

- a bend radius in main waterways in classes (Z)M-C or D must be at least 40 m and, for the larger waterway classes, at least 50 metres, measured along the axis of the waterway
- bend widening will be applied to bend radiuses (R) smaller than 100 m and bow angles (ß) of 20º or more (Figure 14)
- bends in main waterways in classes (Z)M-C and D will be widened by 1 m, and in larger waterway classes by 2 m. The bend widening will be regarded as the width increment in the plane of the reference draught; the widening will be effected on the inside of the bend.
- the transition between the width of the tangent and the width of the bend must be gradual
- the transitional length for classes (Z)M-C and D is 20 m and for other classes 40 m

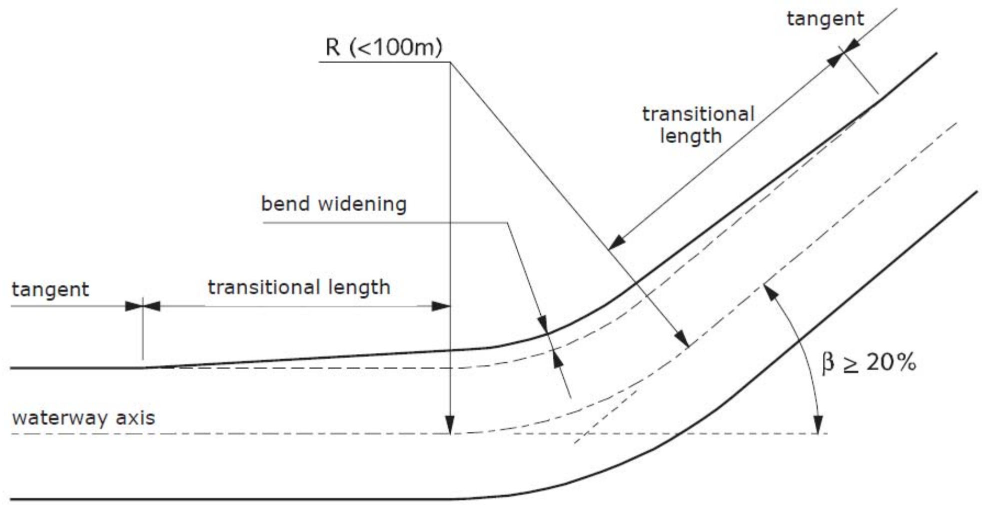


Figure 14: Transitional length and bend widening for recreational waterways

3.8 Junctions

Departing vessels' view of through traffic in both directions, and vice versa, must be sufficiently guaranteed at connections to ancillary harbours and at junctions and intersections of waterways (Figure 15). There must be an unimpeded angle of vision with a length of 5.L in the axis of the main waterway in both directions for classes I to Va and VIa, and 3.L for classes Vb, VIb and VIc, up to a maximum of 600m and a length of L along the axis of the ancillary harbour to the theoretical shoreline, where L is the length of the reference vessel on the waterway along with the line of sight is being measured. There must be no buildings or obstructive vegetation on the water side of the line of sight. The plane to be kept free of obstruction may not be any higher than 2.5 m above the average water level, based on eye level on a laden commercial vessel. Where mandatory use of a VHF radio or traffic control applies a line of sight at least 3.L m will be sufficient. At busy ancillary harbours the corners of the harbour mouth are rounded off in such a way that the radius of the path of vessels leaving and entering the harbour is at least 1.5.L.

On discharge-dominated rivers the unimpeded line of sight along the axis of the waterway at ancillary harbours, junctions and intersections of waterways must be at least 5.L for classes I to Va and VIa, 3.L for classes Vb, VIb and VIc travelling downstream, and 4.L for classes Vb, VIb and VIc travelling upstream.

On rivers dominated by tides, at a reference current speed greater than 1.5 m/s a line of sight of at least 4.L will need to be used for classes Vb, VIb and VIc in both directions (ref. 74).

Finally, when designing junctions on rivers, it is important to ensure that they are easy to interpret, with sufficient visual indications along the waterway to enable skippers to make timely manoeuvres, responses and to properly assess the movement of their own vessel relative to the current speed (relative position).

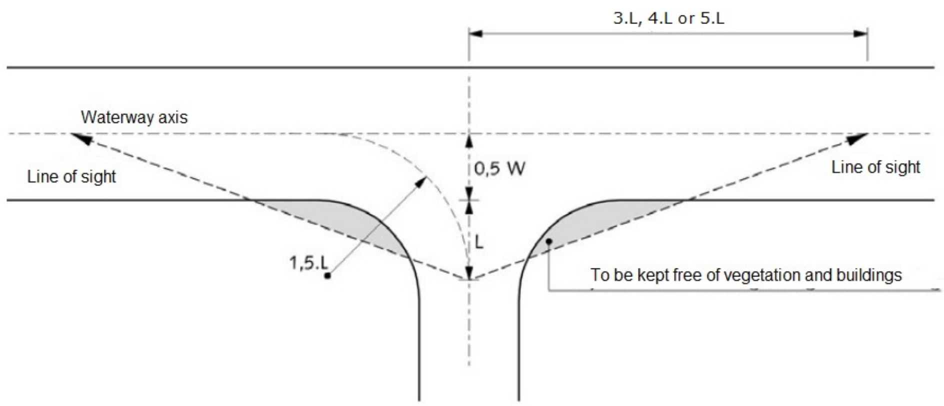


Figure 15: Unimpeded line of sight at a junction

The minimum value for the radius of the inside bend between two waterway axes at junctions and intersections on canals is 1.5.L. This gives enough room and obviates the need for bend widening to provide the extra path width required by vessels navigating the bend.

3.9 Turning facilities

3.9.1 Turning at wharves

A wharf should in principle have a place where vessels can turn, either a dock or turning basin. Vessels generally return in the direction from which they came and therefore have to turn around. The turning facility must be an acceptable distance from the wharf and, depending on how much traffic there is, it should be possible to reach it travelling forward.

It is only acceptable for vessels to have to travel backwards to a turning facility by way of an exception, and if it does not obstruct other shipping. The distance that the vessel is required to travel backwards may not exceed 1000 m. These rules may be applied with a certain amount of flexibility on canals with a low volume of traffic.

3.9.2 Turning in harbours

It is desirable for harbours that are over 1000 m long, or over 10 times the length of the reference vessel, to have a turning facility at the end.

If it is difficult to provide a separate turning basin, if fewer than 30,000 cargo vessels a year pass on the main waterway, and if the harbour is perpendicular or virtually perpendicular to the waterway, then the space where the harbour joins the waterway can be used. The junction must be in the form of a T (Figure 15). At the point where vessels turn, any vertical banks that they may collide with must have contiguous coping along the top to prevent damage from overhanging ships’ bows.

3.9.3 *Turning on the river*

Vessels may turn on the river where the space required is available. Possibilities include junctions, harbour entrances and areas between groynes. Space need not be specifically reserved in the planning of the waterway, provided there are opportunities for turning at regular intervals.

3.9.4 *Diameter of turning basin*

A turning basin is a circular widening of the waterway or harbour where vessels can turn. The circle has a diameter of 1.2.L (L = length of reference vessel) on canals. Within this circle, the depth should be the same as that of the waterway or harbour. On through waterways where more than 15,000 vessels a year pass, the turning vessel must not enter the other half of the waterway. In all cases, measures should be taken to protect the bank from extra erosion due to the eddies caused by propellers.

Pushed convoys with two or more barges or coupled units in long formationcan uncouple if necessary. It is not therefore necessary to build turning basins in class Vb or VIb waterways for vessels longer than 135 m.

3.10 Quays and wharves

3.10.1 *Conditions*

In this section, wharves are parallel moorings situated on the waterway itself, along an embankment or sheet piling, where the hawsers are lashed to bollards on the bank specially intended for the purpose.

On busy waterways, i.e. those with more than 30,000 commercial vessel movements a year, and along waterways in class V or higher, bankside quays and wharves should be avoided as much as possible, and docks constructed instead. This cautious policy with regard to bankside quays is informed by the ban (as laid down in the inland waterways police regulations (BPR) art. 9.03, and other places) on mooring along almost all national waterways. Exemptions may be granted from this mooring ban. The waterway management authority is advised to set out its policy on exemptions and publish it in the *Staatscourant* (Government Gazette, ref. 60).

On normal and quiet waterways, a reference vessel moored at a wharf must be situated entirely outside the contiguous shoreline. The embankment must be recessed at least as far as the beam of the reference vessel, plus a safety zone S whose size is equal to the value given in Table 37, so that the moored vessel does not present any obstacle to through traffic. Where there is a longitudinal current > 1.0 m/s (rivers), an increment of 1.B should be applied to S to prevent excessive hawser forces, which is sufficient at a navigation speed through the water of 12 km/h at a current speed of 2.5 m/s, or 15 km/h at 2.0 m/s. At speeds greater than these, further investigation will be required (ref. 73). The bed in front of the wharf will also generally need protection from erosion due to propeller races.

The greater the distance over which a waterway is flanked by quays and wharves, the less suitable it will be for through traffic. Quays and wharves should be grouped as far as possible in order to prevent speed restrictions from being imposed over long distances, which has a negative impact on overall journey speed. The distance between harbours and/or wharves must be no less than approx. one hour's travelling time. In other words: 10 km on waterways in class III or lower, and 15 km on waterways in class IV and above. Local conditions may however justify deviation from this rule.

The actual shoreline must remain visible for shipping despite the presence of wharves. The number of wharves already present will therefore be a factor in the decision as to whether construction of a new wharf is acceptable.

A sudden change in the dimensions of a canal's cross-section, at a wharf for example, can cause controllability problems. The transition in the horizontal plane from a wharf to the waterway must therefore be gradual, at least 1:2.

The depth of a wharf must be the same as that of the waterway. The length of the wharf must be at least 1.1.L, where L is the length of the reference vessel. Where there is a single fixed crane or hopper, the length must be 2.L so that vessels can move from one mooring to another.

3.10.2 Loading facilities for dangerous substances

Loading facilities for dangerous substances are not in principle permitted beside waterways. This matter is regulated by the Carriage of Dangerous Substances (*Wet vervoer gevaarlijke stoffen)*, the Regulations for the Carriage of Dangerous Substances on the Rhine (ADN) and the Environmental Permitting (General Provisions) Act (*Wet algemene bepalingen omgevingsrecht*).

Rijkswaterstaat has adopted an assessment framework on the matter (available on Werkwijzer RWS), which stipulates that such loading facilities:

1. are permitted in docks and port basins;
2. are not permitted for substances with high potential risk (article 1.10.3.1 of the ADN) along waterways;
3. are not permitted on trunk routes and main waterways, except for bunker stations supply, if smooth and safe passage of shipping can be guaranteed;
4. are not permitted beside other waterways, unless the smooth and safe passage of shipping can be guaranteed.

3.10.3 Houseboats

Moorings for houseboats are not acceptable in or immediately alongside main waterways. Their presence may mean that the waterway management authority has to impose undesirable restrictions on shipping on the waterway. Nor are houseboats appropriate in through waterways, unless the traffic volume is exceptionally low (less than two vessels an hour) and does not cause any obstructive movements of the water. This also applies to houseboats in docks along main waterways and other busy waterways.

3.10.4 Legislation

The Shipping Act is the basis of the inland waterways police regulations (BPR), among other things. General legislation on mooring can be found in chapters 7 and 9 of the BPR. Appendix 14 lists the national waterways where mooring is prohibited. The Rhine Police Regulations (RPR) also stipulate rules for the Rhine basin, and the regulations prohibiting anchorage and mooring on the Waal, Rhine and Lek rivers also list waterways where mooring is prohibited.

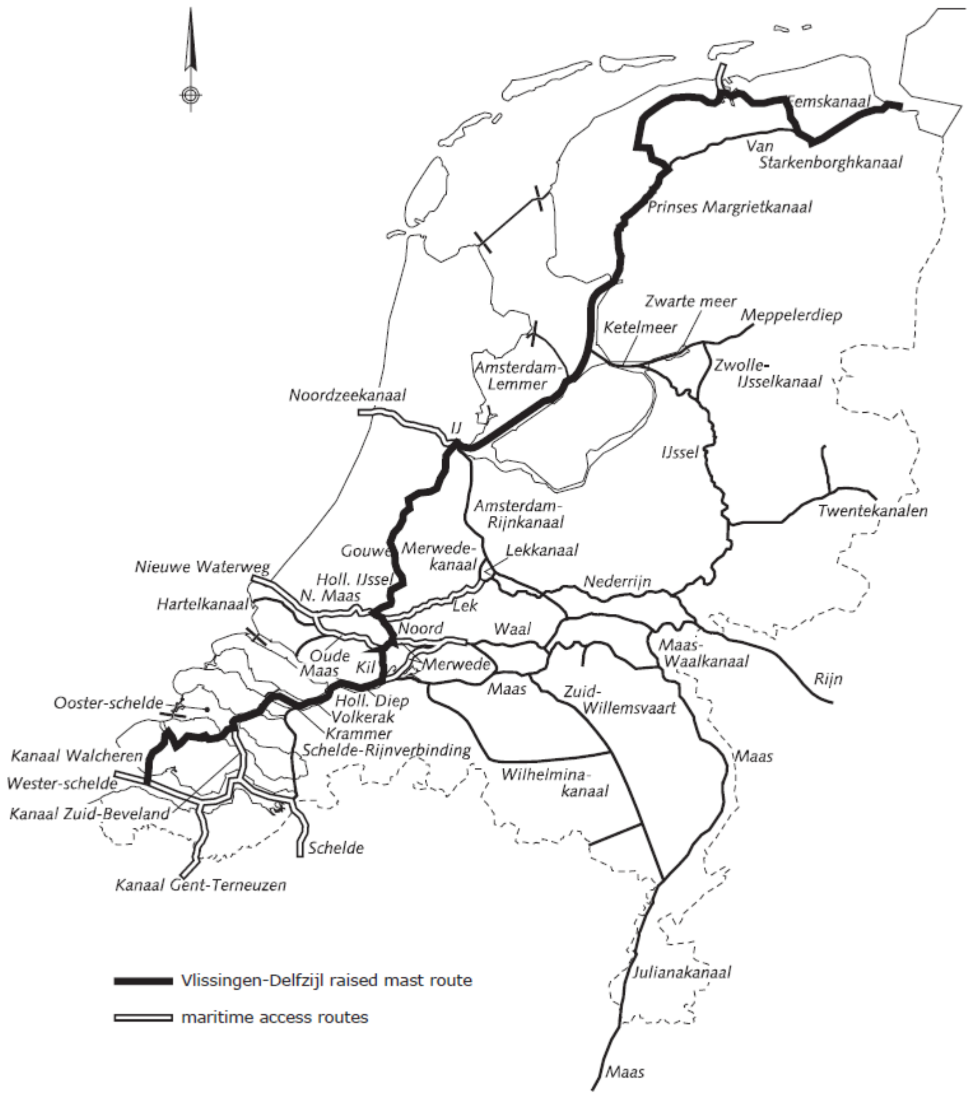


Figure 16: Raised mast route and maritime access routes

3.11 Intersecting cables and pipelines

3.11.1 Open waterways

A number of waterways are deemed to be open waterways. In other words, these are waterways where intersecting pipelines present no practical obstacles to shipping. These include the maritime access routes and the raised mast routes defined in the Basic Blueprint for Recreational Touring in the Netherlands. A minimum headroom of 30 m is required for the latter category. The Vlissingen-Delfzijl raised mast route is not the only open waterway defined in the BRTN, but it is the longest and best known (Figure 16).

3.11.2 Headroom

The height of inland navigation vessels (even when empty) is much lower than that of pontoon derricks, dredgers, abnormal cargoes and sailing boats. The height of these machines and sailing boats determines the headroom beneath high-voltage cables and other intersecting features. High vessels may use closed waterways with fixed bridges, but they will have to temporarily lower their mast. The headroom along a section of canal between two fixed bridges must therefore be greater than the headroom under the bridges.

The height of the lowest high-voltage cable must be at least equal to the headroom required plus a margin for sparkovers and sagging. The margin depends on the type of high-voltage cables in question and the distance between the pylons, and must be determined in consultation with the authority that manages the cables.

The headroom to be left when new high-voltage cables are installed over open waterways, or existing ones replaced, must be at least the same as the existing headroom on the waterway. Local circumstances, such as industrial activity or the presence of shipyards, may mean specific, more stringent requirements have to be observed vis-à-vis the height of high-voltage cables. The minimum requirements for commercial and recreational navigation differ, as can be seen in Table 29 and Table 30.

class	open waterway	closed waterway
I	30	20
II	30	25
III	30	25
IV	30	25
V	30	30
VI	45	30

Table 29: Minimum headroom (m) above MHWS

class	ZM routes	M routes
A	30	15
B	30	15
C	-	15
D	-	15

Table 30: Minimum headroom (m) above MHWS

The CCNR requirements apply to the distributaries of the Rhine (ref. 79).

3.11.3 Oceangoing vesels

The Verrazano Narrows Bridge in New York, with a headroom of 69.5 m at the average high water level, including a safety margin of 4.5 m, is the reference for large oceangoingS vessels, particularly cruise ships and container ships. This measure applies to waterways like the Western Scheldt, Nieuwe Waterweg, Nieuw Maas (as far as Maasbruggen), the North Sea Canal and the Binnen-IJ (as far as the passenger terminal). A minimum headroom of 45 m at MHW applies on the other maritime access routes.

3.11.4 Moorings beneath high-voltage cables

Under article 7 of the inland waterways police regulations (BPR), vessels may not moor beneath high-voltage cables. To be visible on the radar of other vessels, a 20 m zone outside the vertical projection of the outermost cable must be free of moored vessels.

3.11.5 False echoes

High-voltage cables over waterways cause ‘false echoes’ on the radar screens of ships, which can be misleading because they take the form of a ship. To prevent radar disruption, high-voltage cables should intersect waterways narrower than 150 m at an oblique angle. The angle of intersection can be determined by projecting a perpendicular to the line of the high-voltage cables from the axis of the waterway. This perpendicular should cross the starboard bank of the waterway at a distance of no more than 150 m (Figure 17). This will ensure the false echo hits the waterway at a distance of 150 m or less, next to the vessel, as a result of which it will be clear to the skipper that it is a false echo.

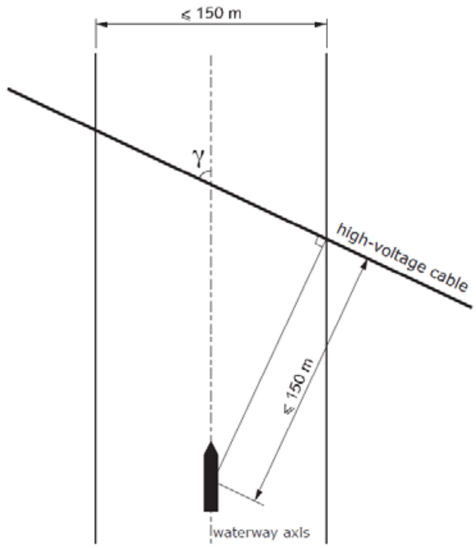


Figure 17: High-voltage cables intersecting a waterway at an angle

Spacers in high-voltage power lines should be avoided above waterways less than 150 m wide. If this is not possible, the spacers should be positioned as close above the banks of the waterway as possible.

3.11.6 *Radar reflectors*

On waterways narrower than 150 m radar disruption caused by high-voltage cables can be reduced by make the cables more easily identifiable using radar reflectors. At least three radar reflectors should be installed 40 m apart in the line above the waterway. The reflectors should have a small aperture angle and face oncoming shipping. The high-voltage line can then be identified on a radar screen by three or more points.

Distinguishing the echo of high-voltage cables from ships' echoes is also facilitated if the angle of intersection between the cables and the waterway is no smaller than 75º on a class IV, V or VI waterway, and no smaller than 80º on waterways in class III or lower. The BPR prohibits moorings in the immediate vicinity of high-voltage cables. Vessels anchored or moored near or beneath high-voltage cables cannot be observed by the radar of other vessels and therefore pose a danger to shipping.

If spacers are used in high-voltage power lines, they must be installed near to the radar reflectors, so that the reflectors can detect each other (Figure 18). The pylons on either side of the intersected waterway must be outside the profile of the free zone.

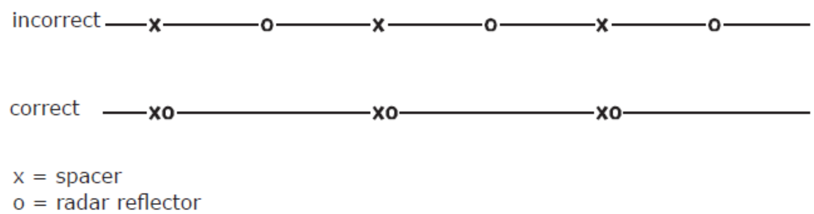


Figure 18: Positioning spacers in high-voltage power lines

3.11.7 *Cover for underwater pipelines and cables*

Cables and pipelines can be laid under the waterway, in which case they will need to be covered by earth, to protect them from damage by ships' anchors and dredging work. The depth of embedment of ships' anchors determines how much earth cover is needed. The depth of embedment depends on the type of anchor, its weight and the local soil characteristics (ref. 56). When high-pressure pipelines are laid underwater, designers must take account of their tendency to distend. Furthermore, the relevant NEN standards, such as the NEN 3650 series, and possible future developments such as upgrading of the waterway, must also be taken into account. For definitions, see Figure 54.

waterway class	sandy soil or hard clay	soft clay or silt*
recreational	1	1.5
I – II	1.5	5
III – IV	1.75	6
V - VI	2	8

*Indicative values

Table 31: Minimum cover for underwater pipelines and cables (m)

Depending on their type and weight, the anchors of oceangoing ships can certainly penetrate 1.0 m deeper into the waterway bottom than the anchors of inland navigation vessels. On the Rhine (waters subjet to the CCNR), 2.5 m cover is required above new underwater pipelines and cables. The management authority must prohibit anchorage if there is less than 1.5 m cover. Where the cover is less than 1.0, the pipelines or cables must be removed.

The ground cover is measured beneath the maximum depth affected after dredging. The minimum ground cover must be present across the entire width of the waterway bottom, taking account of any deepening as a result of erosion, for example. It should continue 2 to 3 m beyond the shoreline under the embankments, to prevent them from being negatively affected. Less cover is acceptable if a good protective layer is used.

Where there are longitudinal currents in excess of 0.5 m/s, and at places where the bottom undulates sharply or there is a strong likelihood of erosion, further investigation of the minimum ground cover needed is recommended. For economic reasons, pipelines and cables may be laid deeper or a protective layer applied over them.

3.11.8 *Tunnels and aqueducts*

The recommendations applying to underwater pipelines and cables also apply to tunnels and aqueducts. For economic reasons, the tunnel shaft may be sunk deeper, or a protective layer may be applied over the tunnel shaft.

3.12 Zoning

Three overlapping zones can be distinguished on the landward side of the waterway:

a. bank strip
b. free zone
c. risk contour

3.12.1 *Bank strip*

A bank strip or verge is needed to preserve the waterway and protect the bank, and as a place to position signs for shipping. This bank strip should be managed by the waterway management authority. The width of the bank strip is determined by the type of bank protection (sheet piling, natural bank) and the method of construction (anchor wall, rock filling). Sometimes the bank also forms the bottom of a flood defence. The recommended minimum width of the bank strip, calculated from the waterway boundary, is given in Table 32. The bank strip forms part of the free zone.

For the purposes of incident reporting, action in the event of emergencies and for management purposes, it is recommended that kilometre or hundred-metre intervals be marked out on the bank strip, readable both from the water and from the embankment. Information on the size, design and installation of the signs can be found in the Shipping Signs Guidelines (*Richtlijnen Scheepvaarttekens*, ref. 22). There may be vehicle access for inspection purposes on the landward side of the bank strip along important waterways, which will also guarantee access for the emergency services. It is recommended that any such path or road be made suitable as a recreational cycling or walking route, too.

3.12.2 *Risk of collision*

There is a risk that buildings (including underground car parks) close to the edge of a waterway with a vertical edge (quay wall, sheet piling) may be impacted by overhanging ships' bows. For the worst-case scenario, i.e. when an empty vessel runs into a fairly low quay (only 1.0 m above the reference high water level) at right angles, the following amount of overhang must be taken into account:

- inland navigation vessel with sharply pointed prow: 3.5 m
- Europa type I or II push barge: 5.0 m
- (large) oceangoing vessels: 15.0 m

On waterways for inland navigation, these measurements fall within the free zone defined below. If there is a sloped embankment, the measurements should be taken from the MHWS + 1.0 m line.

3.12.3 *Free zone*

The free zone is a zone alongside the waterway that is kept free of any buildings, vertical vegetation etc. that may endanger the functioning of the waterway, by blocking the line of sight, for example (ref. 23). The free zone also prevents collision with buildings. The free zone need not be under the management of or owned by the waterway managment authority. Under the Spatial Planning Act, the Spatial Planning (General Rules) Decree (ref. 49) and the Water Act, the waterway management authority has powers to influence how the free zone is used, for example:

- when any structures, not just buildings, are constructed, such as structures at the mouth of a harbour
- when the dimensions of an existing structure are altered
- in the event of any other actions that alter the current conditions, and thus the use of the waterway
- when vegetation overhanging the waterway or obstructing visibility is removed or cut back
- to prevent excessively bright lighting or obstruction of visibility due to smoke or water vapour from industrial plants
- to ensure access for maintenance and the emergency services on at least one side of the waterway

The free zone is measured from the waterway boundary (Figure 19) to the landward side. Where there is a vertical revetment, such as sheet piling or a quay wall, the waterway has a sharply defined boundary and determining the boundary will present few problems. Where there is a sloped embankment or wildlife-friendly bank, the waterway boundary is the point where the waterline intersects the embankment at the reference high water level (MHWS).

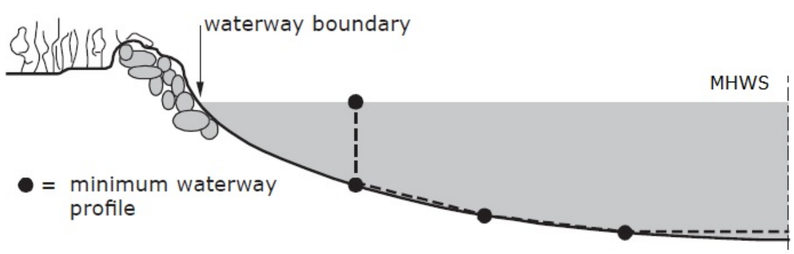


Figure 19: Waterway boundary at wildlife-friendly bank

The groyne line is the waterway boundary on rivers; in the case of lakes or sea inlets with a buoyed channel, the buoy line can be regarded as the boundary. In the case of large open areas of water where it is deep enough to navigate everywhere, the line of depth where an empty class I vessel can sail with enough keel clearance – i.e. the 1.7 m line of depth – at MHWS applies.

Local authority zoning plans must regard the measurements given in Table 32 as zone restrictions, where the powers of the local authority to grant permission for alterations and exemptions are subject to the approval of the waterway management authority. Connections to canalside commerce will be a decisive factor in the approval of building plans. The measurements given in Table 32 are from the waterway boundary (Figure 19). If the waterway fits tightly into a built-up area (generally enclosed between vertical banks), the area can be deemed to be urban, at the discretion of the waterway management authority.

Cranes, elevators, sheds etc. must not overhang the waterway when not in use, and must remain on the landward side of the waterway boundary. Temporary designation of green public spaces, recreational areas, traffic infrastructure, gardens, storage sites etc. along the waterway will not generally be at odds with the objective of protecting waterway function. In the approach to sea ports, measurements will have to be determined on a case-by-case basis.

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situation	CEMT class					
	I	II	III	IV	V	VI
bank strip (part of free zone)	1	2	2	5	5	5
free zone along straight section and outside bend in urban area	10	10	10	10	10	10
free zone along straight section and outside bend in rural area	10	10	10	15	15	15
free zone in inside bend in urban or rural area	10	10	20	25	25	25

Table 32: Minimum measurements for bank strip and free zone (m)

On national waterways the bank strip and free zone have an additional statutory basis in the Spatial Planning (General Rules) Decree, where they are referred to as the indemnification zone. This zone is measured from the boundary line of the national waterway as stated in the register referred to in section 5.1 of the Water Act. Article 2.1.3 of the Spatial Planning (General Rules) Decree stipulates that, when a zoning plan applicable to lands within the boundaries of a waterway or indemnification zone is adopted, any obstacles to the following must be prevented:

- the passage of shipping, in terms of beam, height and depth
- the crew’s line of sight and of the vessel’s navigation equipment
- contact between shipping and operating or traffic control facilities
- emergency services access to national waterways
- management and maintenance operations on national waterways

3.12.4 *Risk contour*

The transportation of dangerous substances by waterway poses risks to ships’ crews and local residents. In the interests of residents’ safety, no buildings are allowed within the defined risk contours, e.g. those with a value of 10^{-6}.

When the basic network for the transportation of dangerous substances (refs. 57 and 58) was introduced in 2015, a maximum PR 10-6 contour was assumed for the parts of the waterways included in the network; this is also known as the ‘PR ceiling’. The indemnification zone in the Spatial Planning (General Rules) Decree (ref. 49) must also be taken into account. When project decisions are taken (and project studies performed), the issue of whether the project might cause this risk ceiling to be exceeded must be considered and/or a collective risk (CR) calculation performed. Consideration must also be given to whether a change in the waterway changes the position of the bottleneck (the narrowest point of the waterway), as described in the guidance on building restrictions in and beside waterways, based on the basic water network. This guidance can be found at www.infomil.nl.

The risks (both PR and CR) for waterways that are not part of the basic network must be calculated, and they must conform to the standards set out in the statutory and policy rules (refs. 57 to 59).

3.12.5 Wind turbines

A separate set of policy rules apply to the installation of wind turbines on, in or above engineering structures (ref. 25). According to these rules, wind turbines must be positioned 50 m from the edge of the waterway to prevent obstruction and disruption of radar and communications equipment.

Wind turbines may be installed within 50 m of the edge of the waterway only if further investigation reveals that they will not create an obstruction. The minimum distance from the waterway boundary must be at least half the rotor diameter. The standards for wind turbines are not differentiated by waterway class. Wind turbines may not be installed in the immediate vicinity of overnight stay areas and waiting areas for vessels.

As a result of the increase in the average rotor diameter, an amendment to the policy rules is being prepared, based on a TNO study (ref. 61) which recommends a distance from the edge of the waterway of half the rotor diameter plus 30 metres.

4 Locks

4.1 Definitions

4.1.1 Lift lock with holding basin

Locks in larger waterways are always tailor-made and cannot be encompassed by a set of general guidelines. The management authority must carefully assess whether the scope of the guidelines is appropriate for the local circumstances. This chapter distinguishes between locks designed for commercial vessels only, for mixed shipping, for recreational craft only and for safety lock gates.

Figure 20 shows a lock complex. From a traffic engineering perspective, the main dimensions of a lift lock are determined by:

- the usable chamber length, this being the distance between the stop lines (L_k)
- the usable chamber length between the walls or floating fenders
- the sill depth at the reference low water level (MLWS)
- the headroom under the lift gates and any bridges over the lock

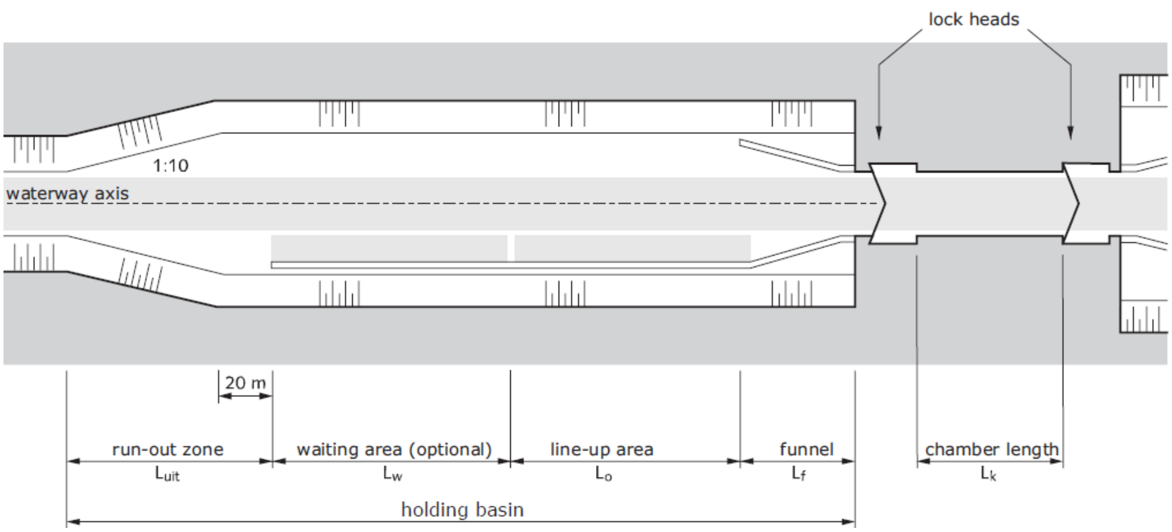


Figure 20: Schematic representation of a lift lock with holding basin

The following elements are found in a lock withholding basin:

- a lock chamber with ladders, mooring rings and bollards
- lock heads with gates
- a levelling mechanism (e.g. sluice or drain)
- control buildings
- shipping signs
- lighting
- communications equipment
- safety devices
- guide fenders (funnel)
- fender (line-up area and optional waiting area) with mooring facilities
- run-out zone – the transitional zone, kept free of obstacles, between the normal waterway profile and the holding basin

Rijkswaterstaat's Infrastructure Department, as it was then known (presently GPO), has published a detailed description of the design of lift locks (ref. 26), based on this chapter of the Waterway Guidelines.

4.1.2 *Wind problems*

The dimensions of the holding basin and the fenders are based on the assumption that most commercial vessels have a bow propeller with sufficient power to compensate for wind problems. In other cases, skippers will anticipate wind effects around engineering structures as they steer their vessel. The wind is not therefore taken into account in the design. It is nevertheless important to ensure that any exposure to side winds occurs gradually when the area surrounding the lock is developed.

4.1.3 *Lock passage water level*

The minimum and maximum lock passage water levels are the water levels below which, or above which, the lock is no longer used. At the maximum lock passage water level the minimum headroom is still available under lift gates and bridges, and at the minimum level the required sill depth is still present. When determining these minimum and maximum levels, the management authority must take account of factors like water level variation, the volume of traffic, the positioning of the lock, construction costs etc. An exceedance level of 1% is generally used for the maximum/minimum lock passage water level. The lock passage water levels must be laid down in the authority's management plan.

4.1.4 *Flood defence requirements*

The Guidelines do not examine the dimensions and design of the lock elements such as outer gates and lock gates resulting from flood defence requirements. This information can be found in guidelines produced by the Network for Flood Protection (ENW), previously known as the Technical Advisory Committee on Flood Defences (TAW).

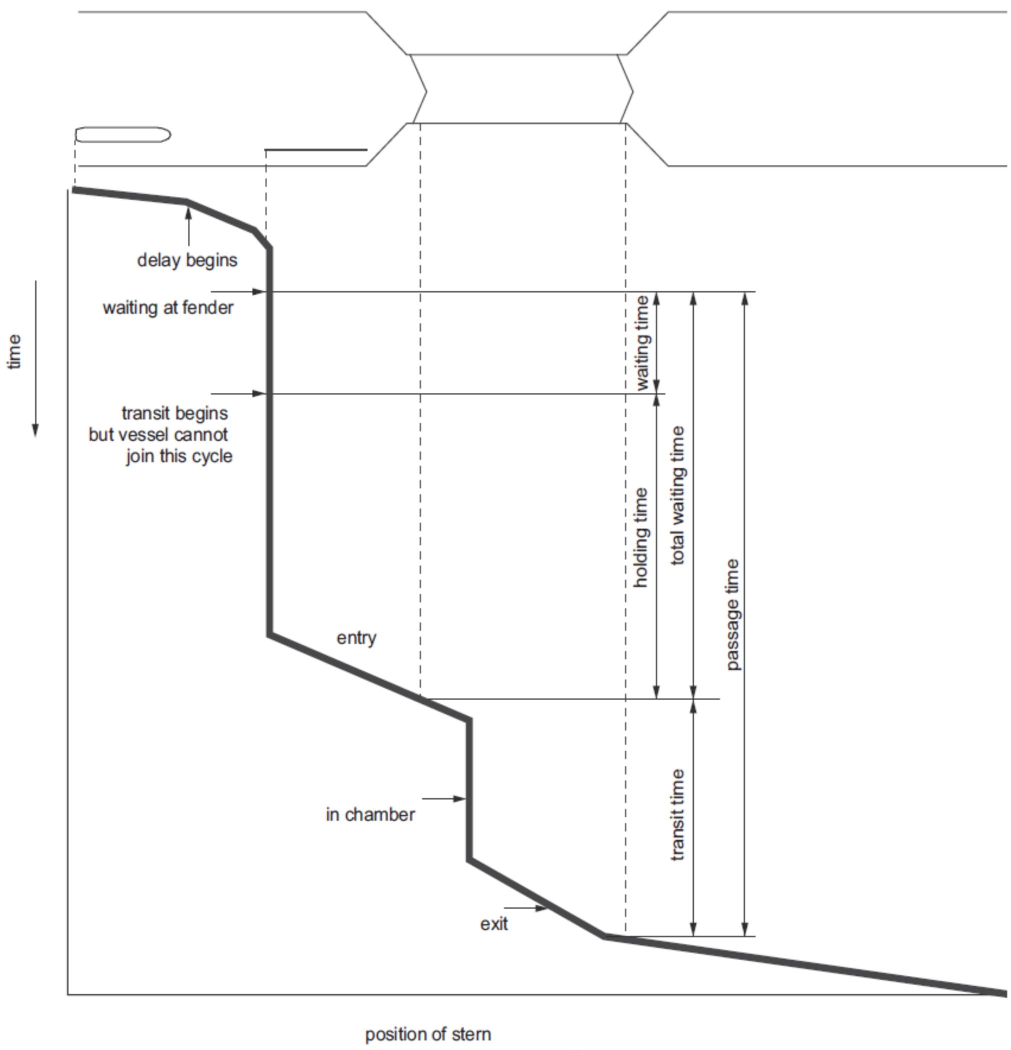
4.2 Lock capacity

4.2.1 *Capacity and traffic volume*

Besides chamber dimensions and cycle duration, the capacity of a lock also depends on the traffic volume and the dimensions of passing ships. At 10,000 to 12,000 commercial passages a year, the minimum capacity lock discussed in § 4.3.2 will provide sufficient capacity.

One option for increasing the capacity of a new lock would be to make it wider than the minimum capacity lock, so that smaller vessels would fit side by side in the chamber, and more vessels could pass in a single cycle. Widening is generally more attractive than lengthening from the point of view of cost. It is also possible to create extra capacity by constructing a separate lock for yachts, which can be used for smaller commercial vessels outside the recreational sailing season.

When designing a new lock for more than 10,000 to 12,000 commercial passages a year, the capacity – i.e. the number of chambers, and the chamber size – must be determined using a simulation model. *Rijkswaterstaat's* Centre for Water, Transport and Environment (WVL) and Centre for Major Projects and Maintenance (GPO) have such simulations performed using the SIVAK program (an acronym of the Dutch for 'simulation of traffic handling at engineering structures'). Capacity is generally determined for an average month and a reference month.



Figuur 21: Time-distance diagram of entry into a lock (waiting vessel)

4.2.2 *Definitions*

The following definitions (taken from SIVAK), which are illustrated in Figure 21, are useful when determining lock capacity:

- the passage time is the time a vessel requires to pass through a lock, comprising the waiting time plus the transit time and any holding time
- the waiting time starts when the vessel arrives at the lock and possibly moors at the fender, and ends when the transit time or holding time starts (the time taken to enter the chamber is thus part of the waiting time)

- the holding time starts when the entrance gates of the lock close and ends when the transit time for the vessel in question begins
- the total waiting time is the sum of waiting time and holding time
- the transit time begins when all vessels are in the lock (and the gates can be closed) and ends when the stern of the last vessel passes the exit gate

The transit time is therefore the time needed for:

- the gates on the entry side to be closed
- the water in the chamber to be levelled
- the gates on the exit side to be opened
- all vessels to leave the chamber

The concept of operating time refers to the time needed to open and close the gates and to level the water in the chamber. In practice, the term 'SNO time' is often used in the Netherlands – an abbreviation of the Dutch for 'close, level, open' – which is equivalent to the transit time excluding the time it takes for vessels to exit the chamber.

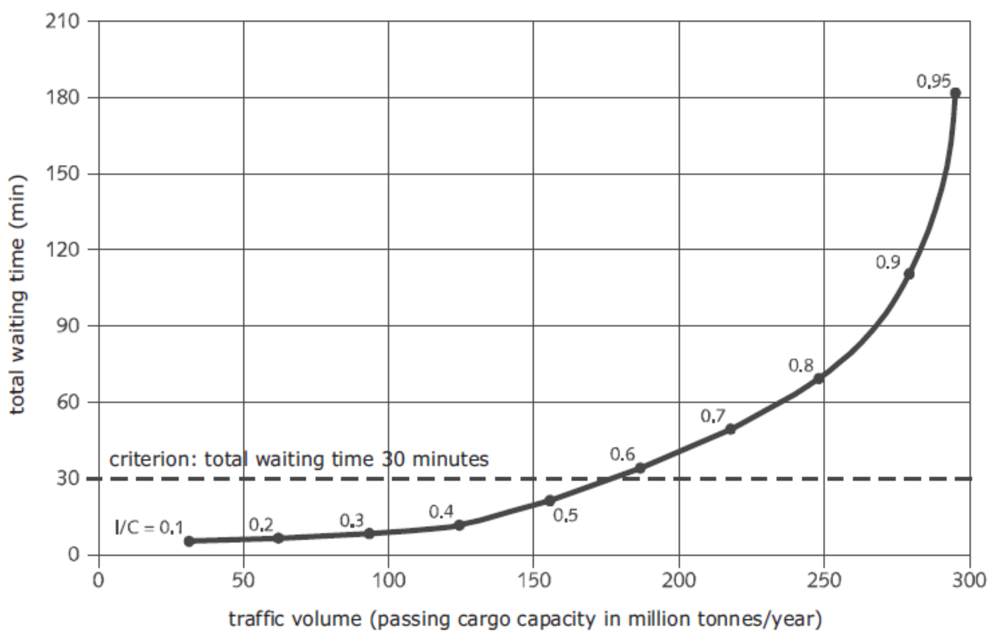


Figure 22: Waiting time at locks as a function of traffic volume (in this example: Kreekrak Lock)

4.2.3 *Standard waiting time at locks*

The obstruction caused by the handling of shipping traffic at a lock can be expressed as a standard waiting time at locks, or as an I/C factor, which is the ratio of traffic volume to lock capacity.

According to the Policy Document on Mobility (ref. 15) the standard for traffic handling at locks on main waterways is an average total waiting time of 30 minutes for commercial vessels in the reference period, usually the busiest months in the spring and autumn (Figure 22).

The standard for recreational navigation is an average waiting time of no more than one hour on the tenth busiest day of the season. The nine busier days may be spread over the season.

4.2.4 *I/C factor*

The obstruction caused by traffic handling at a lock can also be expressed as an I/C factor, representing the ratio of traffic volume to theoretical lock capacity. Traffic volume and capacity are expressed in terms of millions of tonnes of passing cargo capacity per year.

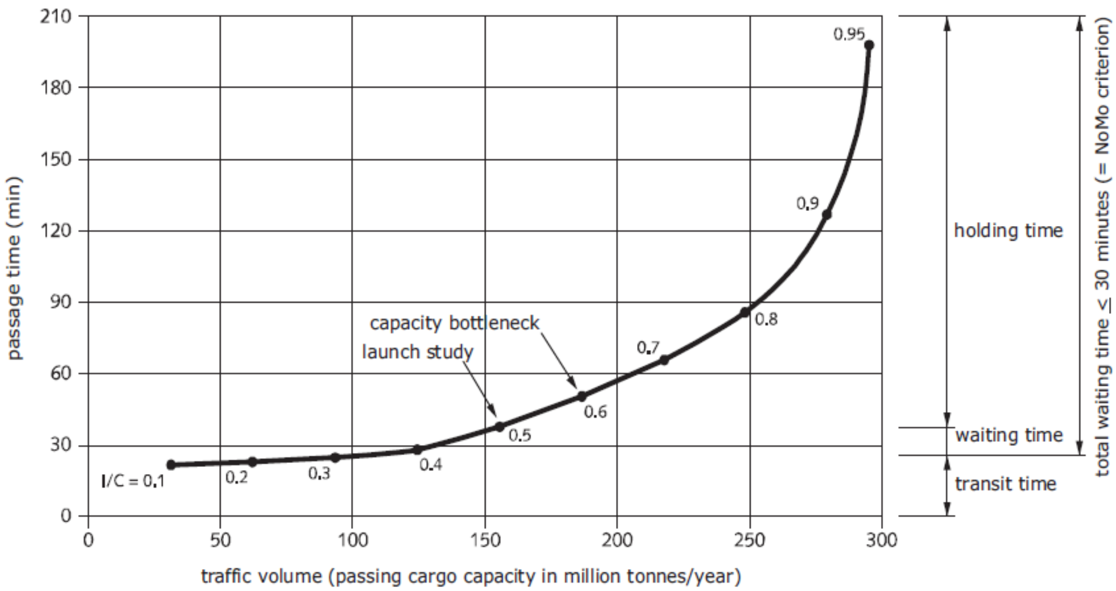


Figure 23: Passage time at locks as a function of traffic volume (in this example: Kreekrak Lock)

As the value of the I/C factor increases, so does the delay. The Policy Document on Mobility stipulates an I/C factor of 0.6 as the limit (Figure 23). In practice, waiting time has been found to increase exponentially above a value of 0.5 to 0.6 as a result of an increase in the number of waiting vessels which cannot join the next cycle. An extra transit cycle generally takes around 45 minutes in the Netherlands. The average total waiting time thus soon exceeds the 30-minute criterion, creating a capacity bottleneck.

An I/C factor of 0.5 can be regarded as a warning of a potential future capacity bottleneck, and time to launch a study of the likely future load. The management authority must take timely action to prevent such long waiting times occurring.

4.2.5 *Reliability*

The reliability of journey times is particularly important for scheduled services: container shipping, cruises etc. When planning a journey, it is not the average passage time at a lock that is the benchmark, but the probability of a longer passage time. Longer passage times sometimes mean fewer journeys can be made, resulting in higher transport costs.

The policy letter ‘Navigation for a vital economy’ (*Varen voor een vitale economie*, ref. 16) uses the 90% value of passage time as a measure of reliability at locks. This denotes the time it takes for 90% of vessels to pass through the lock. The reliability of the journey time (90% value) depends heavily on the I/C ratio of the lock. The higher this ratio, the longer the passage time. An analysis of the average passage times and the associated 90% values is given in Table 33.

I/C-ratio	average passage time (min.)	90% value relative ave. passage time	90% value of passage time (min.)
0.3	25	1.5	38
0.4	30	1.6	48
0.5	45	1.7	77
0.6	60	1.8	108
0.7	80	1.9	152
0.8	125	2.0	250
0.9	235	2.1	494

Table 33: Reliability of passage time at lock

4.3 Locks on commercial routes

4.3.1 *Dimensions*

The amount of water needed for the lock chamber is proportionate to the lift, and to the length and width of the chamber. Besides construction costs, this might be another reason to keep these two dimensions as small as possible. The depth of the lock depends on the maximum laden draught of the stern and the likelihood that the stern will touch the sill. The width and sill depth at the upper and lower gates depend both on the risk of damage and on the requirement that vessels can enter and exit the lock quickly and smoothly. This is generally sufficiently guaranteed if the ratio of the underwater cross-section of the reference vessel to that of the lock chamber (above the sill) is no more than 0.75. When the lock is built, the chamber length L, the usable length of the chamber between the stop lines, is at least 1.1 times the length of the reference vessel, for the same reason. The chamber width takes account of a 0.2 m wide timber fender on either side of the ship while it is moored up. The narrow width measurements given assume that guide fenders are present to correct the course of ships entering the lock.

4.3.2 *Minimum-capacity lock*

A minimum-capacity lock is a lock complex consisting of a single lock chamber that can take a single reference vessel at a time. The dimensions in Table 34, based on the reference vessel measurements (Table 2), apply to the chamber. The first figure in the sill depth column is based on the draught according to the Waterway Guidelines 1996. In practice, however, vessels have a slightly larger draught. Depending on demand, the waterway management authority may decide to apply the second value when building or enlarging a lock. The keel clearance above the sill is 60 cm up to and including class III, 70 cm in classes IV to Vb and 100 cm for classes VIa and VIb at the minimum lock passage water level or the reference low water level.

Many extended vessels exist in classes III, IV and Va, so it would be reasonable to opt for the longest vessel length (see also § 2.2.2). Sometimes it is better to opt for a greater length L_K: 240 m in a Vb lock, for example, instead of 210 m, would just accommodate two 110 m-long Va vessels, or a 270 m chamber could take a 135 m and a 110 m vessel.

waterway class	usable chamber length L_k	usable chamber width B_k	sill depth*
I	43	6.0	2.8 - 3.1
II	60	7.5	3.1 - 3.2
III	80 - 95	9.0	3.1 - 3.3
IV	95 - 115	10.5	3.5 - 3.7
Va	125 - 150	12.5	4.2
Vb	210	12.5	4.7
VIa	160	23.8	5.0
VIb	215	23.8	5.0

* sill depth = maximum draught of reference vessel + keel clearance
an extra increment might need to be applied for translation waves

Table 34: Dimensions (m) of minimum-capacity lock

A minimum-capacity lock will be able to cope with 10,000 to 12,000 commercial vessels a year. If the volume of traffic is greater, the number of chambers and the optimum chamber dimensions will have to be determined using a simulation model like SIVAK. A minimum-capacity lock is seldom sufficient on a waterway of class V or higher, and further investigation will generally be needed.

4.3.3 *Intermediate gates*

Locks where there are major fluctuations in the volume of traffic may be fitted with intermediate gates. These are installed in long lock chambers. The shorter partial chamber must also be able to accommodate at least one reference vessel. An intermediate gate – which is rare in the Netherlands – does not increase the capacity of the lock, because the entire chamber is used at busy times.

The drawbacks of intermediate gates include the costs of construction, management and maintenance, the latter particularly because the intermediate gates are vulnerable in the event of a collision. The advantages include a reduction in passage time when traffic volumes are low, increased availability thanks to the permanent presence of reserve gates, the presence of extra safety lock gates, and reductions in water loss and, where applicable, in saltwater incursion.

4.3.4 *Stop lines and distances*

The stop lines must be the following minimum distances from certain features on the chamber wall:

- where there are mitre gates: for classes I and II 1 m and for other classes 2 m from the caisson chamber
- where the gates are perpendicular to the axis of the lock: 2 m from the caisson chamber
- at a sill near the upper head that protrudes above the chamber bottom: 2 m from the sill
- When lock gates are secured against collisions there: 1 m from the anti-collision device
- in locks with separate gates for high and low tide: stop line before both high- and low-tide gate

Some types of filling and emptying systems specify greater distances. Further information can be found in ref. 26. The stop line must be at least 20 cm wide, and have red and white stripes at least 50 cm wide. Where there is CCTV, the stop line must also be visible along the top of the chamber wall.

It is desirable that 5 m distance markings be applied over a distance of 20 m (classes 1 and II) or 40 m (other classes). They must be easily visible on the chamber wall and lock plateau from both laden and unladen vessels at both high and low water levels. At a minimum-capacity lock, they may be positioned along one side. In wide chambers (over 12.5 m) they must be positioned on both sides.

A vertical white stripe at least 0.3 m wide must be applied to the chamber side of the gates denoting the axis of the lock to allow the distance between the vessel and the closed gate to be estimated. Such a white stripe must also be applied on the outside, to prevent collisions with the gates.

4.3.5 *Bollards and mooring rings*

Since, on vessels with a rectangular bow, the bollards are often further forward than on a conventional vessel, from class V upwards the distance between the mooring rings and bollards should be kept relatively small near to the stop line to ensure that the most suitable mooring rings and bollards can be used, ensuring full use of the length of the chamber. The first bollards and mooring rings should be immediately next to the stop line, on the chamber side. The distances between bollards are then twice 10 m followed by every 15 m. This also applies to smaller classes of vessel.

The bottom mooring ring is some 1.5 m above the lowest reference water level, but no more than 1.75 m above the minimum lock passage water level. The top ring should be as close as possible to the edge of the lock plateau. The vertical distance between the mooring rings should be approximately 1.5 m. A bollard should be positioned on the chamber wall above each vertical row of mooring rings. It should be painted white for safety reasons (to ensure it is visible). The measure of height is the foot. Bollards and mooring rings are installed symmetrically on both sides of the lock.

Given the fact that recreational craft use all waterways in the Nethelrands, locks for commercial vessels should have at least two moorings for yachts (see § 4.4).

4.3.6 *Hawser forces on bollards*

Bollards and mooring rings should be dimensioned for a typical load (excluding any safety factor) of 150 kN for classes I and II, 200 kN for classes III and IV and 250 kN for class V (ref. 27). The loads for classes VIa and VIb are 300 kN and 350 kN respectively. The basis for these values is derived from the regulations on the strength of hawsers for use on inland navigation vessels, which is calculated as follows:

- vessels where: L.B.T < 1000m3: F = 60 + (L.B.T) / 10 kN
- vessels where: L.B.T > 1000m3: F = 150 + (L.B.T) / 100 kN

The hawser force must be absorbed both parallel and perpendicular to the chamber wall. The shape of the head of the top bollard must be suitable for the steeply slanting hawser of an empty vessel. Bollards should yield rather than break when they are overloaded.

4.3.7 *Floating bollards*

Floating bollards are used when the lift is greater than 4 m. Each float may carry two bollards: one for laden and one for empty vessels. Table 35 shows the heights from the base to the low and high bollards relative to the water surface.

class	low bollard	high bollard	single bollard
I	1.5	2.5	2.0 - 2.5
II	1.5	3.0	2.0 - 2.5
III	1.5	3.0	2.4 - 2.5
IV	1.5	3.5	2.4 - 2.5
V	2.0	3.5	not advised
VIa and VIb	2.0	4.0	not advised

Table 35: Height of base of floating bollard relative to water surface (m)

If it is not possible to position two bollards on each float, high and low bollards will have to be alternated. In this case, a high and low bollard should be positioned as close to each other as possible at the ends of the lock (distance approx. 5 m). If it is nevertheless decided to install only a single bollard, it should comply with the height measurement in the last column of Table 35. The hawser guides on the high bollard near the pile cap require particular attention in connection with steeply slanting hawsers.

4.3.8 *Ladders*

Ladders are mounted on both chamber walls no more than 30 m apart. In principle, they are positioned next to a vertical row of mooring rings, at a distance of no more than 1 m. The first ladders should be mounted 5 m from the stop line. The bottom of the ladder should extend 1 m below the minimum lock passage water level. Ladders are recessed into the lock wall so that vessels do not rub against them, and hawsers do not become caught in them. Hand bars should be mounted at the top, on the lock plateau.

A recessed ladder should be mounted on both fender supports at a distance of 10 to 20 m from the lock head, extending to 1 m below the reference low water level or minimum lock passage water level.

4.3.9 *Lock plateau*

The lock plateau should be level with the top of the chamber wall (coping height) and in a minimum-capacity lock for classes I to IV must lie 1.5 m above the maximum lock passage water level, and 2.5 m for classes V and higher. At a lock that is significantly wider than the minimum-capacity lock, vessels may be moored diagonally in the lock, with their rectangular bow protruding over the chamber wall. The management authority must establish whether the frequency of high push barges, cross winds and high water levels warrants a higher lock plateau.

If the lock head is higher than the lock plateau, the transition in height must be gradual. If the lock plateau is more than 2.5 m above the minimum lock passage water level, under the Working Conditions Act this must be regarded as a fall risk zone. A suitable safety measure would be to install a railing at least 1.2 – 0.5 m behind the bollards, depending on how frequently people walk on the plateau. Life-saving equipment and first aid material must be present and clearly visible.

4.3.10 *Lock heads*

At locks for vessels in classes I to IV the height of the lock head is the same as that of the lock plateau, unless it needs to be higher for flood protection purposes. Locks for class V and above must have lock heads, and fenders beside the entrance to the lock, that are 4.5 m above the maximum lock passage water level. If the lock head is lower, the fender must be extended across the entire head to prevent problems with overhanging bows on empty push barges.

If vessels with a push bow use the lock only infrequently and/or the reference high water level deviates markedly from the average water level, the waterway management authority may, after careful consideration of the risks, opt for a lower lock head. A lock head in a waterway for commercial navigation must be at least 2.5 m above MHWS.

For maintenance vessels, a vertical series of mooring rings must be installed 1.5 m apart in the lock head outside the lock gates, on either side of the chamber. The bottom mooring ring should be 1.5 m above the reference low water level, the top one as close to the edge of the lock plateau as possible. A bollard should be positioned above the row of mooring rings on the lock plateau. For adjacent guide fenders: see § 4.9.

4.3.11 *Securing lock gates*

Lock gates must be able to withstand a collision. It may be wise to install a safety structure or protection from ship impact to protect lock gates from collisions with vessels. Such structures are relatively expensive mechanisms, both to install and to maintain, which can have major implications for the design of the lock. The management authority must weigh up the extra cost of installing and maintaining these mechanisms against the potential cost of damage caused by a collision. Further information on protection from ship impact can be obtained from Rijkswaterstaat’s Centre for Major Projects and Maintenance. Ref. 26 also contains information on this matter.

4.3.12 *Footpaths over lock gates*

Under the Working Conditions Act footpaths over lock gates must be safe to use all year round. Irrespective of whether the management authority permits the public to walk over the lock gates, this means that:

- footpaths for pedestrians and cyclists must have handrails on both sides
- the footpath across the lock gates must be usable when the gates are closed, even after a slight collision in which the gate has not sustained structural damage
- when the gates are open, the handrails may not make the passage any narrower
- handrails must not fold towards the chamber
- landings in a grid form must be non-slip
- differences in height between the footpath or landing and the lock plateau can be safely negotiated

If the lock gates are such that they should not be accessible to pedestrians (e.g. submersible-type lock gates), the design should make it impossible to cross them on foot, by making the top edge very narrow, for example.

4.3.13 *Other equipment*

Other points for attention as regards the equipment at locks for commercial vessels include:

- Every lock must be equipped with a VHF radio and a public address system
- It must be possible to communicate by emergency telephone in the line-up and waiting area
- An acoustic system for announcing the start of water levelling
- Access for the emergency services
- Preventing ice formation, see § 4.10
- The movement mechanism of the gates must be such that the gates can be opened in the event of a small lift (0.1 to 0.2 m)
- Water level gauges should be installed near the gates, both inside and outside the lock, possibly in combination with a warning system for vessels that are too high; at centrally operated locks the water levels and headroom must be visible on a central post
- A flexible reflecting waterside beacon indicating the entrance width should be installed on the points of the lock head to mark the lock wall for the skippers of high container vessels (with a raised wheelhouse).

4.4 Locks for mixed shipping

Locks exclusively for commercial vessels do not in fact exist. Recreational craft are found on every waterway in the Netherlands. When designing and equipping a lock, mooring should be provided for at least **2** yachts, at both the front and the back of the chamber (see Table 36). For details of the design, see § 4.4.2.

Annual volume of recreational traffic	Minimum number of moorings
0 - 5000	2
5000 - 7500	3
7500 - 10000	4
> 10000	5

Table 36: Number of moorings for recreational craft

4.4.1 *Chamber extension*

If the capacity of a lock becomes too small for the amount of traffic using it, a simulation model must be used and a cost-benefit analysis performed to find a solution. The first choice should be a separate chamber for recreational craft, also known as a yacht lock, as described in greater detail in the next section. The chamber may be extended lengthwise or widthwise.

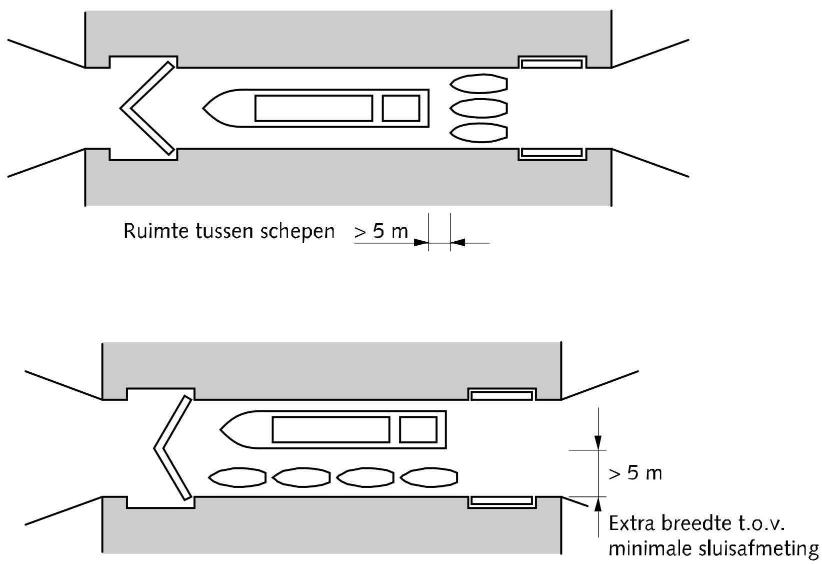


Figure 24: Chamber extension to accomodate commercial vessels and recreational craft

A widened chamber has the following advantages over a lengthened chamber:

- the capacity for commercial vessels only is increased, certainly in the colder half of the year, when there is little recreational navigation
- recreational craft have fewer problems with eddies caused by commercial vessels' propellers

The drawbacks of a widened chamber relative to a lengthened chamber are:

- it is more expensive to widen than to lengthen a chamber
- the safety of recreational craft is more likely to be an issue

With a view to the safety of recreational craft, a lock chamber will usually be lengthened, unless this is technically impossible in the particular situation. Commercial vessels will be expected to exit the lock slowly and carefully, to reduce the eddy problems caused by their propellers.

4.4.2 *Design for mixed shipping*

The following requirements apply to locks designed for mixed shipping, over and above those for locks designed only for commercial vessels:

- the chamber filling and emptying system must take account of yachts' vulnerability to turbulence
- the chamber walls must be smooth
- in the event of a lift of < 4 m, mooring bitts with 40 kN shearing pins should be mounted in the chamber wall between the mooring rings for commercial vessels, at horizontal intervals of 5 m
- mooring bitts should be designed in such a way that a steeply slanting rope will not slide off easily
- the bottom mooring pins or rings should be 1.25 m above the reference low summer water level, but no more than 1.5 m above the minimum lock passage water level. The vertical distance between them should be approx. 1.25 m; the top mooring bitt should be on the lock plateau
- if the lift is smaller than 0.75 m a horizontal mooring rail may be mounted on the lock plateau; the rail must have enough feet to keep the line in place in the event of suction caused by passing vessels
- in the event of a lift of > 4 m, or a rise and fall rate of > 2 m/minute floating bollards should be used; floats with mooring bitts or vertical mooring rails should be used instead of fixed mooring bitts
- at locks in tidal areas, mooring bitts with shearing pins should be mounted on the inner gates
- the maximum distance to the ladders should be 15 m; a secured ladder may be used instead of a row of mooring bitts
- mooring chains or lines may be mounted for sailing boats

4.5 Locks on exclusively recreational routes

4.5.1 *Dimensions*

A lift lock for recreational craft only is known as a yacht lock. Where there are more than 10,000 commercial passages a year, construction of a separate yacht lock may be considered. The yacht lock should be positioned in such a way that commercial vessels and recreational craft are separated and merged well outside the holding basin of the commercial lock. Efforts must also be made to ensure that the two flows of traffic can observe each other over a sufficient distance before the point where they merge again.

For up to 10,000 recreational craft a year, the yacht lock must at least be able to accommodate four yachts (two deep, two across). It is desirable that the dimensions of the yacht lock be such that it can also be used for maintenance vessels and as a reserve lock for small commercial vessels. The dimensions of a yacht lock depend on:

- the nature of the waterway: motorboat, sailing or combined route
- the volume of recreational traffic
- the dimensions of the yachts and maintenance vessels
- possible use as a reserve lock for commercial vessels

Above 10,000 recreational craft a year, simulations can be used to translate the required capacity into dimensions. Expansion should be considered first in terms of length, then of width.

The sill depth is the draught of the vessel plus a keel clearance of 0.4 m. The height of the lock plateau should be kept at 1.0 m above MHWS, provided the height above the maximum lock passage water level does not fall below 0.5 m.

4.5.2 Design

The following recommendations apply to yacht locks, over and above those for locks designed only for commercial vessels:

- the design of the chamber filling and emptying system must take account of yachts' vulnerability to turbulence and translation waves (ref. 26)
- the chamber walls and inner gates of locks in tidal areas must be smooth
- in the event of a lift of < 4 m, mooring pins or rings should be mounted at horizontal intervals of 5 m. The bottom pins or rings should be 1.25 m above MLWS, provided its height above the minimum lock passage water level does not exceed 1.5 m. The top pins or rings should be mounted as high as possible. The vertical distance between the pins is approx. 1.25 m. The first row of pins or rings should be mounted as close as possible to the stop line. A mooring bitt should be positioned on the lock plateau above each row of bitts, as close as possible to, and at any rate no more than 0.5 m from, the chamber wall. If the lock plateau is no higher than 1 m above the average water level in the upper canal section and the lift is no greater than 0.75 m, a mooring rail may be mounted on the lock plateau
- mooring bitts should be designed in such a way that a steeply slanting line does not easily slip off
- where the lift is more than 4 m and/or the rate of rise and fall is more than 1 m per minute, a vertical mooring rail or floating bollards should be used instead of mooring bitts
- ladders should be mounted on both chamber walls, extending to 1 m below the minimum lock passage water level. The distance between the ladders should be no greater than 15 m, and the first ladder should be positioned 5 to 10 m from the stop line. Hand bars should be mounted on the lock plateau above the ladders
- bollards and mooring bitts should be dimensioned to withstand a force of 40 kN and designed in such a way that they continue to hold a hawser even when it is steeply slanting
- at self-service or fully automatic locks, an emergency stop button should be installed to interrupt water levelling
- stop lines should be 1 m from the caisson chamber
- water level gauges or, possibly, dynamic matrix signs should be installed near the gates both inside and outside the locks, showing the current lift status

4.6 Holding basins

4.6.1 Function and position of holding basin at locks for commercial traffic

A holding basin is used for handling traffic at the lock. It also gives incoming vessels the opportunity to reduce their speed and to moor up at a fender if necessary. These guidelines consider only the main dimensions, the design and several general aspects of holding basins. In determining the dimensions it has been assumed that the entire commercial fleet already has or will be fitted with a bow propeller, allowing vessels to compensate for side winds and low speeds.

The holding basin must be straight along its entire length, and its axis in line with the axis of the lock. If necessary due to local circumstances, the axis of the holding basin may be at an angle of up to 5º to the axis of the lock. This must be implemented in such a way that vessels exiting the lock are not obstructed by moored vessels.

4.6.2 Length of holding basin

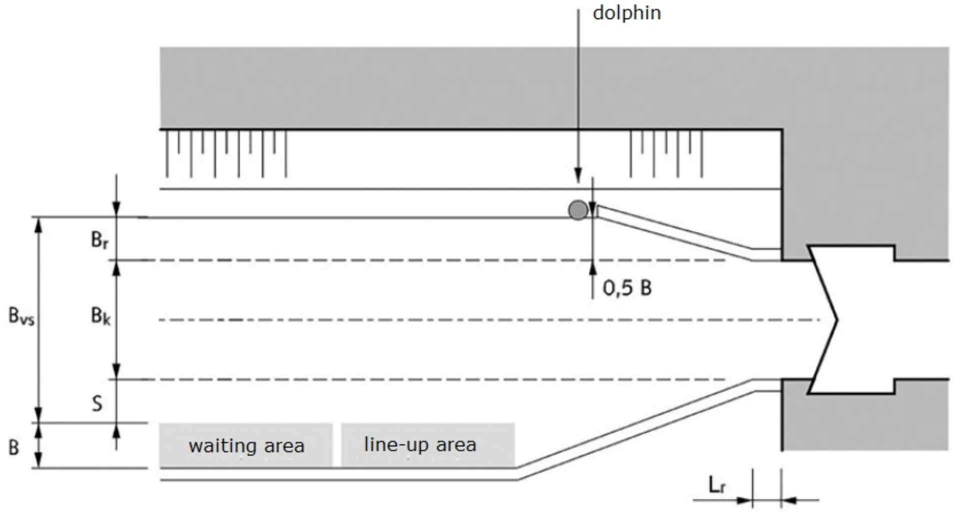
The length of the holding basin and the angle of narrowing should at least comply with Figure 20, and consist of the following elements:

- the length of the funnel L_f
- the length of the line-up area L_o
- the length of the waiting area (optional) L_w
- the length of the run-out zone L_{uit}

4.6.3 Width of holding basin

The width of the holding basin at a minimum-capacity lock with a one-sided line-up area is determined by (Figure 25):

- the beam of the vessel B, measured from the fenders or mooring posts
- the width of the safety strip S
- the width of the traffic lane = width of chamber B_k
- the width of strip B_r between the traffic lane and the depth of the maximum permissible draught



B = width of reference vessel

B_k = chamber width

S = safety strip: distance measured perpendicular to the lock axis between the line of the chamber wall and the line-up area

B_r = distance between the line of the chamber wall and the depth in the keel plane of a laden vessel, measured perpendicular to the lock axis

B_{vs} =traffic lane width in holding basin = $B_r + B_k + S$

L_r = length of the straight connection of the funnel to the lock head

Figure 25: Design of holding basin for a lock with a one-sided line-up area

The value of B_r is designed among other things to ensure a smooth connection between the waterway profile (narrow or normal profile) and the holding basin (Table 37). The difference between S and B_r should be divided evenly over both lanes, so that the axis of the holding basin is aligned with the axis of the lock. Where there is a two-sided line-up area, the strip B_r is replaced by a strip the width of S + B.

class	B	B_k	S	B_r(narrow)	B_r (normal)
I	5.1	6.0	3.0	5.0	6.3
II	6.6	7.5	3.5	6.0	8.8
III	8.2	9.0	4.0	7.5	11.1
IV	9.5	10.5	5.0	8.5	13.0
Va	11.4	12.5	6.0	10.5	16.1
Vb	11.4	12.5	7.0	11.5	15.1
VIa	22.8	23.8	12.0	not advised	32.2
VIb	22.8	23.8	12.0	not advised	32.2

Table 37: Minimum dimensions (m) of holding basin at a lock with a single chamber

4.6.4 *Two chambers*

Figure 23 shows an example of a lock complex with two identical chambers in a situation without a fender in between. A central fender is useful only if the distance between the two chambers exceeds 2.(B_k+S), so that waiting vessels can moor on both sides.

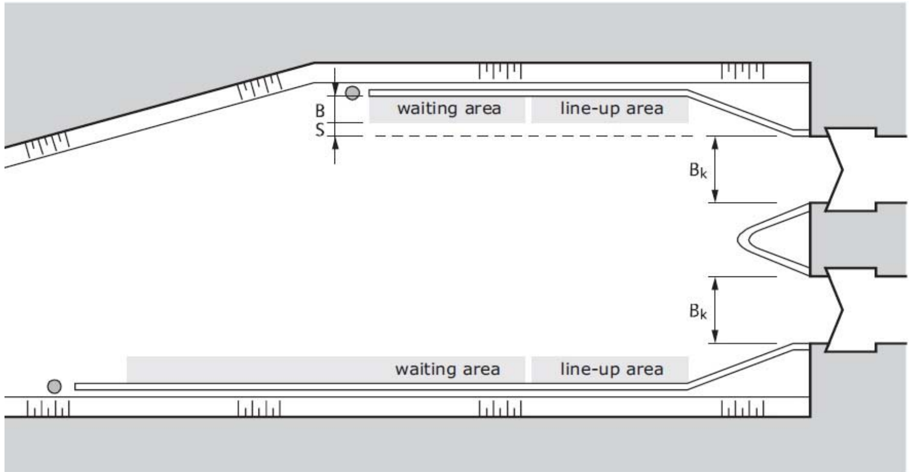


Figure 25: Lock complex with two identical chambers

4.6.5 *Depth of holding basin*

The depth of the holding basin is at least equivalent to that of the adjacent waterway. To prevent sedimentation on the lock sill, the holding basin must be deeper than the sill depth. If the holding basin is on a river, see §6.2.2 and 6.2.5 for the depth requirements.

4.6.6 *Funnel*

The funnel serves to:

1. provide visual guidance
2. provide physical support/guidance of the stern if a vessel is not on course before the lock head
3. prevent a vessel that is slightly skew from becoming trapped in the lock head

The funnel must be as symmetrical as possible to equalise the bank effect and in connection with visual effects. The dimensions of the funnel are derived from Figure 25: on the side without a line-up area, the fender supports should extend from the lock head to a distance of 0.5 B from the chamber wall. The guide fenders or walls should be at an angle of 1:4. In a minimum-capacity lock (see § 4.3.2 for definition) - where B_k can be exceeded by no more than 1 metre – the guide fender should first continue in a straight line from the chamber wall(s) to a distance of L_r (see Figure 25), determined by the following formula:

$$L_r = (B_k \cos(\alpha)-B)/\sin(\alpha)$$

Where:

L_r is the length of the straight section [m];
B_k is the chamber width [m];
B is the beam of the reference vessel [m];
α is the angle of the funnel.

class	B	B_k	L_r
I	5.1	6 - 7	7.0 – 3.0
II	6.6	7.5 – 8.5	6.8 – 3.0
III	8.2	9 - 10	6.2 – 3.0
IV	9.5	10.5 – 11.5	6.8 – 3.0
Va	11.4	12.5 – 13.5	7.0 - 3.0
VIa	22.8	23.8 – 24.8	5.2 – 3.0
VIb	22.8	23.8 – 24.8	5.2 – 3.0
VIc	22.8	23.8 – 24.8	5.2 – 3.0

Table 38: Values for the straight section L_r (4th column) for a minimum-capacity lock or a chamber 1 m wider

At locks that are more than 1 m wider than the minimum-capacity lock, L_r is only 3 m.

The contiguous fenders should in principle extend from the lock head to beyond the line-up or waiting area (see also § 4.9). In a minimum-capacity lock, contiguous fenders are not required between the funnel and the line-up area; this does not apply if there are culverts beside the lock head (see § 4.6.15).

4.6.7 *Line-up area*

The line-up area provides room for vessels that are due to go with the next locking cycle. The length of the line-up area must be at least 1.1 times the chamber length L_k. The width is the same as the chamber width, though if there are physical restrictions it may be at least as wide as the beam of the reference vessel, both at minimum-capacity locks and at wider locks. No embarkation/disembarkation facilities are needed at the line-up area, if the emergency services can board a vessel via the embarkation/disembarkation facility in the waiting or overnight stay area.

4.6.8 *Waiting area*

A waiting area in the holding basin is the space where vessels can wait for the next locking cycle. By communicating with the lock operator, a skipper can often avoid the need to wait by adjusting the vessel's speed. A vessel will not usually moor up if it has to wait less than 15 minutes. Measures to optimise utilisation can remove the need for a waiting area.

If a waiting area is situated beyond the line-up area, it will have the same width. The length depends on the number of ships expected on busy days. Line-up and waiting areas can alternate function if they are situated opposite each other. If there is an imbalance in the volume of traffic coming from each direction, it may be that a waiting area is needed on only one side of the lock. The total length of line-up and waiting areas is based on the total demand for lockage and overnight stays in the prospect year of the design. This can be most accurately determined on the basis of simulations with programs such as SIVAK. In view of the fact that recreational craft are found on all waterways in the Netherlands, at least two moorings must be included for yachts. For the requirements, see § 4.9.5.

4.6.9 *Run-out zone*

The run-out zone extends from the end of the holding basin to the first fender, and gives vessels an opportunity to reduce speed as they enter the holding basin from the waterway. The length required depends on local circumstances; at least 2.5 times the length (L) of the reference vessel will need to be available at any rate.

The run-out zone connects the waterway profile with the holding basin. The transition from the bottom width of the waterway to the line-up area is at an angle of at least 1:10 (Figure 20). A straight section of at least 20 m is required between the transition and the waiting or line-up area. The run-out zone length mentioned above will be inadequate if vessels have to wait before a bridge located near the lock after lifting. This will require extra waiting space, at a distance of L before the start of the line-up and waiting area. It is however better to avoid such situations.

4.6.10 *Overnight stay areas*

Quiet areas must be created in the holding basin where vessels can moor up overnight. Fenders at locks that are not operated at night may not be used, unless the lock staff give permission. If the lock is operated round the clock, vessels staying overnight must be kept as separate as possible from through traffic. The overnight stay area must have a disembarkation facility.

Extra overnight stay facilities can be built near to lock complexes, as separate as possible from the traffic using the lock, or elsewhere in separate overnight harbours (see also chapter 6). But the overnight stay area can also be set up in such a way that all or part of it can be used during the day as a waiting area. The capacity of overnight stay areas is based on vessels being moored up two abreast (ref. 31).

4.6.11 *Line-up/waiting areas for hazardous goods vessels*

Under the ADN and the BPR, vessels carrying hazardous substances must have separate line-up areas that also function as waiting areas. An investigation of the reference traffic volume will need to be conducted to demonstrate the need for such a facility. If there is a low volume of traffic carrying hazardous goods, traffic management measures can help reduce or prevent the need for them to moor up in waiting areas, so they will not always need separate mooring facilities. These should be positioned before and in line with the line-up and waiting area or, if this is not possible, on the other bank. The following distances must be maintained between hazardous goods vessels and other vessels and buildings:

- vessel displaying one blue beacon: 10 m from other vessels and 100 m from contiguous housing, tank storage depots and engineering structures
- vessel displaying two blue beacons: 50 m from other vessels, 100 m from engineering structures and tank storage depots and 300 m from contiguous housing
- vessel displaying three blue beacons: 100 m from other vessels and 500 m from contiguous housing, tank storage depots and engineering structures

While waiting before locks or bridges other, smaller distances may be maintained. The distance may not be shorter than 100 m in any circumstances.

The competent authority may permit smaller distances in view of local circumstances.

4.6.12 *Yacht lock holding basin*

In principle, the schematic diagrams shown in figures 17 and 22 apply to the holding basin of a yacht lock. The following considerations and dimensions also apply:

- the fender supports should be situated at an angle of 1:3
- where there are more than 2000 passages a year, use a two-sided line-up/waiting area with alternating functions
- the line-up area must be big enough to allow an entire passage to quickly moor up there two abreast; the width must be at least equal to the chamber width B_k
- the length of the line-up area L_o should be kept to 1.2 times the chamber length up to a chamber width of 8 m; the ratio for a chamber width of 8 to 10 m is 1.5 to 1.8
- in small locks (up to 6 yachts in the chamber) the run-out zone is 60 m; if the chamber holds more than 6 yachts, the length of the run-out zone must be 10 times the number of yachts in metres
- if a movable bridge is built over the waterway outside the run-out zone, the distance between the bridge and the beginning of the waiting area stipulated above applies
- the safety strip S is 2 m wide (Figure 25); in a one-sided line-up area, the distance B_r is 5 m
- the depth of the holding basin must be at least equal to the sill depth of the adjacent lock head
- an intercom system should be installed at line-up/waiting areas for recreational craft (see § 7.3.1)
- see §4.9.5 and §4.9.6 for the design of the fenders.

4.6.13 *Holding basin for mixed shipping*

The following additional requirements apply to holding basins for mixed shipping:

- the total length of line-up and waiting areas for use by commercial vessels and recreational craft in combination is based on the total demand for lockage and overnight stays in the year of design; this can be determined on the basis of simulations with programs such as SIVAK
- locks used by more than 20,000 recreational craft a year must have a separate line-up area for recreational craft with a minimum length of 30 m. The volume of traffic will determine whether it needs to be longer: the maximum number of yachts that can be expected in each cycle must be able to line up, moored two deep. The line-up area must be outside the traffic lane. The water depth in the line-up area must comply with the guidelines for recreational waterways. See § 4.9.5 for the design of fenders for recreational craft
- where there is a one-sided line-up area for commercial vessels, the line-up area for recreational craft should be on the other side, as close to the lock as possible
- if it is not possible to separate recreational and commercial vessels, recreational craft may use the line-up area for commercial vessels. In some cases the line-up area for recreational craft may be situated behind that for commercial vessels. The transition from the top part of the fender (commercial vessels) and the lowest part (recreational craft) must then be gradual

- if the line-up area for commercial vessels consists only of dolphins, a landing stage (fixed or floating) must be installed for recreational craft

4.6.14 Separate funnel (box) for recreational craft

A good solution for separating commercial vessels and recreational craft is to construct a separate funnel (box) for the latter, where one or more chamber-loads can wait. This solution is appropriate at very busy locks used by more than 30,000 yachts a year. Preparing an entire chamber load speeds up entry into the chamber, gives skippers a feeling of safety, gives structure to shipping movements and reduces aggression. The disadvantage of a box is that it is fairly expensive to construct, and takes up extra space (Figure 27).

The box is situated on the starboard side of the waterway, at least 50 m before the lock, well away from the fairway for commercial vessels. Its length must be at least 1.1 times the length of the chamber. If the lock is expected to become extremely busy, it is advisable to extend the box by one chamber length. The width is equal to the width of the lock plus 1 m, and at least equal to the beam of two reference yachts plus 1 m. The inner walls must be faced with planking to create a smooth finish, and have plenty of bollards. Footpaths along the funnel walls can be useful for drawing a yacht through, but are not strictly necessary. The funnels must offer protection from waves (wind-generated or otherwise). A fixed connection with the embankment is not desirable. The lock master must have a good view of vessels entering the box and have contact with waiting yachts via the VHF radio and public address system. Dynamic information panels can help direct yachts to the correct lock chamber.

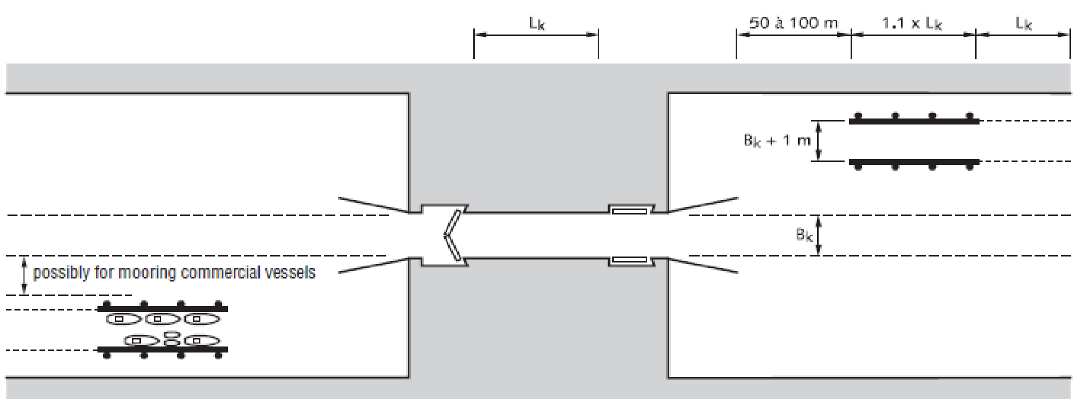


Figure 26: Schematic representation of boxes for recreational craft

4.6.15 Drainage flow

At locks that connect with a waterway where the current is faster than 0.3 m/sec, the design and dimensions of the holding basins require special attention if the current passes the holding basins. This applies to dammed rivers, particularly the upstream side where vessels have to enter the holding basin with the flow (see also § 4.8 weirs). The entrance to the holding basin must be generously proportioned, and there must be enough space immediately after the entrance to give entering vessels the opportunity to reduce speed and adjust their course.

The four most common situations found where there is drainage flow are:

- water conveyance via separate culverts on either side of the lock chamber with inflow and outflow in the front of the lock heads (Figure 28)
- water conveyance via an open drainage channel on one side of the chamber, with inflow and outflow at the point whether the holding basin meets the adjacent section of canal
- water conveyance as a result of the presence of a fish ladder
- through the lock chamber, by lifting or fully opening the gates or valves

Re. 1: When water is conveyed via separate culverts, the following points must be taken into account on the water intake side (acceleration):

- the current must be as symmetrical as possible
- the longitudinal current must be restricted to 0.3 m/s, in connection with mooring in a downstream current while the chamber is filling or emptying, and cross current must be avoided. If there is a disruptive current, drainage warning signs must be installed; see the Shipping Signs Guidelines (ref. 22). See also § 3.3 on hydraulic parameters
- cross current for vessels entering from the line-up area must be avoided near the lock head, for example by having a fender with a closed structure along the first section beside the head, and openings of increasing size in the fender further upstream (Figure 28)
- the horizontal part of the fender should run from the head to the fender of the line-up area to provide mechanical guidance
- where there is a one-sided line-up area it is advisable to position a number of posts on the opposite side, in line with the fender

On the outlet side (deceleration), the following must be taken into account:

- the current must be as symmetrical as possible to minimise the likelihood of eddies and to restrict flow gradients
- cross current must also be avoided here

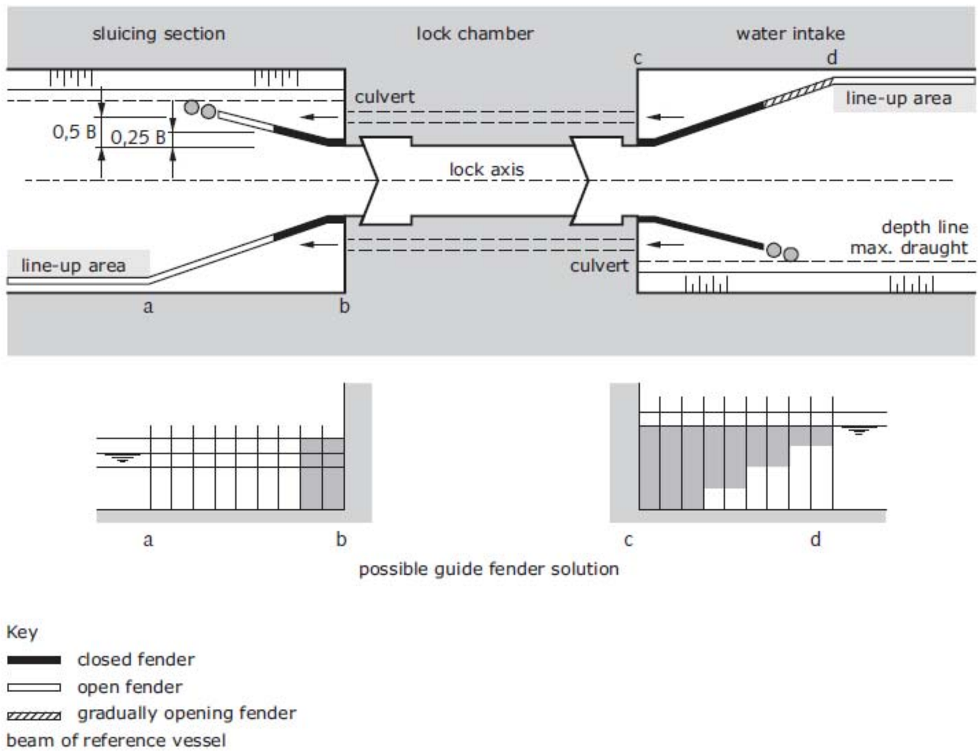


Figure 27: Holding basins with water conveyance via culverts

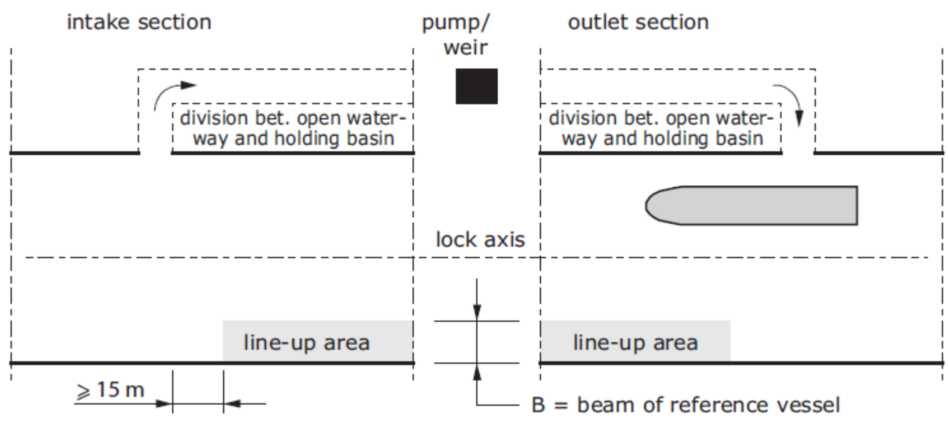
Re. 2/3: Where water is conveyed via an open drainage channel, which also includes fish ladders, the following must be considered on the intake side (acceleration):

- a one-sided line-up area must be situated opposite the intake point if possible
- the cross current must be limited to 0.3 m/s; see also § 3.3; longitudinal currents are less problematic in this situation
- for safety reasons, it may be advisable to position a buoy to mark the bank at the intake point

The following applies on the outlet side (deceleration):

- the angle between the axis of the current at the sluice and in the canal must be as small as possible
- the intake or sluice must be situated more than 15 m before the start of the waiting/line-up area, or on the other side of the holding basin
- any one-sided line-up area should be situated opposite the sluice
- the transverse component of the outflow along the shoreline must be less than 0.3 m/s, in accordance with § 3.3; the longitudinal component must be less than 0.5 m/s
- for safety reasons it is advisable to install a buoy line to mark the bank at the sluice

Re. 4: It might be necessary to close the lock to certain classes of vessel while sluicing is in progress, depending on the expected current speed, the underwater cross-section of the lock chamber and vessels, and the local circumstances.



Figuur 28: Voorhavens met een spuistroom via een open waterloop

4.7 Safety lock gates

4.7.1 *Flood defence function*

Safety lock gates are part of both the waterway and the flood defence, and must therefore meet the requirements of their flood defence function and the regular requirements of the waterway. When closed the lock must function as a fully-fledged water defence structure. As regards the dimensions and design with a view to their flood defence function, the reader is referred to the guidance issued by the Expertise Network for Flood Protection (ENW), previously known as the Technical Advisory Committee on Flood Defences (TAW).

On waterways that may not be blocked, a lift lock may be installed instead of safety lock gates. A lift lock is open most of the time. On busy waterways, safety lock gates with a lift lock alongside must always be chosen. The lift lock may be equipped with basic fittings and a 'green lock chamber'.

4.7.2 *Position of safety lock gates*

Safety lock gates may not be situated within a distance of 2.L from the intersection of the axes at a junction or intersection. There must be a straight section of waterway over a distance of at least 1.5.L before and after the safety lock gates.

The axis of the lock must coincide with that of the waterway section in which it is situated, to provide a good view of oncoming traffic and to allow vessels to pass in a straight line. This also leaves room for a waiting area.

To reduce excessive flow gradients (return current and currents due to wind effects), particularly when the passage is narrow, the transition between the profile of the lock and that of the adjacent section of waterway must be gradual.

4.7.3 *Safety lock gate requirements*

The requirements that safety lock gates must meet in respect of their waterway function depend on the type of profile in the adjacent waterway:

- where there is a normal waterway profile, the safety lock gates must not present any obstacle to shipping
- where there is a narrow profile, they may represent a slight obstacle, more or less similar to that caused by a fixed bridge
- where there is a single-lane profile, some level of hindrance is also permitted, commensurate with single-lane traffic

4.7.4 *Dimensions of safety lock gates*

The cross section of a lock with safety lock gates in a waterway is based on a rectangular cross-section. On new waterways with a a normal profile or high-volume profile the safety lock gates must have the same navigable width as the waterway profile in question to ensure fully uninterrupted navigation. A reduction in the width of the waterway to 95% in the keel plane of an unladen vessel may be justified on the following grounds:

- a lock with safety lock gates is short; any disruption will therefore be less problematic than in a long narrow passage
- the likelihood that a reference manoeuvre will have to be performed in reference circumstances in the lock is small

Where there is a narrow profile (traffic volume < 15,000 vessels a year) the assumption is that overhauling and passing in the lock will be avoided by use of the VHF radio. In such a profile it is acceptable for reference vessels to experience more hindrance than on the waterway itself. The waterway width may be reduced to 90% in the keel plane of an unladen vessel in class I to Va.

Safety lock gates present a greater risk to vessels in class Vb (long two-barge pushed convoy) and higher, than to the class Va motor cargo vessel because of their greater length. A 95% reduction is permissible for class Vb with bow propeller. No reduction is permitted for vessels with no bow propeller, or when traffic volume exceeds 15,000 passages a year.

On existing waterways the design should be based on the existing waterway width, insofar as it is larger than the normal or high-volume profile.

Where the traffic volume is between 5000 and 15,000 passages a year, the management authority decides what width measurement is appropriate.

Where there is a single-lane profile, up to class Va the minimum lock width is 1.6.B (B = beam of reference vessel). This leaves slightly more room than under fixed bridges, because there are no hydraulically open abutments at a lock with safety lock gates. A width of 1.7.B applies to class Vb if the units are equipped with a bow propeller, and 2.0.B otherwise.

On a waterway with a longitudinal current > 0.5 m/s a current increment as given in §3.5.8 should be applied to the width of each navigation lane.

Where the passage is long, an increment of no more than 0.02.L is applied to the width. This is applied in a linear manner, from 0 for a passage length of 0.3.L (L = length of reference vessel) to a maximum of 0.02.L for a passage length of 0.7.L.

For all classes, at least 1.4 times the draught of the reference vessel is required for the sill depth and above the ground sills. A factor 1.3 applies to narrow and single-lane profiles.

Where there are safety lock gates in rivers, the sill depth is determined both by the amount of keel clearance and by the maintenance depth of the fairway (see §3.5.2). Further investigation is required, including into hydromorphological effects.

4.7.5 Design of safety lock gates

Safety lock gates must meet the following design requirements:

- where there is also a lift lock, guide fenders, line-up areas and waiting areas must be provided; where there is no adjacent lift lock, waiting areas must be provided to prevent blockage of the waterway
- where there is a normal or narrow profile, no guide fenders are required; a protective structure must however be positioned before any elements susceptible to collision
- guide fenders must be provided where there is a single-lane profile

4.8 Weirs

Where there is a weir or other drainage facility in a shipping waterway, the access channel to the adjacent lift lock must branch off in good time, to allow shipping to leave and enter the flow when the weir is closed without problems, in all circumstances. This applies particularly upstream of the weir.

The following guidelines also apply to the design of the waterway around weirs (ref. 78):

- Where there is a weir, ensure that the waterway is designed in such a way that the choice of route clearly points towards the lock, and no confusion can arise, e.g. as a result of a Y-junction rather than a perpendicular intersection
- When the weir is closed, place a diagonal buoy line in the vicinity of the point at which the choice has to be made, so that it is clear at this point where the safe route is, and that the access channel to the weir is closed. The buoy line is usually removed in the winter season due to the possibility of damage by floating debris or ice. The buoy line is not intended to provide protection from impact
- Ensure the weir is clearly recognisable both with the naked eye and by radar, and that it is clearly marked on the Inland ECDIS (see ref. 22);
- If the waterway is lit, only the part that needs to be used at any given moment should be illuminated (fairway through weir or access channel to lock)

- If shipping can use the opening or openings in the weir in certain circumstances, the passage through the weir must in that situation comply with the same conditions concerning width, position and sill depth as a lift lock (see §4.7), and the same height conditions as a fixed bridge (see §5.4).

It is also important to prevent any disruptive flow gradients (both longitudinal and transverse) as much as possible, taking account of the following: in the immediate vicinity of the weir to 1.L upstream (where L is the length of the reference vessel), there must be good symmetrical flow guidance and no cross current. Beyond that, at the edge of the waterway there must be compliance with the criteria set out for cross current (see §3.3.6). In this case, the edge of the waterway is the line extending from the inside surface of the passage opening in the weir.

There should preferably be only a single passage opening. The axis of the opening should coincide with the axis of the waterway section, to ensure a good view of any oncoming traffic, and allow vessels to pass in a straight line as much as possible.

If, for compelling reasons of a water management or structural nature, two separate passage openings are provided for vessels travelling upstream and downstream, both openings must at least comply with the requirements for the single-lane profile. It is important to bear in mind that, at traffic volumes of more than 5000 vessels a year, the weir could constitute a problem for the capacity of the waterway.

4.9 Fenders

These guidelines are limited to rules for the main dimensions and design of fenders. Normal fenders (for line-up and waiting areas) are suitable for mooring purposes; guide fenders (funnels) are not. Guide fenders can also be positioned near bridges (see § 5.9). Recommendations on the dimensions of fenders can be obtained from *Rijkswaterstaat* GPO.

Unless indicated otherwise, the heights given are relative to the reference high water level (MHWS) or the reference low water level (MLWS) in the holding basin, as described in § 3.3.

4.9.1 Fenders for commercial vessels

The position of the fenders has been shown in the previous sections. The following additional specifications apply:

class	I	II - III	IV	V	VI
height	1.5	2.0	2.5	3.0	3.5

Table 39: Height of top horizontal fender above MHWS in holding basin (m)

- the measurements in Table 39 are a minimum requirement for the top of the highest horizontal fender; if the funnel is formed by sheet piling or retaining walls, they need not be higher than the lock head which they abut
- if a guide fender is considerably higher or lower than the adjacent lock head, the change in height must be gradual

- the vertical distance between the horizontal fenders must be chosen in such a way that the bows or push bows of vessels do not impact the structure where the horizontal fenders are attached; this distance is approximately 0.5 m; this also provides good protection from the wind; the same distance applies to timber fenders on sheet piling and retaining walls
- except for in the case depicted in Figure 28 fenders must have an open structure underwater and be positioned symmetrically in relation to the lock axis to prevent suction effects
- to prevent ships from becoming stuck the bottom of the fender must extend to 0.5 m below the reference low water level and/or the minimum lock passage water level using a horizontal fender or log attached to the piles
- the structure must be finished in such a way that damage and abnormal wear and tear to the hawsers and lines is prevented
- the positioning of bollards, mooring rings and ladders on a fender or sheet piling must be coordinated with the dimensions for chamber walls given in § 4.3 to § 4.5. Paint bollards on sheet piling white for safety reasons (tripping hazard). Bollards and ladders should not be positioned close together to prevent hawsers and lines from crossing in front of ladders
- the first bollard should be positioned as close as possible to the point where the funnel gives way to the line-up area.

4.9.2 Design of fenders for commerial vessels

The following design options exist for line-up and waiting areas for commercial vessels in a holding basin:

A. mooring dolphins
B. freestanding fenders
C. quay walls or sheet piling
D. floating fenders

Types A, B and D are sprung, while type C is rigid. The decision as to whether rigid or sprung structures are more appropriate depends on local circumstances. The water depth relative to the required distance between the point of application of the load and the bottom is important in this respect to ensure that a sprung structure can absorb sufficient energy.

Types B, C and D provide a contiguous mooring facility, which is the standard solution as it has the followind advantages:

- it is more suitable for use by vessels of varying lengths
- it is better able to cope with unsuccessful mooring manoeuvres
- it has a simple connection with the embankment
- it has a good connection with the guide fender (funnel)

In a few cases, type A will be sufficient, see § 4.9.4; the frequent passage of river cruise ships might justify choosing types B, C or D, with a view to rapid disembarkation in the event of an emergency.

In the interests of visibility, it is recommended that the tips of the piles be painted white or yellow.

The waiting and/or line-up areas must be accessible for the emergency services from the embankment. Vertical ladders are not permitted in connection with emergency services access.

4.9.3 Floating fenders

Where the water level varies by more than 1.0 m it is recommended that a floating fender be used. Such floating structures are made of steel; they can be produced in series and are easy to maintain in a yard (Figure 30).

The height of a floating fender should be the same as that of the guide fender (Table 39). Any central fender should take the form of a floating double-sided structure that can be used for mooring on both sides. The footpath should be water-permeable and covered with non-slip material.

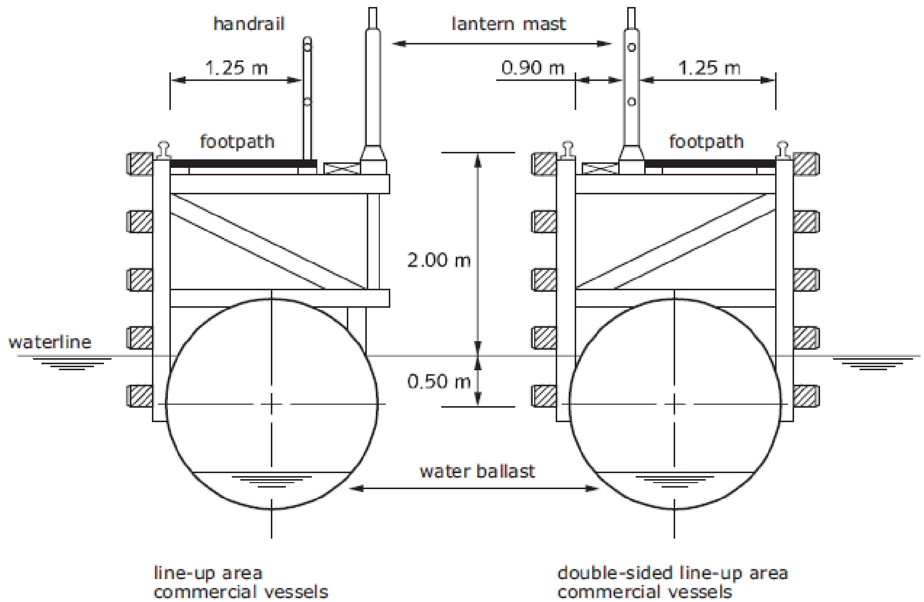


Figure 29: Example of a floating fender for commercial vessels

4.9.4 *Mooring dolphins*

Mooring dolphins are adequate at minimum-capacity locks (see § 4.3.2 for definition). They will be adequate for waiting areas at locks if the holding area is wide enough, i.e. it at least complies with the requirements in § 4.6.3. Mooring dolphins should be positioned no more than 20 m apart on class I waterways, and no more than 30 m apart on waterways in class II or higher. If the lock is frequently used by vessels of class I or II, it is recommended that some pairs of piles be positioned no more than 15 m apart. The piles must be 1 m higher than the values given in Table 39.

The mooring dolphins should have a flat fendering of at least 60 cm, so that at least one rib of the vessel is against the fendering, to prevent the hull from being dented.

At overnight stay areas, it is important to bear in mind that the tension on the lines will not be checked for long periods; as a result, the waterway management authority should consider the dynamics of the local situation (variations in water level, wind, and suction from passing vessels) when choosing mooring dolphins.

Ladders should be mounted on mooring dolphins where disembarkation facilities are available – at least one ladder with a connection to the embankment for every three piles. The ladder should extend 1.0 m below the reference low water level. The distance from the vessel to the ladder must not exceed 50 cm. If there is no disembarkation platform, it is not necessary to mount a ladder.

4.9.5 *Fenders for recreational craft*

If the water level is virtually constant, the following guidelines apply to the design of a fender for recreational craft:

- when situated alongside sheet piling, it is recommended that the horizontal fenders be position as shown in Figure 31; in the holding basin, where the minimum lock passage water level may occur, the bottom of the lowest horizontal fender must be no more than 0.5 m above the minimum lock passage water level
- the fender should have a closed surface. Alternatives include horizontal fenders, though they have the disadvantage that a vessel can get caught under them; such horizontal fenders placed at vertical intervals of 0.5 m (see also 4.9.1) should be linked with vertical sliding fenders at intervals of 1 m. If the horizontal fenders are positioned < 0.25 m apart, no sliding fenders will be necessary. Spindles should be attached under the facing or the bottom horizontal fender to prevent boats from becoming stuck there
- the horizontal distance between the mooring bitts is approximately 5 m; the first should be approx. 3 m from the stop sign; a horizontal mooring rail should connect the mooring bitts
- mooring bitts/mooring rails should be positioned on the edge of a quay wall without horizontal fenders as for sheet piling; mooring rings should be mounted on the wall as for mooring bitts on sheet piling with horizontal fenders described above
- the height indicated for the pile cap depends on the waterway class; in the case of high walls, the vertical distance between any extra horizontal fenders is approx. 1 m
- where the pile cap overhangs, the ladder must be inset to make it easier to climb out
- ladders extending 1 m below the reference low water level should be mounted on sheet piling and quay walls; the horizontal distance between them should be less than 30 m; the first ladder should be no more than 10 m from the start of the line-up area; hand bars should be fitted at the top of the ladders

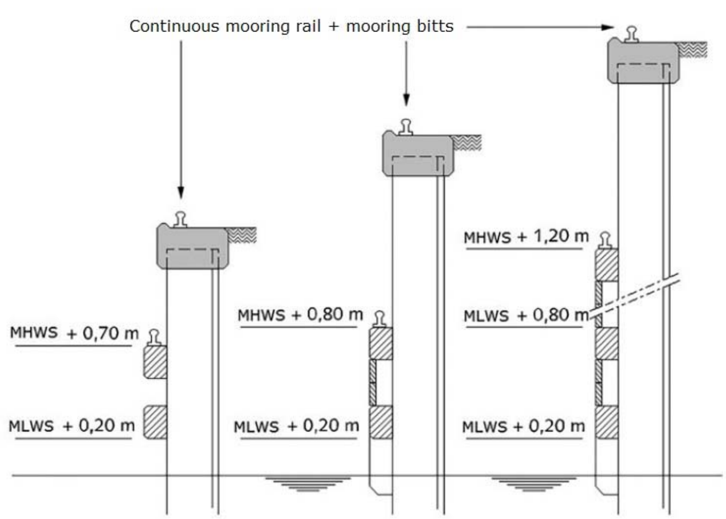


Figure 30: Line-up area for recreational craft alongside sheet piling

- when a freestanding fender is used, dimensions as shown in Figure 32 are recommended; horizontal fenders, mooring bitts/rails and ladders should be positioned as for sheet piling; the gangway alongside the fender should branch off to the embankment

- in holding basins where the water level varies by more than 0.5 to 1.0 m, floating landing stages will be needed; these should be fitted with a mooring rail (Figure 33); mooring facilities should be designed in such a way that steeply sloping lines do not come loose
- if the line-up area is permanent, sufficient mooring rings or horizontal fenders with mooring bitts should be fitted
- where water is conveyed via an open drainage channel (Figure 29), physical measures will be needed on the inlet side in line with the shoreline to prevent vessels from becoming stuck due to suction

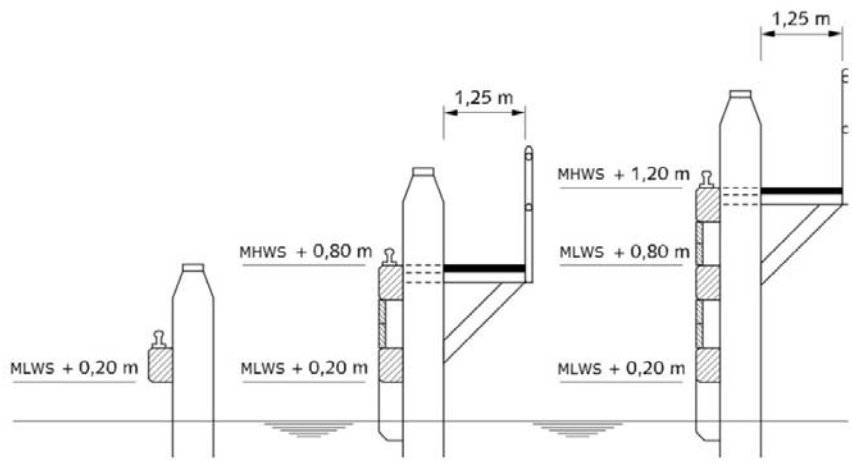


Figure 31: Line-up space for recreational craft in the form of a fender

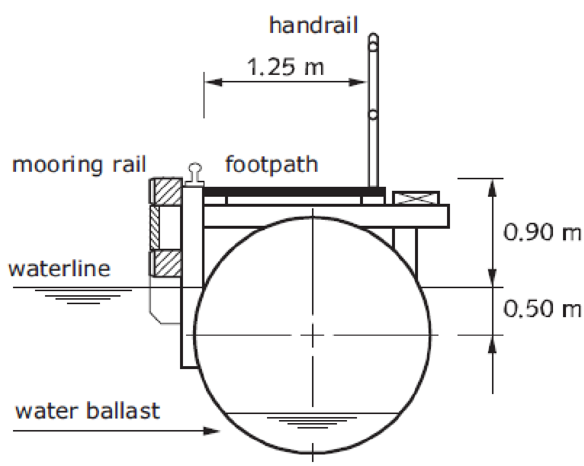


Figure 32: Floating fender for recreational craft

4.9.6 Small-scale water sports

Small-scale water sports require a minimum of facilities without fenders. Figure 32 shows an access point for canoeists, rowers and skaters in a setting where the water level is virtually constant. Excessively large translation waves in locks (or yacht locks) can increase the need for such facilities.

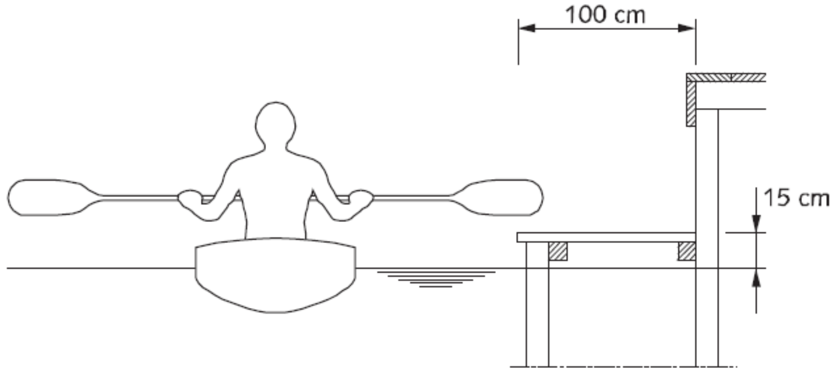


Figure 33: Access point for small-scale water sports

4.10 Preventing ice formation

4.10.1 Central government policy

The policy of the Ministry of Infrastructure and Water Management is to keep main waterways navigable for as long as possible using ice-breakers. Other management authorities may also opt to use ice-breakers to keep waterways or harbours open. This means that the engineering structures in and over the waterways must also be kept in operation. When such structures – particularly locks – break down, the entire waterway is obstructed.

Effective ice prevention is not generally possible without special measures in terms of construction or operation. As always, 'prevention is better than cure'. In other words: ice formation should be taken into account when engineering structures are first built. The fact that there has not been a harsh winter for several years does not mean there will never be one again!

4.10.2 Preventing ice formation at locks

The most ice-sensitive parts of a lock are the gates and the mechanisms that open and close them. Every type of gate is sensitive in a different way:

- mitre gates are sensitive to ice formation and accumulation in and immediately in front of the gate recess
- single lock gates have the same problem, to an even greater extent

- sliding lock gates can becoming stuck in floating ice accumulating in the gate recess, which can cause them to become frozen fast
- vertical lift gates are sensitive to ice accretion; the ice can fall on vessels passing below, cause the gate to become stuck or make it so heavy that it can no longer be lifted

Structural measures can overcome these problems to a great extent. Table 40 summarises the options and applications. For more information on structural details, calculations of the capacity of air bubble screens, and details of ice prevention requirements to be included in technical specifications, the reader is referred to ref. 28 and to *Rijkswaterstaat* GPO's support desk for ice prevention on engineering structures (*Steunpunt IJsbestrijding Kunstwerken*).

type of gate/measure	mitre gates	hinged gate	sliding gate	life gate
air bubble screen	x	x	x	x
blower in gate recess	x	x	x	
heating elements			x	x
smooth, closed structure	x	x	x	x

x = suitable

Table 40: Structural measures for ice prevention at locks

Besides structural measures, operational measures may also be taken. These mainly involve keeping ice and ice floes out of the chamber, gate recesses and chamber entrance, or sluicing ice through the chamber. Details can be found in a special manual on ice prevention for waterways (*Handboek IJsbestrijding Vaarwegen*, ref. 29).

4.11 Lighting

4.11.1 Requirements

Locks and holding basins must be equipped with lighting that meets certain minimum requirements:

- vessels must be able to obtain a clear view of lock complexes from the water as they approach
- the lighting must be sufficiently even; if not, dark areas will be created
- lighting must not dazzle or cause nuisance in the surrounding environment as vessels enter and leave the lock
- signals and site lighting at a lock must be coordinated and must attract sufficient attention
- signs must be lit in such as way as to ensure that the site lighting does not make it difficult or impossible to recognise the colour
- the lighting in the control building must be adjusted as it becomes dark outside
- images recorded by CCTV must be clear enough to provide lock staff with sufficient information
- lantern masts, the height of light sources and the colour of the lighting should be uniform

- it is useful to mark vertical surfaces and the tips of piles, e.g. on fenders, to provide skippers with extra visual guidance
- the extra effort required to observe and orient a vessel at dusk must not be so great, either for skippers or for lock operators, that dangerous situations arise
- places where manoeuvres and other actions must take place at dusk must be sufficiently visible
- the places on which skippers tend to focus are:
    - the run-out zone
    - the waiting and line-up area
    - the chamber entrance
    - the chamber
    - the lock site
    - the chamber exit
- focal points for lock operators are:
    - vessels in the waiting and line-up area
    - vessels entering and leaving the lock
    - the chamber and gates
    - the lock site

4.11.2 Required lighting level

The brighter the lighting, the smaller the risk. The optimum lighting level is that at which the desired level of safety is achieved and the costs of any extra lighting can no longer be justified (Figure 35).

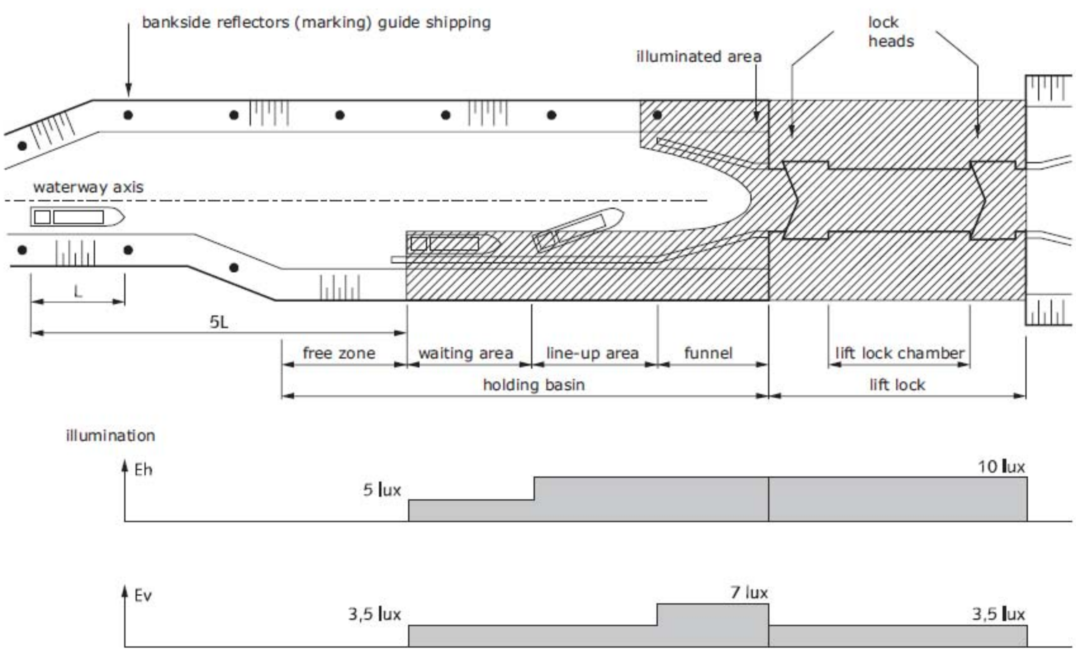


Figure 34: Minimum lighting levels for lock and holding basin

4.11.3 *Horizontal surfaces*

A value of at least 10 lux is regarded as an average value for the illumination E_h of horizontal surfaces on the lock elements mentioned above. In these conditions, the human eye can readily observe a factor 2 difference in contrast. The situation at dusk, in moonlight is 0.1 cd/m^2. To distinguish an object in the surrounding area, a luminance of 2 x 0.1 = 0.2 cd/m^2 is required.

A reserve of a factor 3 must be built in for poor weather conditions (rain or fog). The luminance must then be a minimum of 3 x 0.2 = 0.6 cd/m^2, which corresponds to an illumination of horizontal surfaces of 10 lux.

4.11.4 *Vertical surfaces*

Vertical surfaces perpendicular to the line of sight are more noticeable than horizontal ones, which are seen at an angle. The illumination E_v of vertical surfaces may therefore be lower than the illumination E_h of the horizontal surfaces. Practical measurements have shown that E_v = 3.5 lux is appropriate.

4.11.5 *Critical elements*

A number of critical elements of the lock require greater contrast, both for shipping and for lock operators. This can be achieved by using stronger lighting on the horizontal and vertical surfaces of these elements, or applying contrasting white markings. This latter option is to be preferred, since it helps skippers and operators and takes less energy, requires fewer obstacles in the form of lantern masts, does not cause confusion or dazzle, and also works in daylight.

Critical elements of a lock include the chamber entrance and exit, particularly the gates and funnel. The vertical illumination here should be a factor 2 higher, at 7 lux. The chamber, line-up area and, to a lesser extent, the waiting area are places where actions requiring precise observation are performed as vessels manoeuvre and moor up. Sometimes the skipper will need to disembark. Cast shadows in the chamber can lead to a risk of collision and must be avoided. Any obstacles must be clearly visible at the lock site.

The lighting in the run-out zone and waiting area mainly serves to enable skippers to orientate themselves. A vertical illumination of 3.5 lux and a horizontal illumination of 5 lux are sufficient in the waiting area.

4.11.6 *Ambient light and guidance*

Lighting in the area around the lock can have an impact on the lighting at the lock complex. How this is dealt with depends entirely on the local situation. Misleading ambient lighting can give skippers an incorrect idea of the current or the access to the lock chamber. The solution is to light the waterway or lock complex over a sufficient distance, or to adjust the ambient lighting.

The ratio of illumination may not exceed a factor 2. It is recommended that reflectors or retroreflective material be applied, on existing buoys or bankside boards for example, over a distance of at least five reference vessel lengths to provide visual guidance into and out of the lighted area

4.11.7 *Evenness and dazzle*

To ensure the lighting is even, a value of at least $E_{min}/E_{gem} = 0.3$ must be applied to both vertical and horizontal surfaces.

Lighting can cause dazzling. The correct combination of fitting, bulb and positioning is therefore vital. The threshold increment indicates the level of dazzle. This value should be lower than 10%.

The amount of lighting needed can be adjusted using markings. White markings are a good way of guaranteeing sufficient contrast at dusk.

4.11.8 *Colour recognition and type of bulb*

The colour of the light is important for recognising boards and signs. White or yellow light has no demonstrable impact on safety and comfort, so energy costs can be regarded as the main consideration.

This means that low-energy bulbs are the most suitable. They include high- and low-pressure sodium bulbs. High-pressure sodium bulbs give a light in which it is reasonably easy to recognise colours. This is impossible with low-pressure sodium bulbs, which are monochrome. If the colour of traffic signs needs to be recognisable, this can be achieved through external illumination using white light, or by internal illumination. Low-pressure sodium bulbs are not permitted within a radius of 3 km of hazardous goods vessels.

If LED or other lighting is used, the same requirements concerning light levels apply as to conventional bulbs.

4.11.9 *Lighting and dimming*

For reasons of cost, it is important that critical consideration be given to when lighting is actually needed – both the times when it is switched on and off, and circumstances when it can be dimmed or switched off at dusk. A threshold value commonly used for switching lighting on and off is approx. 40 lux, measured horizontally.

4.11.10 *Light fittings*

Various fittings are available for conventional lighting, depending on the type of bulb, the power of the bulb and the desired spread of light. A distinction is drawn between floodlighting and narrow angle lighting. Narrow angle fittings are generally recommended for locks. The fittings should be mounted away from the inner side of the chamber wall and guide fenders; the foot of the lantern mast should be at least 2 m from bollards etc. The equipment and fittings must be designed in such a way that they are easy to access for maintenance purposes, with due regard for health and safety legislation.

5 Bridges

5.1 Applicability

These Guidelines have been drawn up for the construction of new or renovation of existing bridges. Some existing bridges do not fully comply with the guidelines. This does not mean that they must be replaced before the end of their technical lifespan, but it does mean that traffic handling on the water is not optimal there, given the changes in the inland navigation fleet (scaling up).

The efficiency of traffic handling can be improved by numerous measures, but sometimes a decision to replace a bridge becomes unavoidable. Measures in terms of usage are highly location-specific and are not dealt with specifically in this chapter.

The CCNR requirements (ref. 79) take precedence in the case of bridges over waterways covered by the Mannheim Convention (Rhine, Waal, Lek and through connections to the sea).

The dimensions of the fenders are based on the assumption that most commercial vessels have a bow propeller with enough power to compensate for the effect of the wind. In other cases, skippers can anticipate these effects. The design of bridges does not therefore take specific account of wind problems. It is however important that there is no sudden exposure to side winds in the area around the bridge.

5.2 Position and distance between bridges

Bridges should preferably be situated on straight sections of waterway and perpendicular intersections. If this is not possible, the following factors must be taken into account.

5.2.1 Bridges on bends

A fixed bridge on a bend in a waterway should not have a central pier. The passage width of a fixed bridge on a bend must be at least equal to the passage width stipulated for a straight section of waterway, plus a width increment for bends as described in § 3.7.2.

It is not desirable for a movable bridge to be situated on a bend, in view of the need for visibility on the waterway. If this cannot be avoided, the movable part must be situated on the inside of the bend and the width increment for a laden vessel must be added to the passage width of the fixed span in accordance with § 3.7.2.

Sometimes it is not possible to position the movable part of the bridge on the inside bend, due to local circumstances, leaving no other choice but to place it in the axis of the waterway. In this case, the width increment for an empty vessel must be added to the movable part. In a single-lane profile, too, the movable part of the bridge is in the axis of the waterway. Here, too, the passage width of the movable part must be increased by the width increment for an empty vessel in accordance with § 3.7.2.

The positioning of the piers must be such as to guarantee an unimpeded line of sight (§ 3.7.4).

5.2.2 *Angled crosings*

Problems can arise if the axis of the passage opening and the axis of the waterway are not parallel, mainly as a result of uneven hydraulic forces and misleading visual guidance. Such an angled crossing increases the risk that a vessel will collide with one of the bridge's piers. The piers must therefore be placed parallel to the waterway axis. If an angled crossing is unavoidable, as in the case of a railway line, it is recommended that the design of guide fenders shown in Figure 36 be used.

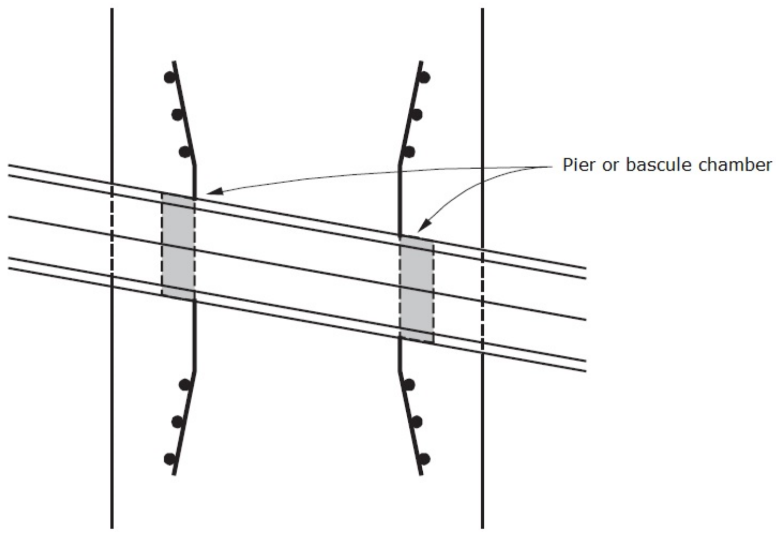


Figure 35: Positioning of guide fenders at an angled crossing

5.2.3 *Distance between bridges*

There are four reasons to set certain requirements concerning the distance between two successive bridges or other structures spanning a waterway:

- the skipper needs time and distance to correct his course if a bridge causes an obstruction
- the distance between movable bridges must be either so small or so great that it is possible to stop, moor up if necessary, set off and put the vessel on course in front of the bridge without too many problems
- the skipper needs time to allow the wheelhouse to descend and ascend again on a vessel with a high cargo, such as containers
- because of the likelihood of false radar echoes, as discussed below in § 5.11

At a fixed bridge without a central pier with a passage width equal to the total waterway width there is no nautical rule dictating a particular distance between two successive bridges, provided that there is a straight section of at least 1.5.L before and after any bend in the waterway, L being the length of the reference vessel. When bridges are situated in close proximity, the requirements concerning a long passage set out in § 5.4.4 apply.

Where there is a strong cross wind bridges cause irregularities in the wind field that have an effect on shipping. If no wind width increment has been applied to the width of the waterway, two successive fixed bridges must be at least 3.L apart to give vessels the opportunity to correct their course. Where bridges have a central pier the distance between them must also be 3.L, or the bridges must be built as close to each other as possible.

5.2.4 *Vertically movable wheelhouse*

Vessels with a high cargo, such as containers, generally have a vertically adjustable wheelhouse that is temporarily lowered when they pass under a bridge. Between bridges it must be possible to raise the wheelhouse long enough for the skipper to gain a view of the waterway and the traffic before it is lowered again. The distance required has been set at ≥ 500 m.

5.2.5 *Stopping and mooring*

For stopping and mooring before a movable bridge a distance of at least 3.L is reckoned to be needed, while at least 1.5.L is required to cast off and put the vessel on course before the bridge. The total distance between two bridges therefore comes to 4.5.L, with a minimum of 300 m. This applies in situations with no longitudinal current, i.e. a flow rate of no more than 0.5 m/s. Generally speaking, a vessel will require a distance of 5.L to get up to speed from a stationary position.

5.2.6 *Distances when longitudinal current > 0.5 m/s*

Where there is a longitudinal current > 0.5 m/s the distances given in §5.2.3 to 5.2.5 should be multiplied by a factor k (see § 5.9.2) for longitudinal current. If there is insufficient space, further investigation will be required.

5.2.7 *Operating bridges in tandem*

If two movable bridges are built close together, without taking the intervening distance mentioned above into account, they must be operated in tandem. This means that they must be opened and closed at the same time.

5.2.8 *Protection from stone throwers*

Vessels are repeatedly the target of stones and other objects thrown from bridges. This generally happens on fixed bridges for commercial vessels in urban areas. If warranted by the local circumstances, it is recommended that fencing, screens or something similar be mounted on the bridge to prevent stone throwing, or at least to make it more difficult, or that the bridge be equipped with surveillance cameras. Any loose objects should be removed as a precaution.

5.3 Choice of fixed or movable bridge

The Guidelines distinguish between fixed and movable bridges for commercial vessels and recreational craft. As with waterway sections, a normal, narrow or single-lane profile applies, depending on the volume of shipping traffic. A fixed bridge is generally cheaper to maintain than a movable bridge, does not need to be operated and does not cause any obstruction to traffic on land or on the waterway. In this respect, a fixed bridge of sufficient height is preferable to a movable bridge, except on open waterways, as discussed below.

5.3.1 *Open waterways*

A number of waterways are defined as open waterways. In other words, they are waterways with virtually no restrictions as regards headroom. They include maritime access routes, waterways for high cargoes and the BRTN raised mast routes (ref. 8). See § 3.11 for details of the open waterways. If the required height cannot be achieved with a fixed bridge, which is often the case in the Netherlands, a movable bridge, tunnel or aqueduct must be built.

5.3.2 *Interaction problems*

Interaction problems can be expected at points where motorways and railway lines intersect main waterways or recreational waterways that carry a lot of sailing boats. Increasingly, tunnels or aqueducts are being built instead of movable bridges (see also § 2.1.3), despite the higher costs of construction. Reasons for this include the higher costs of operating or of managing and maintaining movable bridges on waterways that are not too wide. A tunnel or aqueduct is a sustainable solution to interaction problems between traffic on land and in the water, which can lead to long delays.

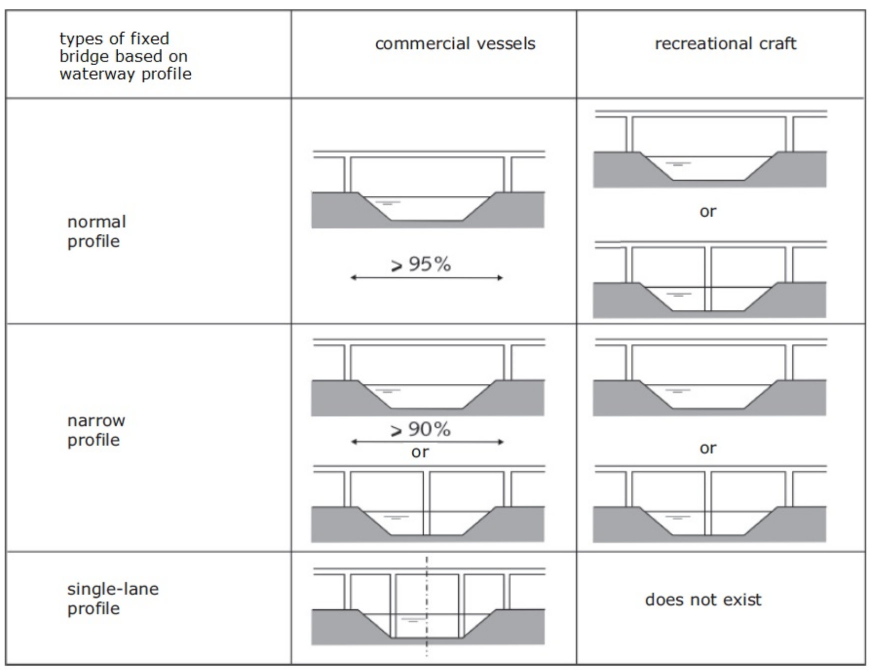


Figure 36: Schematic overview of fixed bridges

Where there is little traffic on land, or the situation is of only short duration, a ferry crossing may offer a temporary solution. Ferries can of course lead to interaction problems with other shipping.

5.3.3 *Schematic overview*

Figure 37 shows a schematic overview of the various types of fixed bridge for commercial vessels and recreational craft. In the case of mixed shipping, commercial vessels will generally be taken as the standard. Sections 5.4 and 5.5 contain more detailed information. Figure 38 gives a schematic overview of movable bridges for commercial vessels and recreational craft. Sections 5.6 and 5.7 contain more detailed information.

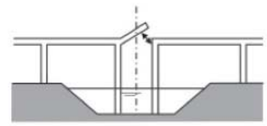
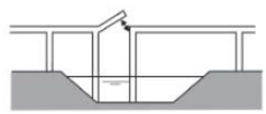
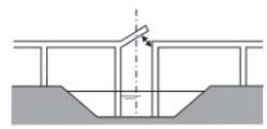
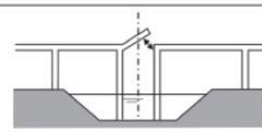
types of movable bridge based on waterway profile	commercial vessels	recreational craft
normal profile	 fixed bridge unless open waterway	 for Z and ZM routes max. 10,000 PAE/day
narrow profile		 for Z and ZM routes max. 10,000 PAE/day
single-lane profile		does not exist

Figure 37: Schematic overview of movable bridges

5.4 Fixed bridges on commercial routes

5.4.1 Passage width

Fixed bridges for commercial vessels span the entire waterway. The waterway profile may not be narrowed when a new bridge is built. Where there is an existing bridge and a normal or narrow profile, a reduction of up to 5% or 10% respectively is permitted, measured in the keel plane of an unladen vessel. Such a reduction is not permitted if a bridge over a waterway with a narrow profile has a central pier. In a single-lane profile, the passage under the bridge must be in the axis of the waterway. This is represented schematically in Figure 37.

5.4.2 Headroom

The headroom under a fixed bridge is the same for all three profiles (normal, narrow, single-lane). The height of the bridge must be such that reference vessels can pass under it unobstructed. Where both commercial vessels and recreational craft use the same waterway, the highest value is applicable. The headroom is the vertical distance between the reference high water level for shipping and the underside of the span over the waterway when fully laden. This is expressed in the following formula:

$H_B = H + S$

where:

H_B = headroom to the underside of the fully laden bridge at reference high water level (MHWS), in accordance with § 3.3
H = height above waterline not exceeded by 90% of unladen reference vessels in a certain CEMT class, in accordance with § 2.3.2
S = safety margin

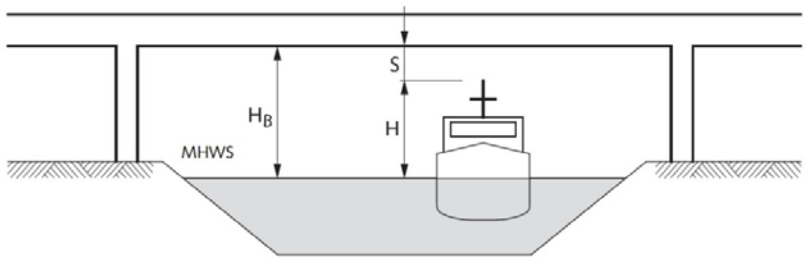


Figure 38: Definition of headroom H_B

In the righthand column of the CEMT table in § 2.1 and in Table 41 the stated headroom H_B includes a safety margin. This margin has been set at 0.3 m for all waterway classes and takes account of the following factors:

- inaccuracies in knowledge of the actual height above waterline
- errors in reading the height scale beside the bridge
- vertical movements of the vessel due to waves or to variation in the number of revolutions and/or speed

class	headroom* at MHWS
I	5.25
II	6.1
III	6.6
IV	7.0
V	9.1
VI	9.1

*headroom including 30 cm safety margin; other headroom values may apply in certain situations, see §2.1.3.

Table 41: Minimum headroom H_B (m) at fixed bridges on commercial routes

Major differences in water level as a result of translation waves must be taken into account separately. When designing a bridge, a generous margin must be included to compensate for any sagging during the bridge's lifetime.

The minimum headroom H_B shown in Table 41 should be available over the entire width of the bridge at MHWS, at newly built bridges in any case.

The minimum headroom at new bridges may not be less than the headroom at existing or planned bridges in the vicinity, in order to avoid any additional restrictions.

The waterway management authority must indicate the actual headroom H_B (including safety margin) on a clearly visible height gauge on the sign G.5.1 (ref. 22). It is up to the skipper to decide whether that gives sufficient clearance for his vessel to pass safely under the bridge. The actual headroom should be checked regularly, and the frequency of measurement should be incorporated into the management or preservation plan.

5.4.3 *Vaulted underside*

The introduction of single-lane traffic for the highest vessels may be considered at existing bridges that have a vaulted underside. These vessels can only pass under the highest part, which is narrower than the waterway itself. The headroom indicated must be available over a width of at least 2.B, where B is the beam of the reference vessel (Figure 40). Waterway users can be alerted to the situation using reference symbol G.5.1b or G.5.1c, which can be found in the Shipping Signs Guidelines 2008 (ref. 22).

In nautical terms, a vaulted underside provides no benefits. On the contrary, a single lane with more headroom introduces the risk of impact with lower parts of the bridge. The required height should therefore be available over the entire width of the waterway when a new bridge is built.

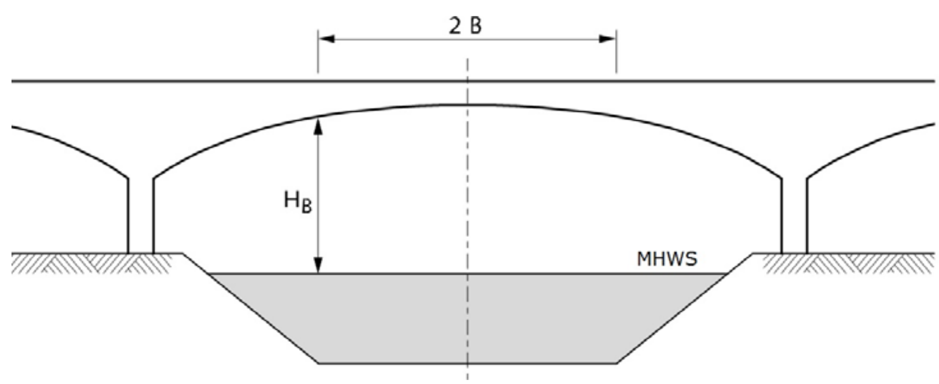


Figure 39: Bridge with vaulted underside

The passage width of a fixed bridge is the smallest width under the bridge, measured perpendicular to the axis of the waterway between any horizontal timber fendering, that can be fully utilised by a reference vessel at the reference water level. A distinction is drawn between the normal, narrow and single-lane profiles (see § 3.2 for definitions and Figure 37 for an overview).

5.4.4 *Long passage*

When passing under a bridge, a vessel can usually be manoeuvred in such a way that the width used is smaller than when navigating on the waterway itself. If the passage under a bridge or a combination of bridges with central piers, or over a single-lane profile, is relatively long, an increment must be applied to the passage width, on a linear scale from 0 for a passage length of 0.3.L (L = length of reference vessel) to a maximum increment of 0.02.L when the passage is 0.7.L.

5.4.5 *Passage width for normal profile*

With a view to traffic safety, no central pier is used in bridges over waterways for commercial vessels with a normal profile. The bridge must have the same navigable width as the waterway to ensure fully undisturbed navigation (§ 3.5).

Piers along the waterway should be designed and executed in such a way that they can withstand impact from shipping and drifting ice, in accordance with the Building Decree (*Bouwbesluit*). Ability to withstand impact can be substantially improved by installing collision protection, which takes a certain amount of space and may not adversely affect the minimum waterway width. A location-specific study can identify the most appropriate reduction in the impact loads. On national waterways, this rule applies to the entire zone subject to the Spatial Planning (General Rules) Decree (Barro, see §3.12.3); *Rijkswaterstaat* GPO can provide more information on this structural design.

At existing bridges, a reduction of no more than 5% of the waterway width (for minimum waterway widths, see § 3.5, Table 18) in the keel plane of an unladen vessel may be justified on the following grounds:

- where a bridge is short, any obstruction will be less problematic than in a long narrow passage
- the likelihood that a reference manoeuvre will take place under that particular bridge in reference circumstances is relatively small

Any reduction in the width of the waterway may not lead to an asymmetrical profile.

The option of narrowing the waterway profile set out above does not apply to new bridges, or to bridges over new waterways.

5.4.6 *Passage width for narrow profile*

A fixed bridge over a waterway with a narrow profile must also have the same navigable width as the waterway, and a central pier will be acceptable only as an absolute necessity.

Piers along the waterway should be designed and executed in such a way that they can withstand impact from shipping and drifting ice, in accordance with the Building Decree (*Bouwbesluit*). Ability to withstand impact can be substantially improved by installing collision protection, which takes a certain amount of space and may not adversely affect the minimum waterway width. A location-specific study can identify the most appropriate reduction in the impact loads. On national waterways, this rule applies to the entire zone subject to the Spatial Planning (General Rules) Decree (Barro, see §3.12.3); *Rijkswaterstaat* GPO can provide more information on this structural design.

Where there is no central pier, it is acceptable for reference vessels to experience slightly more obstruction than on the waterway itself. Under an existing bridge, a reduction of no more than 10% of the waterway width in the keel plane of an unladen vessel (for minimum waterway widths, see § 3.5, Table 18) will be acceptable for classes I to Va. An abutment presents a greater risk to class Vb than to class Va vessels, because a pushed convoy is more susceptible to wind effects, especially when empty. The reduction in width for class Vb is therefore restricted to a maximum of 5%.

A central pier in a narrow profile is acceptable if strictly necessary, but each of the passage openings must be wide enough for safe single-lane navigation. An increment of 0.2.B additional to the single-lane profile applies as the minimum passage width where there is a central pier, because of the eccentric position of the passage. It has been assumed here that the abutments and the base of the central pier are open in hydraulic terms (see also § 5.6.6) over at least 50% of the profile. Where a central pier is present, the axis of the pier must as far as possible coincide with that of the waterway.

The option of narrowing the waterway profile set out above does not apply to new bridges, or to bridges over new waterways.

A width increment applies to bridges on bends, as described above in § 5.2.1.

5.4.7 *Single-lane profile*

The passage under a bridge over a waterway with a single-lane profile must coincide with the axis of the waterway.

5.4.8 *Passage where longitudinal current exceeds 0.5 m/s*

Where a waterway has a longitudinal current in excess of 0.5 m/s (rivers), the standard is a fixed bridge that spans the entire waterway. The passage should at least comply with the relevant design profile for the waterway (§ 3.5.5 to 3.5.8); if the existing waterway is wider, the width should be maintained (ref. 88).

There may not at any rate be any piers in the fairway in waterways governed by the Mannheim Convention (Waal, Bovenrijn, Nederrijn/Lek and the through routes to the sea, ref. 79); see §5.4.5 for structural requirements.

5.4.9 *Overview of passage widths*

The minimum passage widths for fixed bridges over the various waterway profiles are listed in table 42.

class	waterway with normal profile	waterway with narrow profile		waterway with single-lane profile
		no central pier	with central pier	
I	same width as waterway no central pier allowed	same width as waterway	9.0	8.0
II			11.5	10.0
III			14.0	12.5
IV			16.5	14.5
Va			19.5	17.0
Vb			22.0	18.5
VIa, VIb and VIc		not advised*	not advised*	not advised*

* = Classes VIa, VIb and VIc must at least comply with the normal profile

Table 42: Minimum passage width (m) of fixed bridges on commercial routes

5.5 Fixed bridges on recreational routes

5.5.1 *Headroom*

Fixed bridges over waterways used exclusively by recreational craft on motoboat routes (M) or sailing/motorboat routes (ZM) should have headroom of at least H_B above MHWS in accordance with Table 43, measured relative to the reference high water level. The letters A, B, C and D in the BRTN 2008 (ref. 8) indicate the status of the route. Note, however, that the ECE uses other standard heights (Table 10). It is recommended that the higher value be used. If higher bridges already exist along a route, these should be preserved as they are.

category		M route	ZM route
connective waterway	A	3.75	30.0
access waterway	B	3.00	30.0
	C	3.00	30.0
	D	2.60	-

Table 43: Minimum headroom H_B (m) under fixed bridges for recreational craft, in accordance with BRTN

5.5.2 *Passage width*

On waterways used exclusively for recreation fixed bridges must span the entire waterway profile. A central pier may be used in the axis of the waterway, in which case each passage must be at least as wide as the bridge width for the narrow profile. No extra passage width is generally required for eccentrically positioned bridge openings, except in cases of extreme eccentricity.

No guidelines exist for waterways with a single-lane profile used exclusively for recreation. Similarly, no guidelines exist for bridges over such waterways. Bridges with a passage length of more than 25 m must have two separate passage openings divided by a central pier.

Table 44 shows the minimum passage widths of fixed bridges for recreational craft. The categories of route type and waterway class are explained in § 2.6.

category	waterway with normal profile	waterway with narrow profile	waterway with single-lane profile
A	9.5	8.5	no guideline
B	9.5	8.5	
C	8.5	7.5	
D	7.5	7.0	

Table 44: Passage width (m) of fixed bridges for recreational craft

The dimensions listed in Table 44 apply to all situations where oncoming traffic is sufficiently visible. In general, this is the case if the adjacent waterway sections provide unrestricted passage over a distance of at least 50 m, or there is an open bridge structure with two or more openings, for example, which provide an adequate view of oncoming traffic.

Figure 37 above presents a schematic overview of fixed bridges for commercial vessels and recreational craft.

5.5.3 *Small-scale water sports*

The Water Sports Council presented a policy vision in 2001 (ref. 13) describing desired and minimum heights and widths of bridges for small-scale water sports.

bridge passage width	waterway with normal profile	waterway with narrow profile
canoeing	2.5	1.5
weed cutters	4.0	2.0
skating	4.0	2.5
windsurfing	5.0	1.5
rowing[1]	6.0[1]	2.5[1]

bridge headroom	waterway with normal profile	waterway with narrow profile
canoeing, rowing[2] and weed cutters	1.25[2]	0.9[2]
skating	2.5	1.5
windsurfing	2.5	2.0

1. These values apply to rowing tours; for training purposes and small races, the rowing association KNRB uses 2 x 12.5 and 8.0 m for normal and narrow respectively.

2. These values apply to rowing tours; for training purposes and small races, the rowing association KNRB uses 1.65 and 1.25 m for normal and narrow respectively (ref. 85).

Table 45: Bridge dimensions (m) for small-scale water sports

5.6 Movable bridges on commercial routes

5.6.1 Passage openings

Only fixed bridges may be built over a waterway with a normal profile, unless it is an open waterway (maritime access route or raised mast route). Movable bridges are however permitted on waterways with a narrow or single-lane profile. In the case of a narrow profile, the movable part must be on the edge of the waterway, assuming there are two passage openings under the bridge. In the case of a single-lane profile, the movable part must be in the axis of the waterway (see Figure 38: Schematic overview of movable bridges).

Where there are side openings, it is efficient to use them for recreational craft and low commercial vessels. The side opening allows certain vessels to pass when the bridge is closed outside the navigation channel used by larger vessels, which do require the bridge to be opened. The minimum headroom of the side opening is thus the same as the headroom listed in Table 46. When a side opening is used, extra care must be taken in positioning waiting areas, so that vessels waiting for the bridge to open do not obstruct vessels wishing to use the side opening.

5.6.2 Headroom

In the case of a movable bridge, a headroom H_B above MHWS when the bridge is closed must be chosen. The standards are based on the height above the waterline of empty motor cargo vessels (Table 3) or the number of layers of containers that a vessel of the class in question can carry. There are three versions for commercial navigation, linked to the three different profiles defined in § 3.2 (Table 46):

- the high version goes with the normal profile: the bridge does not present any obstacle to shipping; the headroom is the same as that of a fixed bridge (see § 5.4.2); the bridge need only be opened for tall vessels, special cargo transport and sailing boats with raised masts
- the medium version goes with the narrow profile: the bridge may cause a slight obstruction to waterway traffic; in other words, the bridge may require opening for 25% of empty reference commercial vessels
- the low version is suitable only for a single-lane profile without recreational craft, and the underside of the bridge must be at least 1.0 m above MHWS

If a waterway is used for recreational navigation, it is recommended that the height of the movable part of the bridge when closed be based on that of the reference motorboat for the waterway (Table 43). A headroom of 4.0 m is sufficient for virtually all motorboats (almost 100% of which will fit under this).

If the low version in Table 46 is used, the bridge will have to be opened for virtually every commercial vessel. Headroom of 5.5 m is sufficient for laden commercial vessels up to class IV, excluding container vessels, so opting for this amount of headroom will drastically reduce the number of times the bridge needs to open.

On certain national waterways – listed in §2.1.3 – the Minister of Infrastructure and Water Management may decide to construct a bridge higher than the values given in the 2nd and 3rd columns of Table 46. The minimum headroom under new bridges may not be any lower than the headroom of planned or existing bridges in the vicinity, so that no further restrictions are introduced.

class	high version	container shipping	medium version	low version
I	5.25	5.25	4.75	0.5 à 1.0 or height of recreational craft
II	6.1	5.6	5.6	
II	6.6	6.2	6.2	
IV	7.0	7.0	6.4	
V	9.1	9.1	7.4	not advised
VI	9.1	9.1	not advised	

Table 46: Headroom (m) under movable bridges on commercial routes

5.6.3 *Passage width under movable part of bridge where longitudinal current exceeds 0.5 m/s*

The desired passage width under the movable part of the bridge depends on the desired balance between smooth, safe navigation and obstruction of traffic on land and on the waterway. The passage width for commercial navigation is linked to the three waterway profiles described in § 3.2, which are represented schematically in Figure 38.

A bridge over a waterway with a normal profile should be a fixed bridge that spans the entire waterway. On an open waterway (see 3.11.1) that carries vessels with special cargoes, the bridge should have a movable part and a central pier. In that case, the passage width for the narrow profile in Table 47 is sufficient for the movable part of the bridge, although the width of special cargoes may sometimes be regarded as the standard.

If the waterway has a narrow profile, it is acceptable for the bridge to cause some obstruction on the waterway in the form of a central pier. In most cases, there will be a fixed passage opening as well as a movable part. The width of the fixed passage opening must comply with the required width for a fixed bridge with narrow profile, as given in Table 42.

If the waterway has a single-lane profile, the axis of the passage opening coincides with the axis of the waterway, and is therefore always in a centric position.

class	waterway with normal profile	waterway with narrow profile	waterway with single-lane profile
I	No movable part (fixed bridge), unless it is an open waterway	8.5	7.0
II		10.5	8.5
III		12.0	10.5
IV		14.0	12.0
Va		16.5	14.5
Vb		19.0	16.5
VIa, VIb and VIc		n.a.*	n.a.*

* = Class VIa and VIb must at least comply with the normal profile

Table 47: Passage width of movable part of bridge (m) on commercial route

If vessels that tend to catch a lot of wind, such as container ships, use the waterway it is recommended that a greater passage width be used for all profiles, such as an increment of 2.0 m for a class IV waterways, 2.5 m for class Va and 3.0 m for class Vb.

If the bridges are positioned immediately next to each other, the specifications concerning a long passage set out in in § 5.4.4 apply.

5.6.4 *Positioning the movable part of the bridge*

The movable part of the bridge must be on the side of the waterway used most by empty vessels, which are more likely to need to have the bridge opened than laden vessels. Depending on the situation and the composition of the shipping traffic, however, it may sometimes be better to situate the movable part on the high side in connection with the prevailing – generally westerly – winds.
The positioning of the movable part of a bridge on a bend was discussed in § 5.2.1.

5.6.5 *Movable bridge where longitudinal current exceeds 0.5 m/s*

Bridges over waterways with a normal or high-volume profile should span the entire waterway without piers (see also § 5.4.1). If an extra passage with a movable part is required in connection with headroom then – as on ‘open waterways’ (§ 3.11.1) – piers in the waterway will be unavoidable. In such cases the part of the waterway with the least current will be the most suitable position for the movable part of the bridge, because this is where the least transverse resistance can be expected from vessels (ref. 88). Bridge piers must of course be adequately protected from collision (see also § 5.4.5), and easily recognisable in good time to the skipper, the ship’s radar (see also § 5.10.4) and on the electronic navigational chart. In waters governed by the Mannheim Convention (Waal, Bovenrijn, Nederrijn/Lek and the access routes to the sea) they must be outside the fairway**.** The width of the passage opening in the fixed part of the bridge must be at least the same as the width of the design waterway profile for the waterway (§ 3.5.5 to 3.5.8). The passage width of the movable part must at least be suitable for single-lane traffic, i.e. 2.2B. In this case, B is not the width of the reference vessel for the waterway class, but the width of the broadest vessel or combination that is likely to have to pass under the movable part (ref. 88).

If these requirements cannot be met, further investigation will be required.

5.6.6 *Underwater profile of passage opening*

The underwater transverse profile of the passage opening must be reduced as far as possible, due to suction effects. From a nautical point of view, the following design specifications are important:

- bridge piers must be designed in such a way that water can flow sideways while a vessel is passing under the bridge, i.e. in hydraulic terms they must be at least 50% open
- the cross-section between the pier and the bank must be reduced as little as possible, and must be at least 50% open
- passage openings must always be symmetrical

Under the bridge a horizontal distance in the keel plane of a laden vessel of at least 0.5.B, where B is the beam of the reference vessel, between the inner surface of the bridge and the bank must remain free to allow vessels sailing up to the bridge enough room to manoeuvre. If necessary, the canal profile must be enlarged.

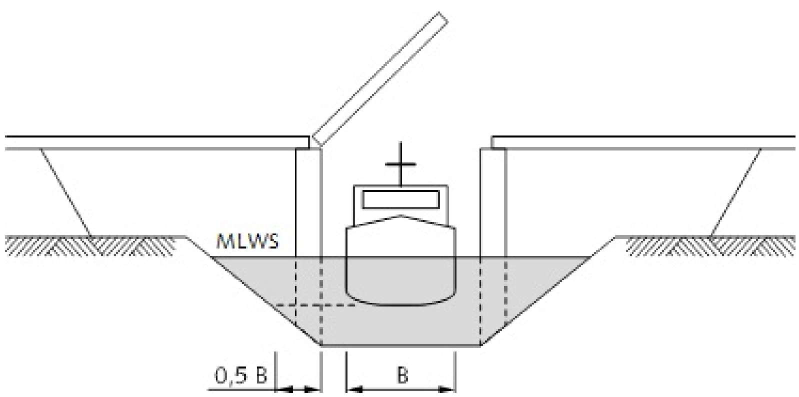


Figure 40: Required width under a movable bridge

The enlargement must continue for a distance of at least 1.5.L on both sides of the bridge, where L is the length of the reference vessel. Adjacent to this, a transition with a bank sloping at an angle of at least 1:6 is needed to return to the normal profile. Over and above this, the underwater transverse profile under the bridge must be at least 85% of the minimum waterway profile. This can be achieved by deepening the waterway at this point. The recommended waterway depth must be present across the entire width between the piers (Figure 41).

5.6.7 *Profile above water*

The passage width, measured between any horizontal timber fendering, must be available over the entire width of the passage opening. To minimise the chance of a collision with the movable part of a bridge when open, the design of lift bridges and bascule bridges must be such that the leaf – the movable part – does not fall within the clearance of the bridge when open, taking account of any protruding parts of vessels or tilting due to the wind, and is protected by guide fenders.

type of waterway	maximum no. of hours per year unavailable due to wind (1 day is 24 h)
1. Oceangoing vessels [1) 2)]	12
2. Trunk route	
headroom ≥ 9.10 m [3)]	24
headroom < 9.10 m	6
3. Main waterway [4)]	
headroom ≥ 6.00 m	48
headroom < 6.00 m	12
4. Other waterways [2)]	72 [5) 6)]

1) Waterway type 1 includes all waterways carrying oceangoing vessels, except waterways where the oceangoing vessels are solely coastal line traders. Waterway type 1 includes the Caland Canal to the Hartel Canal via Brittaniëhaven.

2) Depending on the local situation, stricter requirements may be needed, particularly when bridges need to be opened to ensure vessels can reach sheltered waters.

3) The headroom applies to a water level that is exceeded 1% of the time. This is the same as the water level defined for navigation on the Rhine.

4) The following are also regarded as type 3 waterways (main waterways, see Figure 2):

- the waterway between Rotterdam and The Hague
- the waterway between Amsterdam and Rotterdam via Gouda (Gouwe-Schinkel route)
- the waterway between Leeuwarden and Harlingen
- the Winschoterdiep canal
- the waterway between Zwolle and Zwartsluis and Meppel
- the waterway between Amsterdam and Den Helder via the river Zaan
- the Zuid Willemsvaart canal

5) A bridge over a type 4 waterway that can be deemed unimportant, and which is spanned by a manually operated bridge, may be unavailable for a greater number of hours per year.

6) Where bridges over waterways may be opened for only part of the year, the number of hours that the bridge is not available must be agreed.

Table 48: Maximum number of hours of non-availability per year in accordance with NEN 6786

5.6.8 *Wind stress*

The flap of a movable bridge and the movement mechanism are subject to wind stresses when open, and during opening and closing. It is not wise to open the bridge when the wind speed is too great. Table 1 of NEN 6786 'Requirements for the design of movable bridges' (*Voorschriften voor het ontwerpen van beweegbare bruggen*, VOBB) is shown here as Table 48. This standard shows the maximum number of hours a year that a bridge may be unavailable.

The number of unavailable hours is related to wind force 8 or 9 or higher on the Beaufort scale. The precise values needed to calculate the required strength of the bridge are listed in NEN 6786. Note that this is a mandatory standard, which must be observed. If the waterway management authority regards the number of unavailable hours as too high for the waterway, and wishes to reduce the number, the bridge must have an extra robust structure, or a different profile must be chosen.

5.7 Movable bridges on recreational routes

5.7.1 *Position relative to the axis*

In principle, only fixed bridges are used on motorboat routes (M routes). Where there are already movable bridges on M routes, the BRTN recommends they be replaced, without introducing any further restrictions. Movable bridges are however needed on routes that are also used by sailing craft (ZM routes).

On recreational waterways the centre line of a movable bridge must always coincide with the axis of the waterway, except in situations where the bridge does not need to be opened frequently. No extra passage width is required for an eccentrically positioned bridge opening, provided the adjacent sections of waterway provide an adequate view of oncoming vessels.

5.7.2 *Headroom*

The required headroom when the bridge is closed depends on the type of waterway and the traffic load. Upscaling in recreational navigation has meant that masts have become taller. At the same time the possibility to lower the mast has decreased.

It has not proved useful to define a standard for headroom when closed, which must be determined on a case-by-case basis, partly on the basis of the volume of traffic on the intersecting road. Where more than 15,000 vessels pass a bridge every year, it is recommended that the dimensions in Table 43 be observed, in the interests of road traffic. This prevents the bridge having to be opened for every motor cruiser. Four metres of headroom is sufficient for virtually all motor cruisers (almost 100% of which will fit under this).

5.7.3 *Passage width*

The passage width of movable bridges for recreational craft is shown in Table 49, which distinguishes between a normal and a narrow profile; single-lane profiles do not occur (for definitions see § 3.2). The narrow profile is appropriate up to 5000 passing vessels a year, the normal profile up to 30,000. The passage width in Table 47 applies up to a maximum of 30,000 recreational craft a year.

The dimensions given apply in situations where there is a good view of oncoming traffic. Generally speaking, this is the case if the adjacent sections of waterway provide unobstructed passage over a distance of at least 50 m or the bridge has an open structure with two or more openings, which provide an adequate view of oncoming vessels.

If sailing boats regularly use the waterway, the ZM guideline should be applied. In other cases, the M guideline for the narrow or normal profile will be adequate.

class	M profile		ZM profile	
	waterway with normal profile	waterway with narrow profile	waterway with normal profile	waterway with narrow profile
A	8.5	7.0	9.5	8.5
B	8.5	7.0	9.5	8.5
C	7.5	6.0	8.5	7.5
D	7.0	5.5	7.5	7.0

Table 49: Passage width (m) of movable bridges for recreational craft

5.7.4 *Charter traffic*

The following passage width values apply to fixed and movable bridges for charter traffic: BVA at least 8.5 m and BVB 7.5 m.

5.7.5 *Greater width*

It may be necessary to choose a greater passage width than that shown in Table 49, due to local circumstances. Important factors in this connection include:

- the need to counter effects that make it difficult to judge the width of the opening, such as the visual effect of a high, narrow passage opening
- inadequate view of oncoming traffic due to a solid bridge structure or a bend in the waterway just after the bridge
- wind variations that cause problems for sailing boats, and the need to create sufficient room for them

5.7.6 *Enhanced capacity*

Movable bridges with a greater traffic volume require more passage capacity. Simply expanding the passage width is not the solution. Capacity can be enhanced by altering the operating regime or constructing a high fixed bridge, adding a second movable section, or building a tunnel or aqueduct. Further investigation is recommended in such cases. Displaying the current headroom on a matrix sign can prevent unnecessary requests for the bridge to be opened.

5.8 Bridges over locks

5.8.1 *Positioning*

The following points must be considered when designing a bridge over a lock:

- bridges must not be built over the chamber or the holding basins, but over the upper or lower head and outside the lock gates, to allow the latter to be replaced

- a single bridge should be built over the lower gates, outside the lock gates, since there is more headroom there
- the chamber walls should be lit beneath the bridge; see § 4.11.2 for lighting requirements
- the bridge must not obstruct the view of the holding basins from the control room
- the bridge piers must stand at least 1.5 m outside the chamber walls
- the headroom under fixed bridges must comply with § 5.4

5.8.2 *Movable bridges*

The following additional requirements apply to movable bridges over locks:

- where there are large volumes of road and shipping traffic, a bridge should be projected over both lock heads
- for recreational craft the headroom under the closed bridge must be at least the value specified for fixed bridges on M routes in Table 9
- operators in the control room at the lock must have a good view of both shipping and road traffic; the control room must be situated on the side opposite the leaf hinge
- the leaf must be outside the chamber wall to prevent collisions

5.9 Waiting areas and guide fenders

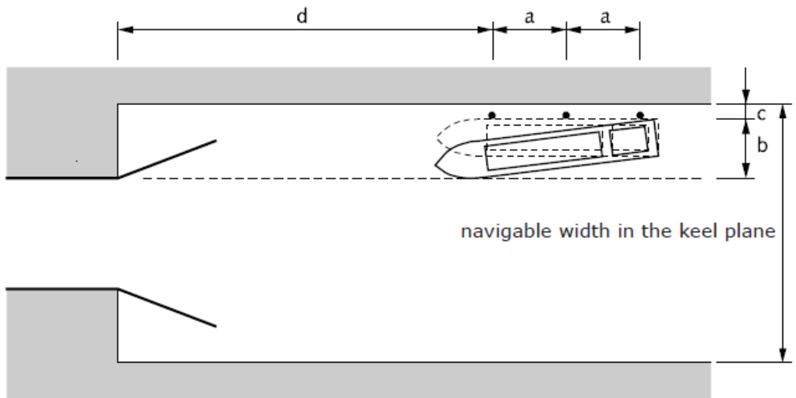
5.9.1 *Waiting areas for commercial vessels*

A movable bridge must have waiting areas on both sides of the bridge, since there will always be situations where the bridge is not being operated. The use of bow propellers has reduced, but not removed, the need for waiting areas. The waterway management authority will need to decide how many waiting vessels need to be accommodated.

5.9.2 *Waiting area requirements for commercial vessels*

A waiting area should be situated on the starboard side of the waterway (Figure 42). The increased use of bow propellers means it is less necessary to take account of wind direction when vessels arrive, moor up and set off. However, in certain cases it can be advisable to create a sheltered spot, by planting vegetation for example. A waiting area for commercial vessels must meet the following requirements:

- vessels must be able to smoothly moor up and put themselves on course in front of the bridge
- the waiting area must not obstruct through traffic
- the height of and distance between mooring dolphins and the height of bollards must be appropriate for the waterway class
- bottom and bank protection must be sufficiently erosion-resistant
- the distance requirements in § 4.6 apply to hazardous goods vessels



class	a (m)	b (m)	c (m)	d/L[3]	e (m)	f (m)
I	15	6.5	2.0	0.5	3.0	2.5
II	22	8.5	2.0	0.5	3.5	3.0
III	22	10.0	2.0	0.5	3.5	3.0
IV	22	11.5	2.0	0.5	4.5	3.5
Va	22[1]	13.5[2]	2.5	0.5	5.0	4.0
Vb	22[1]	13.5[2]	3.0	1.5	5.5	4.5
VIa (M12)	22[1]	20 (25)	3.0	1.0	6.0	5.0
VIa (BII-2b)	22[1]	27 (33)	4.0	1.5	5.5	4.5
VIb	22[1]	27 (33)	4.0	1.5	5.5	4.5
VIc	22[1]	27 (33)	4.0	1.5	5.5	4.5

all measurements in m (except d/L)

1. 30 m if class I vessels rarely or never use the waiting area
2. 19 m for a frequently used waiting area
3. this is the minimum for classes I to Va; to ensure smooth passage, d/L=1.0 is recommended; a shorter distance may be selected for class Vb if there are relatively few Vb vessels; L = length of reference vessel
4. top values motor vessels, bottom values push combination or coupled unit (wide formation)

a. centre-to-centre distance between mooring dolphins; at least 3 mooring dolphins should be provided
b. distance from mooring dolphins to inside edges of bridge opening, measured perpendicular to the waterway axis. The values in brackets apply in the case of frequent use
c. distance from facing of mooring dolphin to bank (in keel plane)
d. distance from waiting area to bridge
e. minimum height of first and last dolphins at waiting area, relative to reference high water level
f. minimum height of intervening dolphins relative to reference high water level, and minimum height of highest bollard on mooring dolphin relative to reference high water level

Figure 41: Waiting area for commercial vessels

In the event that the option of a movable bridge is chosen for a waterway that has a longitudinal current in excess of 0.5 m/s (rivers), the flow rate must be taken into account when calculating the distance from the waiting area to the bridge on the upstream side. The relative distance to the bridge (d/L) on the upstream side will have to be multiplied by a factor k:

$$k = 1 + \frac{v_c - 0{,}5}{v_s}$$

Where:
V_c = the reference flow rate
V_s = the reference speed of travel through the water when the vessel passes the bridge

The distance on the downstream side remains unchanged (ref. 89).

5.9.3 *Structural requirements for mooring dolphins*

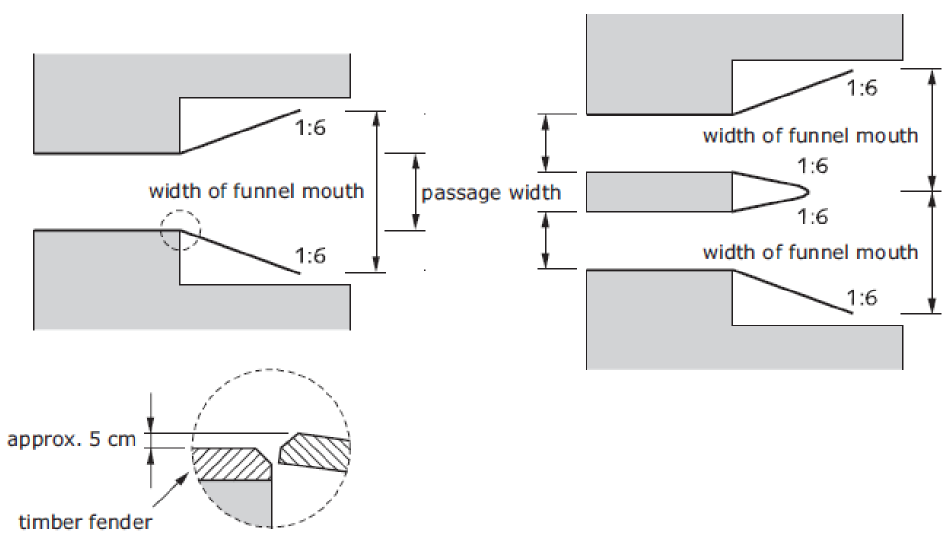
The design strength of the dolphins depends heavily on the local situation and the expected traffic volume; it does not fall within the scope of these guidelines. Further advice can be obtained from *Rijkswaterstaat* GPO.

5.9.4 *Bollards*

The height and positioning of bollards are subject to the same considerations as fenders at locks, as discussed in § 4.9. The lowest bollards should be positioned 1.5 m above the reference low water level (MLWS). Intermediate bollards should be placed between the lowest and the highest, to create a difference in height of approx. 1.5 m.

5.9.5 *Fenders*

Fenders are intended to prevent or at least limit damage to bridges and vessels by providing mechanical and visual guidance. The design of fenders at bridges is consistent with that at locks, as described in § 4.9. A fender must stand at least 15 cm proud of the abutment of the bridge when unloaded, and must not narrow the passage width of the waterway by any more than 5 cm on either side (see Figure 43).



fenders required when threshold values not exceeded			
profile	classes I to Va and VIa		classes Vb, VIb and VIc
	without bow propeller	with bow propeller	all with bow propeller
single-lane	1.8.B	1.6.B	1.8.B
narrow	1.8.B	1.6.B	1.8.B
normal	2.0.B	1.8.B	2.0.B

B = beam of reference vessel

Figure 42: Threshold values for passage width of bridge for fenders on commercial routes

Guide fenders for commercial vessels are used when the passage width of the bridge is smaller than the values in the table belonging to Figure 43. The guide fenders are mounted symmetrically in a funnel shape, the mouth of the funnel complying with the values in the table. It is acceptable to deviate from these instructions where there are two passage openings with a narrow central pier.

5.9.6 Waiting area requirements for recreational craft

There must always be a waiting area for recreational craft at a movable bridge. In principle, it should be on the starboard side of the waterway, but if this is an unsheltered leeward bank or the movable part of the bridge is on the port side, the waiting area should also be on the port side. The waiting area must be as close to the bridge as possible, between the waiting area for commercial vessels and the bridge.

Moored recreational craft must not present any obstacle to through commercial traffic. If long waiting times are likely to occur, information on the opening times should be provided on a dynamic information panel, for example, as described in ref. 22.

The depth of the waiting area must be equal to the depth of the adjacent waterway. Any restrictions applying to the use of the waiting area must be clearly indicated. In determining the depth, problems caused by the wind, wave action and the wake of passing commercial vessels must be taken into account.

The design specifications of guide fenders for recreational craft at bridges are the same as those at locks, as described in § 4.9. The following additional requirements also apply:

- the guide fenders must have a mooring rail along their entire length, positioned 0.8 m above MHWS
- at bridges where lots of sailing boats pass, it is recommended that a footpath be laid on one or both sides; this applies in particular to bridges with a long passage opening and/or a high leaf and/or between high walls

5.10 Lighting

Good lighting at a bridge helps ensure vessels can pass smoothly and safely, by enabling skippers to see where they are going and allowing the bridge keeper to see vessels. The road over the bridge must be lit in such a way that the light is spread evenly and does not dazzle ships' crews.

5.10.1 *Fixed bridges*

Fixed bridges for the normal profile without a central pier do not require lighting. Fixed bridges without a central pier over waterways for commercial navigation with a narrow profile may constrict the navigation channel slightly (see § 5.4), with abutments standing in the water. In that case, at least the vertical surfaces bordering the passage opening and the pile tips of the fenders should be painted white or yellow, and illuminated with 3.5 lux at dusk.

Fixed bridges with a central pier have guide fenders. This situation requires good visual guidance provided by lighting of at least 7 lux projected on a number of vertical white or yellow surfaces: the pile tips in the funnel and the tips of the piers and/or abutments. The passage opening should be lit symmetrically, as shown in Figure 44, or a signal light should be used.

The inside surface of the passage opening should be illuminated with no more than 3.5 lux. Stronger lighting produces too great a contrast with the water beyond, giving the impression of sailing into a black hole. Height gauges and traffic information signs should be made visible using even lighting, but may not blind those using the waterway.

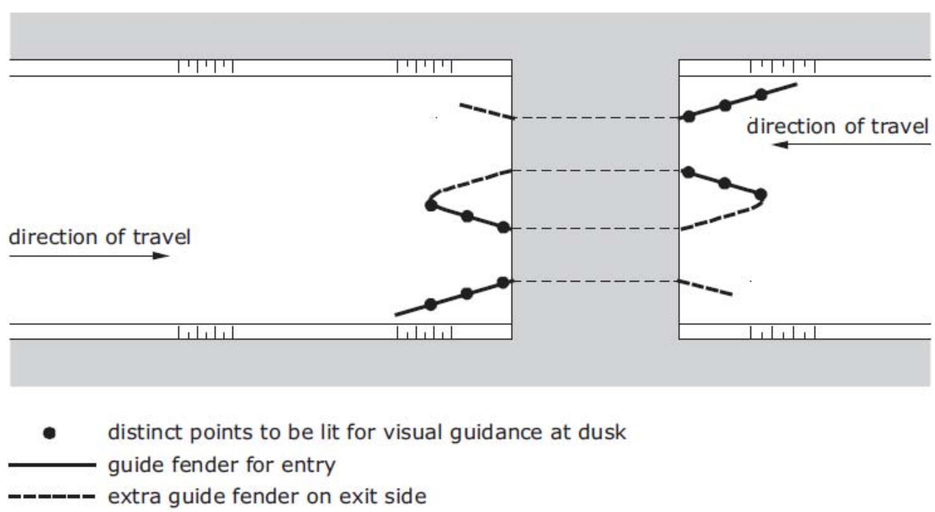


Figure 43: Lighting a funnel with uneven legs

5.10.2 *Movable bridges*

The same provisions apply to movable bridges as to fixed bridges, with the addition of the following:

- red and green signal lights act mainly as visual guidance and must therefore be positioned at the same height and precisely the same distance from the inner surface of the passage opening on both sides of the bridge; these lights must not dazzle and must be turned down slightly at dusk
- waiting areas should be lit with a vertical intensity of 3.5 lux and a horizontal intensity of 5 lux
- if a bridge is controlled remotely using CCTV, extra lighting may be needed

Detailed information on signs, lighting and reflective material can be found in the Shipping Signs Guidelines (*Richtlijnen Scheepvaarttekens*, ref. 22).

5.10.3 Signal lights

When two permanently amber signal lights are used, the distance between them and their brightness should be such that it is possible to distinguish two lights at dusk at a distance of 5.L. At a distance of 1 to 2 L, these amber lights act as a guide mark for the central line of the opening. They must therefore hang precisely above the centre of the opening.

Radar beacons (RACONs) are not suitable as replacements for signal lights. Nor are they necessary in addition to them.

5.10.4 Radar reflectors

Unless they give a clear image on a ship’s radar, bridge piers and guide fenders must be fitted with radar reflectors on 15 m pylons or on buoys.

For more information on the shape and dimensions of radar reflectors, see ref. 22. Radar disruption is discussed in § 5.11. Reflectors or lights may be mounted along the bank over a distance of at least 5.L to provide visual guidance after a vessel has passed under the bridge. The trajectory of the waterway must be clear to the skipper.

5.11 Radar disruption

5.11.1 Radar-blind zone

Bridges can disrupt the radar image and, on a ship’s radar, appear much wider than they actually are. Such disruption and false echoes make it difficult, if not impossible, for a skipper to obtain a reliable picture of other traffic and objects in the navigation channel.

The area subject to such disruption, including the bridge itself, is known as the radar-blind zone. In normal circumstances, and at normal speeds, a vessel should not spend any longer than 20 seconds in a radar-blind zone (making it invisible to other shipping), in order not to jeopardise safety. At a speed of 3 m/s, for example, this would mean that the radar-blind zone may be no more than 60 m long. The length of the radar-blind zone varies from one bridge to another, and depends among other things on the structure of the bridge and the materials used (ref. 30).

5.11.2 *Reducing reflections*

To prevent or reduce problematic radar reflections, a number of structural measures can be taken at both new and existing bridges. They are listed below in descending order of effectiveness. More detailed information can be found in ref. 30.

- build the bridge of concrete instead of steel; concrete is less reflective
- build the bridge with an entirely solid underside, to prevent multiple reflection between cross and/or longitudinal beams
- mount wire netting or a solid barrier between the bottom flanges of the main girders
- apply radar-absorbing material to the underside of the web of girders
- bevel the main girders (Figure 45); the bevelled surface should be at an angle of approx. 10º
- angle the sides of the bridge
- apply absorbent material to the sides of the bridge

The minimum radar reflection of absorbent material should be 13 dB for the radar frequencies 9.5 to 10 GHz used by inland navigation vessels. Suitable absorbent materials include: certain rubbery sheeting, camouflage nets filled with absorbent material and absorbent paints. The effectiveness of paint depends heavily on the precision with which it is applied.

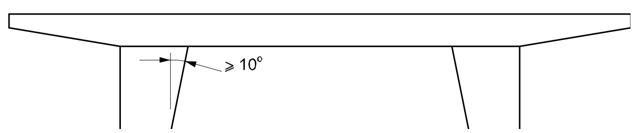


Figure 44: Cross-section of a bridge with bevelled main girders

5.11.3 *Multiple bridges*

If there are several bridges in close proximity, multiple reflections are unavoidable. This can cause an extra bridge to appear on radar screens. This situation is highly confusing and requires extra measures to reduce radar disruption, such as positioning the bridges only a few metres apart, with due regard for the considerations concerning intervening distance discussed in § 5.2.

5.11.4 *Cranes*

Cranes in feathered pitch position may not protrude over the waterway to prevent radar disruption and collisions.

6 Harbours for inland navigation

6.1 Typology

Harbours must offer safe mooring, where vessels are protected from wind, currents, waves and floating ice, and people and/or goods can be transferred or transhipped. Harbours for inland navigation vessels can be divided into five main types:

- quays and wharves (§ 3.10)
- holding basins at locks (§ 4.6)
- docks and ancillary harbours
- overnight stay facilities and harbours
- harbours for recreational craft

This chapter examines docks, ancillary harbours, overnight stay facilities and harbours for recreational craft. Issues associated with loading and unloading are not considered.

6.2 Docks and ancillary harbours

Docks are generally used for transferring goods, and are equipped with piers, pontoons and/or landing stages for the purpose. Docks are also used for waiting and for overnight stays, but do not need to be specially equipped for the purpose.

6.2.1 Entrance and exit

The axis of the docks is generally perpendicular (canal) or at an oblique angle (river) to the axis of the waterway.

Where there is a current, the harbour mouth should be such that a vessel can enter travelling upstream, exit in reverse and turn on the main waterway. Alternatively, it can be assumed that vessels will enter in reverse when deciding on the angle of entry and the shape of the harbour mouth. In that case, there must be sufficient space immediately past the entrance to stop and manoeuvre towards the mooring location. If a vessel first has to pass through a harbour channel before reaching the harbour, entering upstream bow first is the preferred option. In this case, an angle of entry perpendicular to the axis of the waterway will generally be required.

It must also be possible to enter and exit safely when the water level is high and the current fast. Visibility and ways of preventing wind problems for vessels entering the docks and manoeuvring must also be considered.

6.2.2 Harbours where there is a current

When designing a harbour for places where there is a current, hydraulic and morphological factors must be considered alongside nautical factors. These include the following:

- The harbour may cause only limited rise ~~of~~ in the water level
- Sedimentation both in the harbour and in the fairway must be minimised
- Changes to the current pattern must be avoided as far as possible, and cross currents must be limited

These requirements mean that the choices made in the design of a harbour on a river will have to be different than those for a canal harbour. The most important differences relate to:

- The width of the harbour mouth on the edge of the waterway:
  - o As wide as possible on a canal, which is easy in nautical terms. On a narrow canal, the space in the harbour mouth will be used by vessels to turn into the harbour (trapezium shape, see Figure 46)
  - o As wide as possible on a river, and bordered with a vertical structure (e.g. sheet piling) to restrict sedimentation, impoundment and changes to the current pattern (Figure 47)
- The space just inside the harbour mouth:
  - o Small on a canal: the wide harbour mouth and absence of any current means the vessel can enter slowly and in a controlled manner
  - o Large on a river: in view of the current in a river, vessels will enter at much greater speed and need room to stop and line up

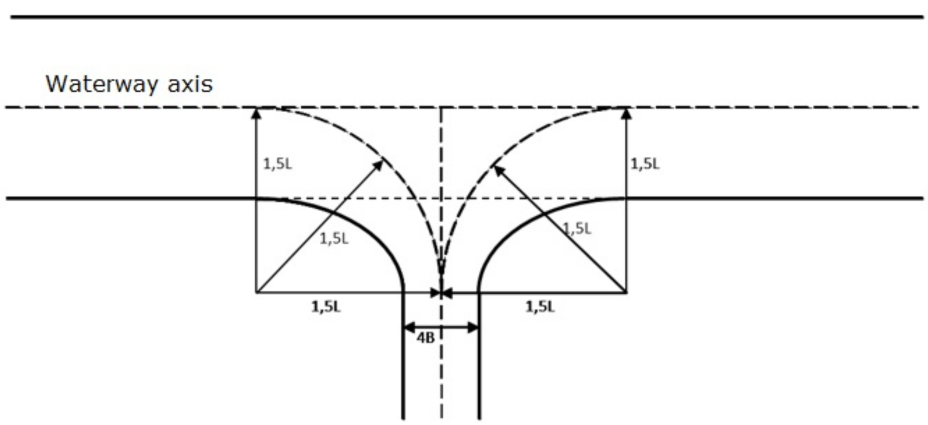


Figure 45: Design of a harbour entrance on a canal

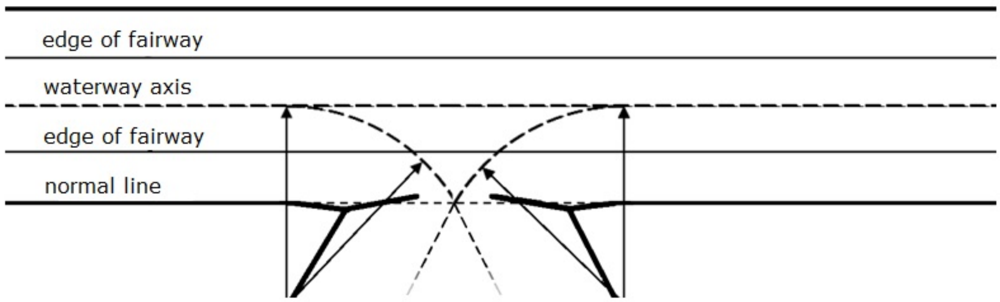


Figure 46: Design of a harbour entrance on a river

To prevent vessels having to reverse over long distances (or entering in reverse and turning just inside the harbour), the norm for harbours over 1000 m in length or more than 10.L remains to enter forwards. The shape and angle of the harbour entrance will then depend on the direction from which most traffic enters, but generally speaking the angle of entry will be perpendicular to the axis of the waterway. If both origin and destination are most frequently downstream, a relatively narrow entrance at a wide angle relative to the axis will be sufficient.

On rivers dominated by drainage, manoeuvres into the harbour downstream and out of the harbour upstream will largely determine the design and width of the harbour mouth, irrespective of the manoeuvre. On tidally dominated rivers, the determining factor is entry downstream and exit upstream at maximum tidal flow.

These principles are applicable to waterways wider than 0.8L. In such situations, the vessel will make the greater part of the turn while still on the river. On narrower waterways a wider entrance is needed to allow vessels to enter the harbour more or less sideways, at a smaller angle to the current. On narrow waterways where the fairway is narrower than 0.8L the required harbour mouth width along the river is approx. 1L. There must be enough space immediately inside (at least 2L) to complete the turn into the harbour. If necessary, a vessel can enter the harbour more or less sideways at a small angle relative to the current. On wider waterways, the harbour entrance may be narrower. The width will then have to be determined by further investigation. The reference situation is entry into the harbour downstream.

To limit localised sedimentation in the harbour entrance, if the direction of current does not change, the upstream harbour head should be bordered by a vertical structure, such as sheet piling. The sheet piling will guide the main current more towards the river. It can also be used to create an area shielded from the current downstream. Vessels travelling downstream will then be able to enter the harbour in reverse more easily. Sheet piling also clearly demarcates the upstream side of the entrance, allowing vessels to make a tighter turn into the harbour. A pile on the end of the sheet piling is then needed to ensure good visibility, even at high water levels.

6.2.3 *Width of harbour*

The width of the harbour channel should be at least 4.B, where B is the beam of the reference vessel. Where the waterway has a fast current and/or is used by long units, it might be desirable to widen the entrance further. This will have to be determined by further investigation. The shape of the harbour mouth should be the same as that of a junction (§ 3.8).

An effective width for mooring in the docks is two vessels on each side. Allowing more than two vessels to moor up alongside each other can lead to difficult manoeuvring when vessels moored on the inside come to depart. The available width between piers, piles or landing stages, including the harbour canal, should be 7.B to accommodate two-way traffic in docks where two vessels are moored up alongside each other.

6.2.4 Length of harbour

Each vessel requires a mooring length of 1.2.L, where L is the length of the reference vessel for that mooring area. If ships moor up only one deep, a length of 1.1.L will be sufficient. Moored vessels must not obstruct the view of the junction with the waterway.

6.2.5 Depth of harbour

The harbour should be the same depth as the adjacent waterway. The keel clearance in the harbour must be at least 1 m, in view of the erosive power of ships' propellers.

On a river the depth at the opening to the harbour should be the same as the depth of the fairway. In the harbour itself, the depth should be based on the keel clearance appropriate to the applicable design profile. The change in depth must be gradual to prevent the harbour from becoming a sand trap. Before performing any dredging work in existing harbours, it is important to ensure that this will not jeopardise the stability of local structures like quaysides and fenders. The possibility of subsidence in the fairway during the lifespan of the harbour should also be considered.

6.2.6 Moorings for hazardous goods vessels

One or more separate moorings must be provided for vessels carrying hazardous substances, depending on demand. These should be arranged in such a way that the legally required distance from objects and other vessels can be maintained. The nature of the load determines how many blue beacons the vessel must display. The minimum distances that must be observed are described in the ADN and have been adopted in the BPR:

- vessel displaying one blue cone: 10 m from other vessels and 100 m from contiguous housing, tank storage depots and engineering structures
- vessel displaying two blue cones: 50 m from other vessels, 100 m from engineering structures and tank storage depots and 300 m from contiguous housing
- vessel displaying three blue cones: 100 m from other vessels and 500 m from contiguous housing, tank storage depots and engineering structures

While waiting at locks or bridges, other, smaller distances may be observed. In no event may the distance be shorter than 100 m, however.

The competent authority may permit shorter distances in view of the local circumstances.

When planning moorings for hazardous goods vessels, all the facilities available on the waterway must be considered. Vessels with one or two blue cones are rare, and vessels with three are very rare. It is therefore recommended that vessels displaying two or three cones be catered for in a flexible way, through some kind of allocation system. In other words, it should be possible to make the moorings available to vessels displaying one cone, or to other vessels on request. The competent authority – the local mayor – must approve mooring facilities for hazardous goods vessels. This also applies to moorings for hazardous goods vessels in overnight stay harbours.
If the mooring is intended for loading and unloading, the ADN stipulates that escape routes must be available at both the stern and the bow. At overnight stay facilities for hazardous goods vessels, it is advisable to provide disembarkation to the quayside, although this is only mandatory for loading and unloading. Emergency services vehicles must be able to drive up to the landing stage. Where mooring structures are made of steel or concrete, measures must be taken to prevent sparking while vessels are mooring up, possibly in the form of protective strips made of timber or plastic. The moorings for hazardous goods vessels must be indicated by shipping signs.

6.3 Overnight stay facilities for commercial vessels

To enable ships' crews to comply with the rest periods prescribed by the Inland Navigation Act (*Binnenvaartwet*, BW), overnight stay facilities should be situated no more than approximately two hours' sailing time apart. On waterways without locks, this equates to a distance of approx. 30 km. There are two types of overnight stay facility:

- at freestanding piles
- at specially equipped overnight stay harbours

Overnight stay facilities at piles serve only to provide a safe mooring for one night. Dolphins are adequate for the purpose (§ 6.5.1). No disembarkation or other facilities are required, given the short duration of the stay. If the overnight stay facility is in a navigation channel, such as in the holding basin of a lock, it must comply with the same conditions as a quay (§ 3.10.1).

Overnight stay facilities for vessels carrying hazardous substances should be located in large overnight stay harbours (accommodating 15 vessels or more), at large lock complexes (for more than 15,000 passing vessels a year) or no more than 60 km apart.

6.4 Overnight stay harbours for commercial vessels

6.4.1 Positioning

Sheltered waters, waiting areas or overnight stay harbours offer commercial vessels a safe mooring for one or more nights. Where there are more than 30,000 passing commercial vessels a year, the overnight stay harbour must be separate from the waterway.

The location of overnight stay harbours depends heavily on the local circumstances. Industrial premises and transhipment facilities should not be located in overnight stay harbours to ensure that the people resting there can enjoy peace and quiet. No quay walls or wharves are needed; simple landing stages or pontoons are sufficient. Certain facilities are usually available in overnight stay harbours. These are discussed in § 6.7.

6.4.2 *Mooring capacity*

The required capacity, dimensions and design of the harbour depend on the local circumstances: the space available, the desired number of moorings for conventional vessels and for vessels carrying hazardous goods, the position of the harbour mouth etc. The number of vessels per night that is not exceeded 95% of the time, counted over a period of at least four weeks (the 95th percentile), should be regarded as the reference number of vessels staying overnight. *Rijkswaterstaat* has drawn up a corporate implementation framework providing further details of the method to be used for determining the required capacity (ref. 31).

This method assumes that existing moorings will continue to be used as they are at present. This can be determined by means of surveys. Observations must be made during the nighttime hours, when most overnighters have moored up, i.e. between 23.00 and 05.00. Given the strong fluctuations in the use of moorings, observations should be made over at least four consecutive weeks, in the spring or autumn. To calculate the required mooring capacity, the following must be determined, in the order stated:

- volume of goods transport in the year of prognosis
- average cargo capacity in the year of prognosis
- number of vessels (laden + empty) needed to carry this cargo
- number of vessels staying overnight in the year of prognosis
- the average length of these vessels
- the required mooring length in the year of prognosis
- any shortage of mooring length

Expressed as a formula:

$$L_O = N_B .(L_P + s).(P_P/P_B)$$

where:

L_O = required mooring length for overnight stays in year of prognosis, expressed as metres of bank

N_B = reference number of vessels staying overnight in base year, i.e. 95th percentile of survey result

L_P = average vessel length in year of prognosis

P_B = number of passing vessels in base year

P_P = number of passing vessels in year of prognosis

s = distance to next vessel

At moorings along a bank or quayside vessels cannot be moored literally top to tail. An interim distance S of 5 m (classes I to IV) to 10 m (class V and higher) is needed.

For a prognosis of the number of moorings at landing stages (NP), the formula can be simplified to:

$N_P = N_B.P_P/P_B$

Goods transport is not included in the formula, but it is used to determine the number of passing vessels in the year of prognosis, as follows:

$P_P = P_B. (G_P .T_B)/(T_P.G_B)$

where:

P_B = number of passing vessels in base year
G_P = cargo transported on waterway in year of prognosis
G_B = cargo transported on waterway in base year
T_B = average cargo capacity of vessels in base year
T_P = average cargo capacity of vessels in year of prognosis

If there are few or no moorings in the area being surveyed, the above method will not be adequate. In that case N_B can be determined in the above formula by estimating the proportion of vessels mooring in the area on the basis of the probability that a journey will have to be broken for an overnight stay in the area being surveyed. This should be done using the following formula:

N_B = number of vessels . percentage of vessels staying overnight

With percentage of vessels staying overnight = average journey time / maximum travelling time, where:

number of vessels: reference number of passing vessels a day, i.e. the 95th percentile
maximum travelling time: the average maximum permitted travelling time of passing vessels
average journey time: length of waterway / average speed

If the moorings are along a bank or quayside, vessels will be moored up no more than two abreast. At landing stages where it is easier to manoeuvre than at a continuous embankment, they may moor up three abreast. Landing stages in overnight stay harbours should preferably be perpendicular, or virtually perpendicular, to the bank.

In waters governed by the Mannheim Convention another method is used to determine the mooring capacity on the different sections of the Rhine, based on the number of moorings required (ref. 86).

Overnight mooring facilities = $I_d \cdot A_{Length\ of\ stay} \cdot A_{Irregular}$

Where:

I_d = vessels per day requiring overnight stay facilities
$A_{Length\ of\ stay}$ = travelling time on each section / each operating type (16 hours or 18 hours)
$A_{Irregular}$ = factor for peak hours (not required on the Rhine)

6.4.3 *Emergency moorings for small vessels*

Separate emergency mooring facilities for small vessels and recreational craft must be created at overnight stay harbours for commercial vessels, possibly in combination with a jetty for maintenance vessels.

6.5 Mooring structures at overnight stay harbours

The mooring facilities at overnight stay harbours for commercial vessels may consist of piles or dolphins, fixed or floating landing stages, pontoons, sheet piling or quaysides no longer used for transhipment. To prevent or limit erosion of the bank protection, vessels should moor up with their bows facing into the embankment.

6.5.1 *Dolphins*

The simplest mooring facilities consist of piles or dolphins. These should be positioned 30 m apart. If large numbers of class I or smaller vessels use the harbour, it is recommended that several pairs of piles be positioned no more than 15 m apart. Long (135 m) motor cargo vessels, coupled units and pushed convoys should also be catered for. The piles or dolphins must comply with the following additional requirements:

- bollards at various heights, so that vessels can also moor up properly at high and low water
- high enough to prevent push bows from overhanging
- the first and last pile should be high enough to ensure that the structure is sufficiently visible from the wheelhouse during mooring

waterway class	I	II	III	IV	Va	Vb	VI
height of intermediate piles	2,5	3,0	3,0	3,5	4,0	4,5	5,0
height of first/last pile	3,0	3,5	3,5	4,5	5,0	5,5	6,0

Table 50: Height of piles above MHWS (m)

6.5.2 *Landing stages*

The conditions applying to fenders, as described in § 4.9, also apply to both fixed and floating landing stages.

The surface of the landing stage should be at least 1.5 m above the reference high water level (MHWS), the surface of a floating landing stage or pontoon at least 0.8 m. The surface should be covered in a non-slip material. The width of the footpath between bollards and rails, which may be positioned along both sides, must be at least 1.25 m; bollards must be painted white with a view to safety (tripping hazard). A fixed landing stage must have a rail on one or both sides.

6.5.3 *Disembarkation facility*

A disembarkation facility, usually a gangway, allows the crew to reach the bank on foot. It must therefore continue to a point on the embankment that is above the high water line. On the embankment, the disembarkation facility must be accessible for emergency service vehicles. Gangways must be at least 1.25 m wide, and have a rail on both sides. The maximum permitted gradient is 1:8 at the reference high or low water level. The surface must be covered in a non-slip material.

6.5.4 *Quays*

No heavy quay structure is required in an overnight stay harbour. A vertical form of bank protection may however be considered, consisting of sheet piling with a concrete cover. The pile cap may not overhang to ensure that vessels do not become trapped under it. The sheet piling and the waterway bottom in front of it should of course be resistant to erosion caused by propeller movements. The pile cap and paving should be able to take a heavy goods vehicle. The paving should be non-slip.

The height of the quay should be at least 1.5 m above the reference high water level. The pile cap or edge of the quay must be smooth and rounded near bollards to prevent hawsers from being damaged, excessively worn or breaking.

A recessed ladder should be mounted every 30 m along the quay, extending to 1.0 m below the reference low water level. Vessels should be no further than 50 cm from the ladder. A hand bar must be installed at the top of the ladder, allowing safe access to and from the quay.

6.5.5 *Bollards*

The design of bollards and mooring bitts should be such that a steeply slanting hawser will not be able to slip off. For the positioning of bollards and mooring bitts, see § 4.3.5.

Bollards must be able to withstand a hawser force of 150 kN for vessel classes I and II, 200 kN for classes III and IV, and 250 kN for class V, 300 kN for class VIa and 350 kN for class VIb (ref. 27). For recreational craft, 40 kN is sufficient.

If the hawsers of more than one vessel are tied to a single bollard, or the hawser has been wound round several times, the bollard may be subject to stronger forces. The required strength of the bollard must be determined in each individual situation.

Bollards in places frequented by pedestrians – such as quays and landing stages – must be painted white for safety reasons (tripping hazard).

6.5.6 *Mooring on spuds*

A growing number of vessels have spuds – telescopic legs below deck which are extended using a control in the wheelhouse, anchoring the vessel in the bottom of the waterway. No mooring structures are needed. Although vessels moored on spuds are in a less compact configuration than vessels moored at piled fenders, the waterway management authority may decide to designate certain areas for the use of spuds. Some restrictions do however apply:

- there must be no cables or pipelines under the waterway bottom
- spuds may not be used on revetments, rock filling etc.
- there must be no waterproof layer in or on the bottom
- there must be no protected benthic life forms
- the water depth must be no greater than the maximum length of the spuds, which is generally 10 m

Mooring on spuds is regulated in art. 7.03 of the BPR, and additional rules may be set out in harbour management ordinances.

6.6 Car boarding facility

Every large overnight stay harbour (with 15 or more moorings) must have a facility that allows a car to be boarded or disembarked. A car boarding facility is also needed at large lock complexes (with more than 15,000 passing vessels a year). Car boarding facilities must be no more than 60 km apart. The presence of a car boarding facility also allows emergency services vehicles to get close to vessels.

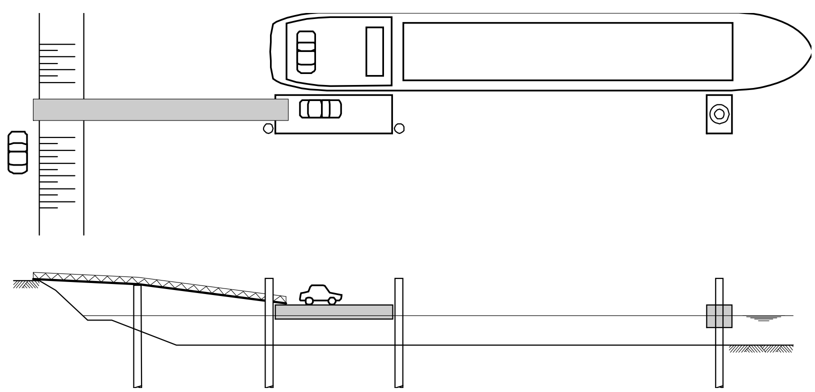


Figure 47: Car boarding facility with pontoon or landing stage for variable water levels

The car landing platform may be a quayside, landing stage or pontoon. Where the water level is constant, a quayside is to be preferred, while a pontoon is more appropriate in places with large variations in water level. The bottom and bank protection must be resistant to the erosive effect of propellers. Where vessels moor with their bow against the embankment a pontoon or landing stage will be required, since cars are usually parked on the stern of the vessel.

The gangway must be at least 3.0 m wide. Landing stages and pontoons must have raised edges to prevent cars from ending up in the water. Figure 48 shows an example of a car landing platform with a pontoon. The harbour site must have sufficient parking above the high water line, within view of moored vessels or fitted with CCTV, to prevent theft.

6.7 Facilities in overnight stay harbours

In terms of the facilities that should be provided, a report by skippers' association *Koninklijke BLN-Schuttevaer* (ref. 32) distinguishes between places designed for an overnight stay (one night) and those designed for weekend stays. These are similar to the requirements set out for overnight stay places at piles and overnight stay harbours in § 6.3. Overnight stay harbours play an increasingly important role in the social life of skippers, and this should be taken into account when deciding what facilities to provide.

6.7.1 *Shore-side electricity*

Power cabinets can be installed to prevent the noise and fumes caused by generators on moored vessels. The power cabinets should be capable of providing enough power. According to the guidance issued by the National Ports Council (ref. 33), 16 A at 240 V is sufficient for connections for small vessels and recreational craft, while 63 A at 400 V is needed for large vessels. Up to 400 A at 400 V may be necessary in exceptional cases, such as for large passenger vessels.

Connectors and sockets should comply with EN 15869 of the Comité Européen de Normalisation, and be CE certified. To prevent break-ins and vandalism, it should be possible to pay using a mobile telephone, bank card, credit card or by some other method not requiring cash.

6.7.2 *Drinking water tap*

A drinking water tap may need to be provided if no other supply is available within a reasonable distance. The tap must not be combined with the car landing platform, as it would then be occupied too often, unless it were possible to moor up on both sides of the platform. Measures to prevent freezing, guarantee hygiene and prevent break-ins and vandalism must be considered when the tap is installed.

The tap should be able to supply at least 3 m^3 of drinking water an hour. To prevent break-ins and vandalism, it should be possible to pay using a mobile telephone, bank card, credit card or some other method not involving cash.

6.7.3 *Site lighting*

Places in or near the harbour that are susceptible to vandalism must be adequately lit by even, non-dazzling lighting with a strength of 3.5 lux on vertical surfaces and 5 lux on horizontal surfaces.

6.7.4 *Camera surveillance*

Camera surveillance from a traffic control centre or a permanently manned control room or surveillance centre should be considered in connection with the prevention of crime and vandalism.

Under the *Rijkswaterstaat* Traffic Registration Systems Privacy Regulations (*Privacyreglement Verkeersregistratiesystemen Rijkswaterstaat*), issued pursuant to the Personal Data Protection Act (*Wet bescherming persoonsgegevens*, Wbp), which applies among other things to video recordings, images may be used only to ensure the safe use of facilities and may not be passed on to third parties. Images may be stored for no longer than 30 days, though they are generally kept for no longer than

24 hours. This does not apply in the event of disasters or when criminal activity is suspected.

6.7.5 *Additional facilities*

Additional facilities at overnight stay harbours might include an information panel with the names, addresses and telephone numbers of local doctors and emergency services, and the address and postcode of the harbour.

If the overnight harbour has facilities for depositing household and/or non-recyclable waste, they should be easily accessible both for skippers and for the collection service. Waste containers must have sufficient capacity and be emptied regularly, particularly in the summer.

It is sometimes desirable to have a fence to keep cattle away from parked cars, and an entrance gate that opens only for passengers, delivery vehicles and other traffic requiring access.

The overnight stay harbour must be accessible by vehicle from the public highway, and should be well signposted.

6.8 Harbours for recreational craft

6.8.1 *Harbour functions*

In terms of functionality, there are two types of harbour for recreational craft:

1. marinas, a collection of permanent moorings under joint management, usually by a sailing club, where recreational craft can be left when they are not in use
2. tourist harbours, a collection of moorings that allow recreational craft to break their journey and/or stay overnight

In principle, there are no objections to harbours for recreational craft being located on the waterway itself, although use of trunk routes by recreational craft is not encouraged. When harbours for recreational craft are developed along waterways, a study will have to be conducted to show that they will not jeopardise the safety of traffic on the waterway.

The Waterway Guidelines do not consider the design and equipping of marinas and tourist harbours in any further detail. See ref. 34 for more information. For the waterway management authority, the choice of location and dimensions of the harbour are the most important factors, as recreational craft entering and leaving the harbour may not hamper the smooth, safe navigation of the waterway.

6.8.2 *Positioning marinas*

Marinas should be situated in or as close as possible to the navigation area used by recreational craft. This prevents an unnecessary burden on the capacity of the waterways and the engineering structures in and on them, and limits interaction with other shipping. In other words, it reduces the risk of accidents. The mouth of the harbour must be positioned in such a way that yachts leaving the marina do not immediately find themselves in a main fairway.

The number of marinas on each route should be enough to minimise obstruction to passing vessels. Marinas should be at least 500 m apart and, where necessary, they should use a single combined entrance. The entrance should be situated some distance from bridges or locks. The recommended distance is at least 250 m.

The provisions set out in § 3.6.1 and 6.2 apply in general to the design of the harbour mouth. Marinas should be situated perpendicular to the waterway, or on a wide, gentle outside bend, at a safe distance from the fairway. If the position of the fairway poses problems, the marina may be situated on a gentle inside bend, provided there is sufficient visibility (see § 3.8) and enough distance from the fairway.

The marina should also be dimensioned in such a way that the wave height (wind-generated waves or ships' wakes) is never greater than 0.2 m. Potential problems with suction caused by passing commercial vessels should also be considered in the design.

6.8.3 Tourist harbours

Tourist harbours or mooring facilities for tourists are needed along waterways used for recreational touring. Unlike marinas, these are an additional facility that have little or no impact on the capacity of the waterway. They offer passing recreational sailors the opportunity to break their journey. The required capacity for tourist facilities is demand-driven. It is up to the waterway management authority to decide whether it is acceptable to have a tourist harbour on a waterway.

The waterway must have enough tourist harbours and/or temporary mooring facilities suitable for recreational craft. A rough guide would be that such facilities should be situated 20 km apart, irrespective of the class of waterway.

If possible, tourist harbours should be combined with existing harbours or marinas to limit the number of locations where vessels enter and leave waterways. Combining them with existing marinas means that their management will be guaranteed. Arrangements for the management of separate tourist harbours will have to be made with the body responsible and stipulated in the licence conditions. This is particularly important in the case of overnight facilities.

A tourist harbour must be designed and managed in such a way that recreational craft obstruct through traffic as little as possible. This can be achieved by conducting a careful study of location options, and by setting additional conditions in the licence concerning the design and the supervision of users. The greater the volume of commercial traffic at the location, the more necessary such conditions will be.

6.8.4 Tourist landing stage

Tourist landing stages situated immediately beside a key waterway or major navigation area must be protected from wave action and/or problems associated with suction caused by passing commercial vessels. If necessary, signs will have to be positioned along the waterway ordering commercial vessels to reduce speed. The harbour should be dimensioned in such a way that the wave height (wind-generated waves and/or ships' wakes) at the moorings is never greater than 0.2 m, by using wave dissipaters.

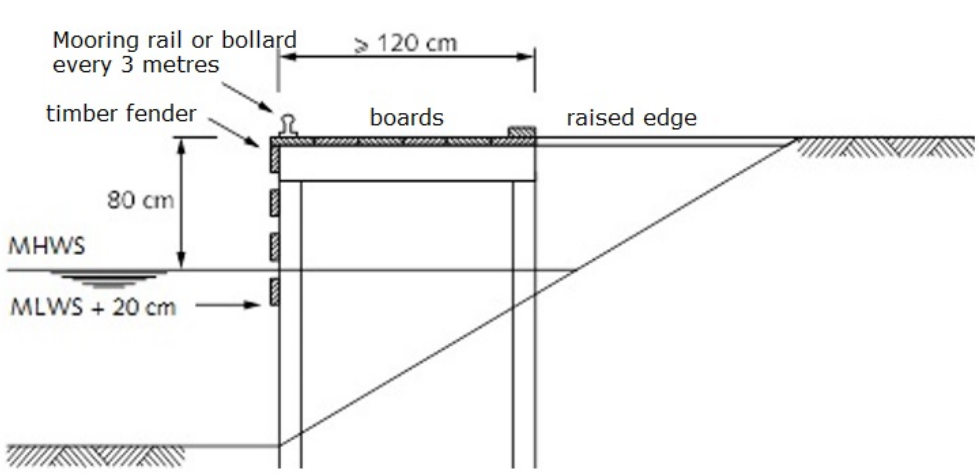


Figure 48: Cross-section of tourist landing stage for recreational touring

A landing stage for recreational touring may be a fairly simple structure (figure 49), provided the following points are considered:

- the mooring must have enough feet to keep the line in place in the event of suction caused by passing vessels
- the tips of the bollards must be shaped in such a way that steeply slanting lines do no slip off; the bollards themselves must be painted white for safety reasons (tripping hazard)
- horizontal pins through bollards must also prevent steeply slanting lines from slipping off
- piles must be higher than the upper deck of mooring recreational craft and be tapered only at the tip

6.8.5 *Disabled access*

One in four people experience some form of restricted mobility at some time in their life. It is therefore important that recreational facilities be designed in such a way as to guarantee access for disabled people. In the case of marinas and tourist harbours, this primarily means that there must be an unobstructed connection between land and vessel. Access ramps must not be too steep, and paths and landing stages should be wide enough, non-slip and free of obstacles (see also ref. 35).

7 Operation

7.1 Principles of operation

Bridges and locks necessitate reductions in speed and disturb the concentration of drivers and skippers. They have moving parts, which means that people or objects can become trapped. This combination of factors leads to an increased risk of accidents. The waterway management authority must ensure these objects are designed and operated, and the behaviour of drivers and skippers is influenced in such a way that the likelihood of an accident is minimised, despite the fact that drivers and skippers are in fact responsible for their own safety. Should an accident nevertheless occur, provisions must be available to minimise its impact. In short, the risk of accidents can be kept to a minimum with a well-considered combination of technical measures and operating procedures. The basic principles are:

- when operating movable objects the operator must establish whether the process is proceeding safely, and perform a visual check to confirm that no people or objects are on or near moving parts
- it must be possible to stop objects moving if danger arises
- an object may only be operated from one location at a time
- safety provisions cannot be overlooked during normal operations; during emergency operations safety and observance of safety provisions must be guaranteed by procedures
- emergency operation is intended to make an object safe, and may never be used as an alternative to regular operation
- only skilled staff may operate a bridge or lock, which means that the method of operation must be laid down in a manual, that staff must have both general training and specific training for the object in question, and they must be aware of the safety risks and safety procedures
- other staff, both those of the management authority and those of sub-contractors, may not work on the object until they have been instructed about the safety risks and safety procedures
- operating processes, powers, procedures, work instructions and IT resources should as far as possible be the same throughout the country
- an integrated security approach is required for operation, either on-site or remote, which fully reflects both technical requirements and the human factor (operator and skippers/drivers)
- security when operating bridges and locks is governed by the Machinery Directive, NEN-ISO-12100, the Use of Work Equipment Directive, NEN 6786-1 and NEN 6787.

Rijkswaterstaat has drawn up additional frameworks for operation, known as the National Bridge and Lock Standard (*Landelijke Brug- en Sluisstandaard*, LBS), which applies in addition to these Guidelines.

7.2 Methods of operation

7.2.1 *Four methods*

There are four methods of operating locks and bridges. They are examined in more detail below.

1. on-site operation by an operator
2. remote operation by an operator from a control room or centre not in the immediate vicinity of the object
3. self-service operation, whereby the skipper initiates the process, which then proceeds automatically
4. automatic operation, whereby an automatic mechanism initiates and completes the entre operating process without human intervention

This depends on whether the movement mechanism of the lock or bridge is operated mechanically, electronically and/or hydraulically. These Guidelines do not include self-service manual operation, as occurs at some small bridges and recreational locks. Whatever method of operation is chosen, on-site emergency and maintenance operation must always be possible in the event of a failure or for maintenance purposes.

7.2.2 *On-site operation*

On-site operation means that the lock or bridge is operated from a control building at the centre of the lock complex or immediately next to the bridge. The operator has a view of the object and relevant features in the surrounding area, either directly or with the aid of technology. Human factors mean that a single mode must be used during operation. Operation of separate lock heads no longer occurs in practice, and is not therefore included in these Guidelines.

7.2.3 *Remote operation*

Staff are not present at the site when a lock or bridge is operated remotely. They therefore require technology to observe the bridge or lock chamber and relevant features of the surrounding area.

Operating several objects remotely from a control centre allows savings on staff costs, and extension of operating hours, which improves the level of service. A single control centre for objects managed by different authorities allows operation of an entire route or corridor to be optimised.

7.2.4 *Self-service*

At a self-service lock or bridge, there are no staff to give instructions, and the skipper must perform one or more actions to initiate or continue the operating process. This might include pressing a button, pulling a lever, turning a key or passing a card through a reader. The process must include a point where the skipper himself indicates, at his own discretion, when the operating process may start.

Self-service is suitable only for bridges or locks on waterways with a low volume of traffic, both on the water and on the intersecting roads. As a rule, these are generally recreational waterways.

7.2.5 *Automatic operation*

Fully automatic operation means that the process is initiated by a system that detects the arrival of a vessel. The skipper need not take any action, as the automatic mechanism operates the bridge or lock without the need for human intervention.

No locks are operated automatically as described above in the Netherlands, except for automatic traffic control at a lock/safety lock gates or narrow passage.

Automatic operation of bridges occurs only occasionally, largely because of the traffic control system's vulnerability to technical faults, the detection system's susceptibility to vandalism, and the risks to road users, particularly pedestrians and cyclists. This form of operation is appropriate only on waterways for recreational craft where traffic volumes are very low, on both the road and the waterway.

7.2.6 *Operation on request*

This involves operation at the request of a skipper or shipper outside normal operating hours, sometimes at extra cost. This applies to both on-site and remote operation. In technical terms, operation on request is no different from the regular operating process. Operation on request can improve utilisation of the waterway.

7.3 Operating locks

7.3.1 *Flow diagram of lock operation*

The process is the same for on-site and remote operation.

A general flow diagram of the process of passing through a lock is shown in Figure 50. It is based on a lock for commercial navigation operated on site.

A1 <u>advance notification</u>

Generally given automatically by an information processing system long before the vessel arrives at the lock, and requiring no action on the part of the skipper.

B1/2 <u>obtain information</u>

Information is generally obtained at the same time as notification is given. See A.2

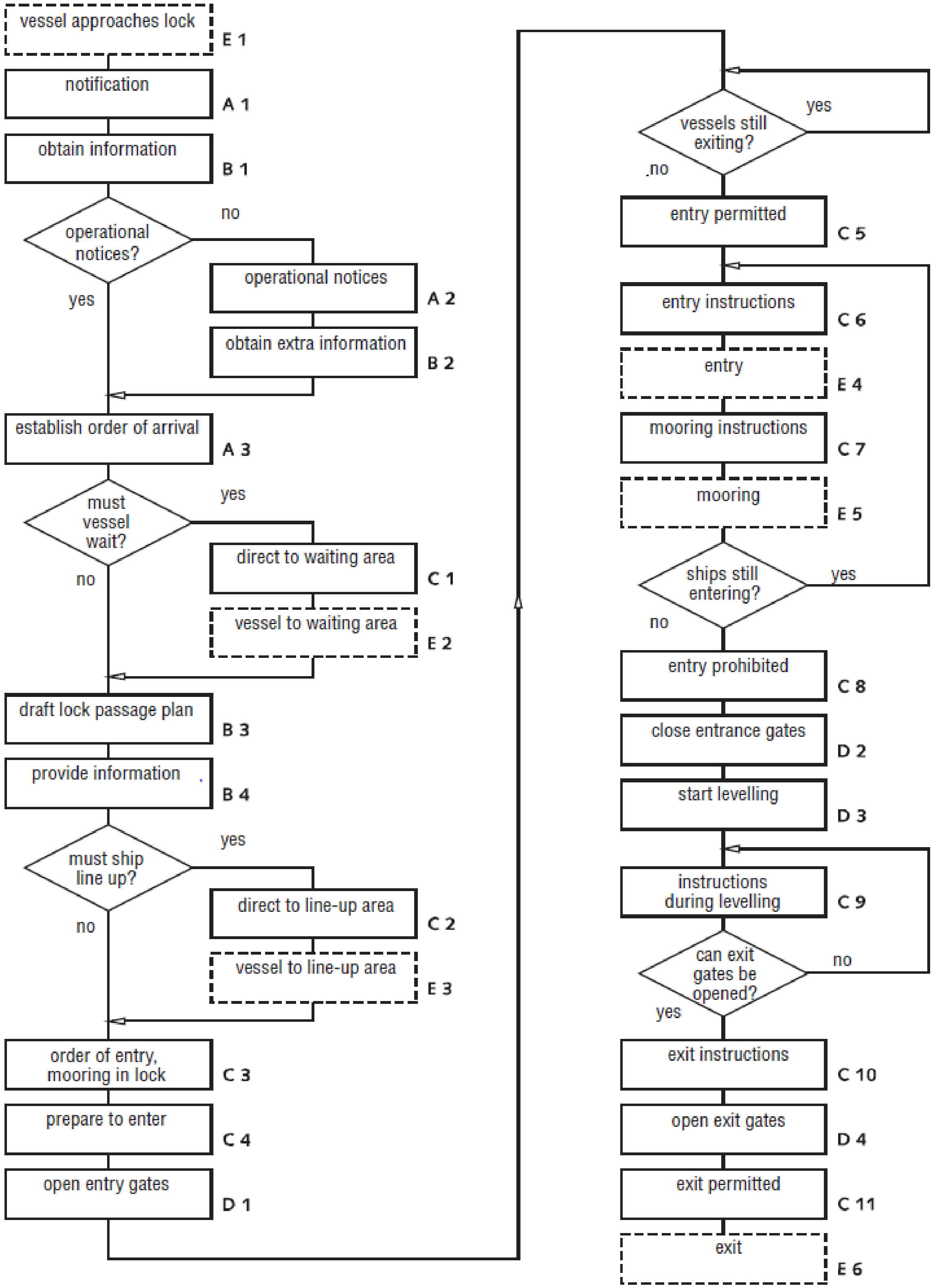


Figure 49: Flow diagram of passage through lock

A2 operational notice

Operational notices provide all relevant information associated with the lock passage. They can be given in the following ways:

- by VHF radio, which can be announced using traffic sign E.21; this option must always be available to commercial vessels
- using an intercom system at the mooring facility; this is intended mainly for recreational craft with no VHF radio
- by mobile telephone
- at the lock keeper's office (on-site operation only)

The lock keeper will of course visually observe the vessel, either directly, or via camera or radar images, or an automatic identification system (AIS). The skipper must receive confirmation as to whether his request is to be dealt with immediately. If not, it is recommended that notice of the likely waiting time be given.

A3 order of arrival

The lock staff determine the order of arrival as vessels pass a turn marker, on the basis of visual observations, or with the aid of technology such as radar or CCTV.

C1 direct to waiting area

If the vessel cannot be included in the next passage, the lock staff must direct it to a waiting area. A direct view of the waiting area is not strictly necessary. CCTV or radar support is desirable.

B3 draft lock passage plan

When drafting a lock passage plan, staff should take account of the order of arrival, regulations concerning hazardous cargoes, weather conditions, the presence of recreational craft etc. At busy locks, the lock passage plan is usually generated by computer.

B4 provide information

Vessels must be informed of the lock passage plan. This usually happens by VHF radio, but a public address system may also be used. If there is more than one chamber, it is recommended that arrows (traffic sign D.3a) be used to indicate which vessel a chamber has been allocated to. If there is more than one holding basin, arrows can also be used to direct vessels to the correct one. The Shipping Signs Guidelines (ref. 22) describe useful images for this purpose. A dynamic information panel can be used to provide additional information.

C2 direct to line-up area

The line-up area is intended solely as a place where vessels due to go in the next passage can moor up. It is recommended that staff have a view of the line-up area, particularly at large locks, using CCTV, direct visual observation, radar or a combination of these methods.

C3 <u>order of entry and mooring in lock</u>
Before vessels enter the chamber, each one must be informed of the order of entry and what position they have been allocated in the chamber. This information can be imparted using a VHF radio or public address system and, in due course, digitally.

C4 <u>prepare to enter</u>
A red/green signal light can be used to inform vessels that entry into the chamber is about to commence. Before the entry signal is given, staff must ensure that there are no other vessels in the chamber.

D1 <u>open entry gates</u>
The entry gates may not be opened until the lock staff have checked that there are no people or objects on or near the moving parts. Staff should monitor the situation as the gates are being opened, with the aid of technology if necessary.

C5 <u>entry permitted</u>
If a red/green signal light has been shown (C4), the green entry signal will automatically be shown as soon as the gate is fully open. Otherwise, staff should manually show the red/green signal light and then – when the gate is fully open and no other vessels are in the chamber – activate the green signal light to indicate that vessels may enter the chamber.

C6 <u>entry instructions</u>
Staff ensure that vessels enter the chamber smoothly and safely, with the aid of technology if necessary, and issue any instructions needed using the communication systems available.

C7 <u>mooring instructions</u>
Skippers may need to be instructed to proceed to the correct mooring position, move closer together, turn off their propeller etc. Staff issue any instructions needed using the communication systems available.

C8 <u>entry prohibited</u>
Once the final vessel has entered the chamber, i.e. its bow is between the gates, the red signal light indicates that no more vessels may enter.

D2 <u>close entry gates</u>
Before closing the gates, staff should ensure that there are no people or objects on or near the moving parts. There must be no vessels just in front of or between the lock gates. Moored vessels must be between the stop lines. Then the gates can be closed. While closing the gates, the operator should monitor the situation, and immediately intervene in the process if any dangerous situation arises.

D3 <u>start levelling</u>
An acoustic signal should be given to mark the start of the levelling process.

The signal – generally a siren – should have a volume of 112 dB. In built-up areas the maximum permitted volume is 85 dB.

C9 instructions during levelling

Staff should look out for any problems with sagging or tautened hawsers, which sometimes affect recreational craft. If necessary, staff should issue instructions using their communication systems. It is the responsibility of skippers to moor their vessels correctly. If a dangerous situation arises, the operator should intervene.

C10 exit instructions

Instructions do not usually need to be issued while vessels are exiting the chamber. If necessary, however, staff should issue instructions using the communication systems available.

D4 open exit gate

Before opening the gates, staff should ensure that there are no people or objects on or near the moving parts. No one must be standing on the lock gates, for example. While opening the exit gates, staff should monitor the situation, and immediately halt the process if any dangerous situation arises.

C11 exit permitted

The green exit signal is automatically shown as soon as the gates are fully open.

7.3.2 Operating locks on site

For the purposes of these Guidelines, on-site operation is synonymous with central operation from a single building, irrespective of whether just a single chamber is being operated, or several chambers in the same complex. Technology is sometimes needed to ensure a good view of all chambers. Notification may be given directly to the lock master if the lock is operated on site. In many cases, however, the control building is too far from the waiting and line-up areas, and some other means of notification is preferable, such as an intercom system, mobile telephone, VHF radio or internet. From the point of view of staff safety, it is not desirable for lock users to enter the office or control room uninvited.

7.3.3 Operating locks remotely

The fact that a lock is operated remotely can be made clear to both road and waterway users by placing a warning sign (shipping sign B.8) at a distance of 3.L, or at least 100 m, from the lock, with a sign below reading ‘remote control’.

The process of operating a lock remotely is no different from on-site operation, albeit that direct visual observation is replaced by CCTV and/or radar and AIS. Cameras should preferably not be installed to the north of the lock chamber, to prevent dazzle due to sunlight. For remote operation, the operator must have a view or overview of:

- the approach areas on both sides
- the adjacent holding basins, including line-up area
- the chamber itself, the stop line and the gates on both sides

Rijkswaterstaat has set out further details on this matter in the document 'Visibility for the operation of movable bridges and lift locks' (*Zicht bij bediening van beweegbare bruggen en schutsluizen*, ref. 37). The operator requires a view in the lock chamber and funnel, and an overview in the approach area and holding basin.

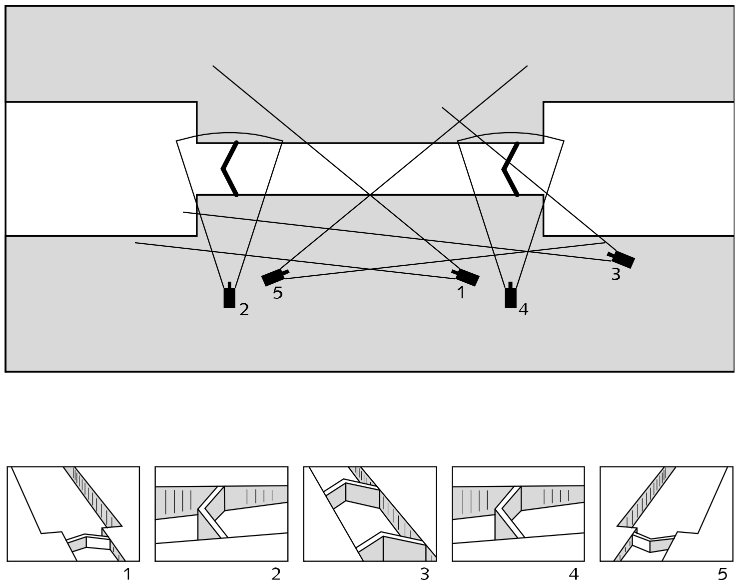


Figure 50: Example of camera positions at remotely operated lock

In many cases, more cameras will be needed. In a wide and/or deep chamber, for example, extra cameras should be installed on the wall on the other side. Visual requirements associated with bridges over locks are discussed in the next section

Where locks are operated remotely, greater consideration must be given to the means by which vessels and operators communicate. The crew of both large and small commercial and recreational vessels must be able to reach intercom speakers. A public address system is needed for issuing verbal instructions. A nameplate (traffic sign H.2.4) clearly visible from the water indicating the VHF channel or telephone number of the lock is recommended.

7.3.4 *Self-service lock*

As stated in § 7.1, the skipper initiates the operating process by some action such as pressing a button, pulling a lever, turning a key or swiping a card. A second action may be introduced to start the levelling process. An emergency stop mechanism must also be provided. Self-service operation takes more time than on-site or remote operation, and is suitable only for small locks handling low volumes of traffic, generally recreational locks. Remote operation technology has however improved to such an extent that self-service barely serves any purpose nowadays.

It must be made clear to waterway users that they are approaching a self-service lock, perhaps by placing a warning sign (shipping sign B.8) at a distance of 3.L, and at least 100 m, from the lock, with a sign underneath reading 'self-service'. It must also be clear to the skipper what actions he needs to perform, what the emergency procedure is and how any faults can be reported, without him having to leave the vessel.

Various things are left to the responsibility of the skipper. Nevertheless, some processes require technological support, such as the detection of vessels or floating obstacles between closing gates, the presence of vessels that have not yet exited the chamber, an acoustic signal to warn that levelling is about to start etc.

A central location must be notified immediately, and at all times, of any technical fault or triggering of the emergency stop mechanism. The skipper must therefore be able to communicate with the central location. There must always be a mechanism for manually operating the lock. If no vessels arrive within a time to be defined by the waterway management authority, the gates should close automatically.

7.3.5 *Automatically operated locks*

Since a vessel must always stop to pass through a lock, giving the skipper enough opportunity to initiate the operating process, a fully automated lock has no added value. Locks are not therefore eligible for automatic operation.

7.3.6 *Radar system*

At large lock complexes visual observation often does not provide enough information. Nor is it possible to determine the position and distance of a vessel. AIS or a radar system enables the position of vessels to be determined as they approach the lock, and while they are in the holding basin and at the fenders. A radar system at a lock will have to meet the following requirements:

- radar observation of navigation area between line-up and waiting areas up to the lock gates, generally approx. 1 km
- radar observation of approaching vessels up to a distance of no more than 4 km from the lock gates

A radar location study must always be performed to ensure that the operational requirements can be met and reflections, interference and blind spots cause little or no disruption.

7.4 Operating bridges

7.4.1 *Flow diagram of bridge operation*

The processes for operating bridges on site or remotely are identical.

A general flow diagram of the process of passing under a bridge is shown in Figure 52. It is based on a bridge for commercial navigation operated on site. Stopping and restarting road traffic safely is discussed separately in § 7.5.

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A1 operational notification

A vessel can indicate that it wishes to pass the bridge by giving an agreed sound signal (long-short-long) or calling by VHF radio, mobile phone, intercom etc. The operator will generally already have seen the vessel approaching and taken action. Any automatic detection should occur at a distance of 3.L, and at least 100 m, from the bridge.

C1 direct to waiting area

The skipper must be informed that he has been seen, that his request is being dealt with, and what the waiting time will be. If it is not possible to open the bridge immediately, the vessel will be directed to the waiting area. Sufficient waiting facilities must be available near the bridge (§ 5.9). The method of notification is likely to change in the near future, thanks to the advent of automatic identification systems.

D1 decide when to stop traffic
The operator decides when the operating process should start, having visually checked the situation on the deck of the bridge using cameras or detection systems to make sure there is no blockage such as congestion or an accident. Given the problems vessels can experience with stopping and mooring up, traffic on the waterway is usually given priority over traffic on the road.

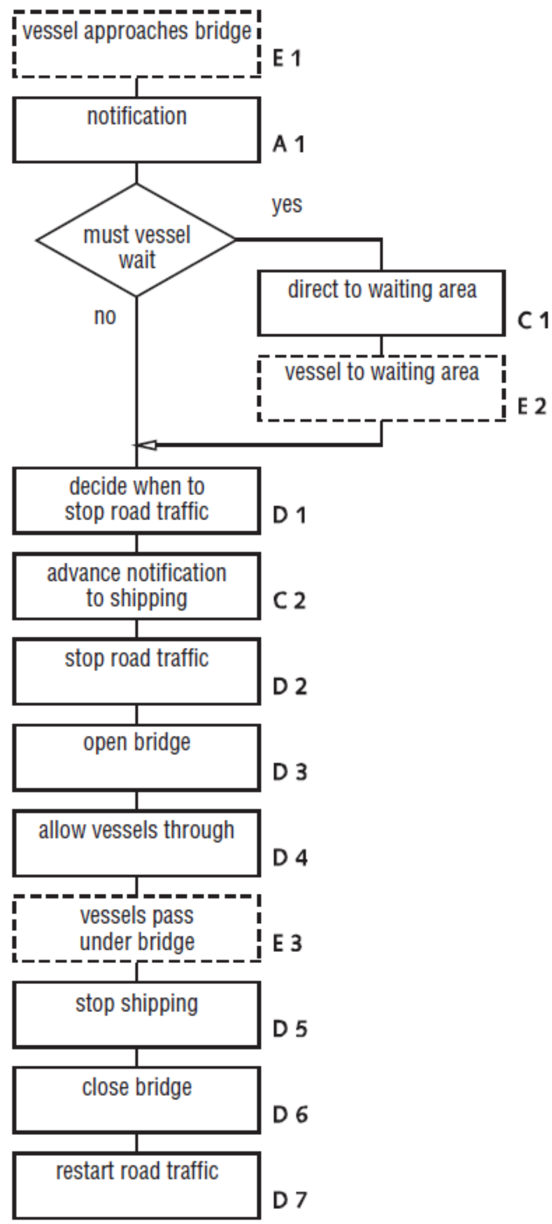

Figure 51: Flow diagram of passage under bridge

C2 <u>prepare to proceed</u>

The vessels on the side that are allowed to move off immediately will be notified in advance by means of a red/green signal light. On the other side, the light will remain red, and will only be switched to red/green when the bridge keeper considers the process of moving off from the other side sufficiently advanced. At bridges with sufficient passage width, it may be possible to switch the sign to red/green on both sides simultaneously, at the discretion of the waterway management authority.

D2 <u>stop road traffic</u>

Flashing warning lights are followed by the bridge lights. From two seconds before and during lowering of the barrier, an acoustic signal is given and the road traffic is brought to a halt. Bringing road traffic to a halt is discussed in § 7.5.

D3 open bridge
After the operator has ensured that the deck of the bridge is empty, and there are no people or objects between the barriers, the bridge can be opened for shipping. The operator must have a full view of the space between the barriers, and of the deck of the bridge in order to open it. It must always be possible to stop the opening process in the event that a road user is still on the bridge deck.

D4 allow vessels through
The operator indicates that vessels may pass through by switching the signal lights from red/green to green. If vessels are waiting on both sides and it is not possible for them to pass simultaneously, the operator regulates the order of passage using the signal lights. In view of safety, and to prevent claims for damages, passage is only allowed once the bridge is fully open. It should not be technically possible to switch the lights to green before the bridge is fully open.

D5 stop shipping
The operator stops shipping traffic by turning the signal lights to red on both sides.

D6 close bridge
Once the operator has ensured that there are no vessels in or near the passage opening, he may issue the command to close the bridge. If he does not have an adequate view of the opening, he will require technological assistance. It must be possible to interrupt the process in an emergency.

D7 restart road traffic
Once the deck of the bridge is fully closed and locked the barriers can be opened. An acoustic signal is given from two seconds before and during raising of the barrier. The landward bridge lights and any warning lights may then be extinguished and road traffic may resume on the bridge.

The total operating time can often be reduced considerably by installing faster opening and closing mechanisms or shortening procedures where possible. This has a positive effect on waiting times for road and waterway traffic, but it must not be at the expense of safety.

7.4.2 *On-site bridge operation*

The flow diagram in the previous section is based on a bridge operated on site. When a bridge is operated on site, any control building must meet the relevant requirements (§ 7.6).

7.4.3 *Remote bridge operation*

Waterway users are now familiar with remotely operated bridges. It can be made clear to waterway users that a bridge is operated remotely by placing a warning sign (shipping sign B.8) beside the waterway at a distance of 3.L, and a minimum of 100 m, before the bridge, with a sign underneath reading 'remote operation'. The process of remote operation does not in principle differ from that of on-site operation, albeit that direct visual observation is replaced by CCTV, or possibly radar. To prevent dazzling by sunlight, cameras should preferably not be situated on the north side of the bridge. Before installing cameras, it is advisable to set up a test array. For remote operation, the operator must always have a view of:

- the approach area for shipping
- the holding basins
- the passage area (the bridge opening)
- the road surface up to the hatched markings

Rijkswaterstaat has set out further details on this matter in the document 'Visibility for the operation of movable bridges and lift locks' (*Zicht bij bediening van beweegbare bruggen en schutsluizen*, ref. 37).

A nameplate (traffic sign H.2.4) clearly visible from the water indicating the VHF channel or telephone number of the bridge is recommended, particularly if the bridge is remotely operated.

The crew of both large and small vessels must be able to reach intercom speakers easily and comfortably. At a remotely operated bridge, and also at self-service and automatic bridges, it is useful to inform skippers that their vessel has been detected.

7.4.4 *Self-service bridge*

The skipper initiates the opening process by performing an action such as pressing a button, pulling a lever, turning a key or passing a card through a reader. Self-service takes more time than on-site or remote operation, and is suitable only for bridges on waterways with low volumes of road and waterway traffic, or at quiet times.

It must be made clear to waterway users that a bridge is self-service, for example by placing a warning sign (shipping sign B.8) beside the waterway at a distance of 3.L, and a minimum of 100 m, before the bridge with a sign reading 'self-service' underneath.

It must also be clear what actions the skipper is required to perform, how the procedure can be interrupted in an emergency, and how faults can be reported. There must be a mechanism that allows the bridge to be operated on site in the event of a fault.

7.4.5 *Automatically operated bridge*

If a bridge is automatically operated, the skipper is not required to do anything. The automatic mechanism detects the vessel and operates the bridge without any human intervention. It must be clear to waterway users that the bridge is operated automatically. In situations where some vessels are able to pass under the closed bridge, the height of vessels must be measured in order to prevent unnecessary opening. The skipper must be sent a signal confirming that his vessel has been detected. It is also desirable that he be informed how long it will be before the bridge actually opens.

A detection system for the automatic closure of the bridge must be installed in the passage opening. An emergency stop button in the passage opening, which is not visible or accessible to anyone on the bank, is also desirable. There must be a procedure for reporting any technical faults to a central point. The telephone number must be indicated on or near the bridge. It must also be possible to operate the bridge on site in the event of a fault.
Before the bridge opens, a check must be performed to confirm that there are no people or vehicles on the deck. Automatic detection systems are available for this purpose. They are virtually all susceptible to technical faults and vandalism, and must therefore be frequently inspected and regularly maintained. A visible and audible announcement must be made for waterway and road users when the bridge is about to open and close.

Fully automatic operation is technically complex and thus expensive, and is therefore rarely used, partly because of the detection system's vulnerability to vandalism, and the safety implications for road traffic.

7.4.6 Bridge over lock

Where a lock has a movable bridge over one or both lock heads, the standard lock signal lights must be installed, and only a double amber under-bridge light on both sides of the bridge.

7.5 Halting road traffic

7.5.1 Statutory provisions

By opening a bridge for waterway traffic, the waterway management authority intervenes in the handling of road traffic. It must therefore observe the statutory provisions applying to road traffic. The following are relevant in this connection:

- The Traffic Rules and Signs Regulations (*Reglement Verkeersregels en Verkeerstekens*, RVV): rules designed to foster the smooth flow of traffic and road safety; the RVV also shows the figuration of signs and their meaning
- Administrative Provisions (Road Traffic) Decree (*Besluit Administratieve bepalingen inzake het Wegverkeer*, BABW): these implementation instructions include rules on the positioning of signs by the road management authority
- Traffic Light Regulations (*Regeling Verkeerslichten*): regulations on the positioning, material, colour and dimensions of signal lights; the general requirements include a section on bridge lights
- Traffic Engineering Guidelines on Motorway Instrumentation (*Verkeerskundige richtlijnen autosnelweginstrumentatie*, VRAI). These guidelines were updated by *Rijkswaterstaat* in 2017, in the Traffic Engineering Framework for Intelligent Speed Adaptation Systems (*Verkeerskundig Kader DVM Systemen*)
- 'Safe procedures for stopping road traffic in order to open bridges' (*Veilig onderbreken van landverkeer bij brugopening*), a *Rijkswaterstaat* framework (LBS, ref. 38) that sets out requirements for road-based systems and the design of bridges

7.5.2 *Two phases*

When halting road traffic the two most important phases are the advance warning phase and the red-before-closure phase.

In the advance warning phase, road users are warned that the bridge is about to open. The process of interrupting road traffic is initiated by illuminating the bridge lights, in accordance with articles 92 and 93 of the Traffic Light Regulations (*Regeling Verkeerlsichten*), generally preceded by some form of advance warning and/or initiation of the bridge opening program at a traffic control installation close to the bridge. The guidelines and regulations listed above should be consulted for instructions on how to position the lights etc. If there are intersections in the immediate vicinity of the bridge that are managed by traffic control installations, these should be linked to the bridge control system and configured in such a way that the traffic at the intersection does not obstruct bridge opening.

In the red-before-closure phase road users must stop (Stop Road Traffic function). This is achieved by activating the bridge lights, with support from the stop line and the approach lights. The Pre-warning for bridge opening and Warning of possibility of queues functions remain applicable during the red-before-closure phase. This phase includes the clearing of the road before the first barriers are closed**.** The red-before-closure phase ends when all barriers are closed.

7.5.3 *Barriers*

Manually operated barriers may not be operated at the start of the bridge until road users have been given the opportunity to stop at the stop line, and the area between the stop line and the barriers is clear. The barriers at the end of the bridge may be lowered only after the barriers at the start of the bridge have been lowered, and the area between the barriers is clear. Automatic barriers at the start of the bridge descend without the intervention of an operator. The process of lowering begins as soon as the red-before-closure phase ends. The acoustic barrier signal is activated 2 seconds before the red-before-closure phase ends. To prevent road traffic from becoming trapped between the barriers, the barriers at the end of the bridge do not descend until the barriers at the start of the bridge are closed. If there is only one barrier on each side of the bridge, they will close simultaneously. Any collision with an automatically descending barrier may not cause fatal injury.

The operator must ensure that pedestrians and cyclists do not become trapped between the barriers by opening the appropriate barrier if necessary. If it is undesirable or impossible to open the barriers, another escape route must be provided. The barriers must be as close as possible to the movable part of the deck or balancing arm and counterweight.

The road surface under the barrier must be marked with cross-hatching, and signs must be installed reading ‘keep marked area free’, in accordance with NEN 6787. Sign J.15 with a sign underneath reading ‘automatic barrier’ must be installed at all automatic barriers. Bridges must be closed with four separate barriers, two at each end on either side of the road.

The bridge lights must comply with section 2 ‘General requirements’ of the Traffic Light Regulations.

7.6 On-site operation

7.6.1 Position

If a bridge is operated on site, with no technology to aid vision, the control facility must be positioned in such a way that the operator has a direct view of shipping, both when standing and when seated at the control console(s).

At locks with a large lift between the upper and lower canal sections, it is recommended that the control facility be positioned near the upper head, in order to afford a view of both holding basins. In other cases it should be halfway along the chamber.

At bridges, the operator must have a direct view of the deck of the traffic, the bridge between the cross-hatched areas and of the waterway on both sides of the bridge up to a distance of 5.L, and at least 100 m, both when standing and when seated at the control console. It is desirable for the control facility to be positioned on the opposite side of the waterway to the bascule chamber. This prevents the bridge keeper's view of the passage opening from being impeded when the deck of the bridge is up. Depending on the location, the following factors concerning working conditions in the control room may be important:

- direct sunlight and reflections on the surface of the water and/or in the interior of the control room that cause visibility problems must be avoided or minimised in the most important directions, such as that from which vessels approach
- any hindrance to operators in the control room caused by car lights must be kept to a minimum
- there must be enough space between the control facility and the waterway that the control facility cannot be damaged by protruding parts of vessels
- traffic noise from outside must be minimised as far as possible using structural measures
- it is desirable for the control building to be lockable from the inside, in connection with possible aggressive behaviour by members of the public

When a bridge is to be built over or near a lock, a good site investigation will be needed. Attention should be focused on visual impediments when the bridge is open or closed, and glare from sunlight.

7.6.2 Exterior view

From an operational point of view, there are no special requirements concerning the location of the controls when a bridge or lock is operated remotely. In other words, they may be operated from any location. It is policy at *Rijkswaterstaat* (LBS) for the operator to focus on the instruments at his or her workstation and to have no exterior view. For practical reasons, it is common for the control room to be situated at a bridge or lock. The view of the outside area can then be regarded as having a bearing on the working conditions of the operator (ref. 37). To ensure operators have an adequate view of the outside area in the dark, it must be possible to dim the lighting in the control room. Windows should be positioned at an angle to prevent reflection.

7.6.3 *Safety precautions*

The bridge or lock must be equipped with safety features in accordance with the Machinery Directive and NEN-ISO-12100. In connection with intersecting road traffic the bridge or lock must for example have the following features:

- it must be clear to waterway and road users if the bridge or lock is operated remotely or automatically
- clear visual signals when the operating process is initiated, barriers are closing (incl. acoustic signals) or the deck of the bridge or the lock gates are opening or closing
- the safety of road and waterway users must not be put at risk even when equipment fails
- safety features incorporated into equipment and software may not be disabled during normal operations

Furthermore, certain additional safety precautions must be put in place at a lock or lock complex, in particular:

- clearly visible 'no smoking' signs must be mounted in and near the chamber and at the waiting and line-up area
- where road traffic passes over the lock gates, measures must be taken to guarantee the safety of passing traffic when the gates are opened
- the control console must have an easily accessible emergency stop button so that the lock passage, opening or closing of the bridge or raising or lowering of the barriers can be interrupted in the event of danger

7.6.4 *Lone workers*

Under the Working Conditions Act (*Arbeidsomstandighedenwet*) a lone worker is a person who performs his or her work without a second person in the vicinity who can see or hear him or her and intervene in exceptional circumstances. Alone workers are therefore exposed to more risk. To reduce this risk, the following measures are recommended:

- ensure there are no medical reasons why the person in question should not work alone
- outside normal working hours lone workers should report in and out with a security service
- the lone worker should be given a personal security device to wear at all times, which sends a signal to an emergency response centre when activated

7.6.5 *Nameplate*

To facilitate communication between the skipper and the operator, it is recommended that the name of the engineering structure and, if available, the VHF frequency be indicated on a sign on or near the structure that is readable from the waterway. Traffic sign E.21 should be used to indicate the VHF frequency. Compulsory use of VHF radio should be indicated using traffic sign B.11.

7.6.6 *Public access*

Locks and, to a lesser extent, bridges are interesting objects. To foster understanding and sympathy for navigation and the hindrance it sometimes causes to the public, it is recommended that information and facilities be provided where possible and appropriate so that the public can follow the lock passage process.

Of course, neither the safety of the public nor the smooth running of the lock passage may be put at risk, and skippers must be able to disembark and embark without hindrance. Rescue equipment and materials for the prevention of ice formation must be present.

7.7 Control centres

For the purposes of this section, a control centre is a place from which more than one lock and/or bridge is operated. The control centre need not be a separate building; it may be a specially equipped room in any building.

7.7.1 Two types of control centre

Control centres designed for operating more than one object fall into two categories:

1. object-independent regional control centre
2. control centres at major locks or lock complexes

At control centres of the second type, a single workstation is reserved for operation of the lock, and at least one other workstation is available for operating objects remotely.

7.7.2 Flexible operation

In line with current practice, control centres are equipped for flexible operation. In other words:

- a single operator can under certain conditions safely perform two simultaneous or overlapping operating processes
- a workstation consists of a standard operating station; the facilities available are used flexibly, depending on the object or objects being operated
- the terminal has no permanent link to an object; the workstations all have the same functionality, but the object can be operated from only one workstation at a time
- control centres can be linked together, allowing control to be transferred from one to another (as preferred as a matter of policy)
- operators work in teams, spreading the workload evenly among all members
- operators are given a variety of tasks to ensure they are not overworked or underworked, and to keep the job interesting

The workstation is set up in such a way that two operating processes can be performed and monitored at the same time, in an interlocking process. This means that several objects can be operated in such a way that steps in one cycle occur at points in the other cycle where no direct monitoring and control is required. This merging of processes has advantages over purely sequential operation.

7.7.3 Operating station

Operators have identical workstations. All information needed to operate the lock or bridge must appear on the computer screens at the operating station. It is not advisable to hang computer screens elsewhere in the room. The position and orientation of the workstations should be such that operators can communicate with each other from their workstation. When operation occurs in an interlocking process, the operating stations used should be positioned close together, or the process should be performed at a single operating station. A simple way of storing recorded commands, images and conversations must be available at all times. Recordings should be kept for 28 days.

7.8 Operating regimes

7.8.1 Commercial navigation

To ensure uniformity of operating times (start, end and total operating time), five operating regimes have been devised for commercial navigation (ref. 41). These are based on the situation in neighbouring countries, normal shift times and usual behaviour on Dutch waterways. The five regimes apply to the following waterways for commercial navigation:

1. trunk routes and other waterways regarded as crucially important (under the BPRW, these are: the Lek Canal, Amsterdam-IJsselmeer, Nederrijn and Lek)
2. waterways carrying more than 15 million tonnes of cargo capacity a year, i.e. the most important main waterways
3. waterways carrying 5 to 15 million tonnes of cargo capacity a year; generally speaking, these are the main waterways
4. waterways carrying 2 to 5 million tonnes of cargo capacity a year
5. waterways carrying less than 2 million tonnes of cargo capacity a year

To prevent drastic changes in the operating regime, the carrying capacity on the waterway or route in question should be determined on the basis of a moving average over the last three years.

The operating regimes are a standard. Waterway management authorities are free to introduce longer operating hours if there is a local need, such as where a container terminal is located behind a bridge or lock. Operating hours are often limited to save on staff costs. With the new methods of operation described above it is possible to extend operating hours and provide more services for shipping. This can also be achieved, particularly on smaller waterways, by providing operation on demand without restriction.

regime	Monday	Tuesday – Friday	Saturday	Sunday	total weekly hours
1	0 - 24	0 - 24	0 -24	0 –24	168
2	6 - 24	0 -24	0 -20	8 – 20	146
3	6 - 22	6 - 22	8 - 20	9 – 17	100
4	6 - 22	6 - 22	8 - 18	--	90
5	7 - 19	7 - 19	--	--	60

Table 51: Standard operating regimes for commercial navigation

There must be a uniform operating regime on each route. Opening times should be defined in such a way that a vessel travelling at normal speed is not confronted with a succession of closures, but can continue its journey smoothly, in a ‘green wave’.

7.8.2 *Lunch break*

On waterways where bridges and locks are operated 10 to 12 hours a day, there will often be a lunch break, generally somewhere between 12.00 and 14.00. Studies of the demand from commercial vessels suggest that this period is not always less busy on the waterway than the period immediately before or after. On busy waterways there is a good chance that a queue will form during the lunch break, resulting in serious problems with traffic handling once operations resume. For these reasons, it is not recommended that a lunch break be introduced.

7.8.3 *Rush-hour closure*

Closure at rush hour is also advised against. The first opening or lock passage after closure generally causes so much delay to road traffic that the net effect of rush-hour closure is negative. The benefit of closing during rush hour must be demonstrated before the practice is introduced.

7.8.4 *Public holidays*

On general public holidays, locks and bridges usually run Sunday operating hours. Whether this is acceptable depends on local demand. It is acceptable not to operate at all, or not to operate during the night, on Christmas Day and New Year’s Day. This applies to all operating regimes. Closure on these days will generally mean that the operating regime will need to be adapted to demand on the days immediately prior to and/or following the public holiday.

7.8.5 *Summer/winter*

Summer and winter operation is found mainly on small waterways that are not heavily used by commercial vessels. These waterways are operated Monday to Friday for an average of 10 to 12 hours a day. This can be justified with respect to commercial navigation because:

- small inland navigation vessels (péniches and kempenaars) are spread throughout the day more in summer than in winter
- the dimensions of small waterways are such that it is more difficult to travel at dusk

There should be no more than two different sets of operating hours. It is recommended that the period of summer operation should begin when daylight saving time begins, and end when it ends.

7.8.6 *Operation for recreational navigation*

On waterways that carry a lot of recreational craft, it is desirable to have different operating times, since recreational navigation is concentrated in the warmer half of the year, at weekends and on public holidays. This means that on Sundays, Ascension Day, Good Friday, the king’s birthday, and at Easter and Whitsun, locks and bridges should be operated during their normal hours.

period	connective waterways	access waterways
winter season (1 November - 31 March)	Monday to Saturday operation on request[1]	Monday to Saturday operation on request[1]
low season (1 April - 31 May and 16 September - 31 October)	Monday to Sunday continuous operation[2] 8.00 - 20.00	Monday to Sunday continuous operation[2] 9.00 - 19.00
summer season (1 June - 15 September)	Monday to Sunday continuous operation[2] 8.00 - 21.00	Monday to Sunday continuous operation[2] 9.00 - 19.00

[1] if there is no regular operation for commercial vessels

[2] continuous operation means at least four times an hour

Table 52: Minimum operating regimes in accordance with Basic Blueprint for Recreational Touring in the Netherlands 2016-2020

At places where there is a busy intersecting railway or road, these operating regimes may not be feasible. All stakeholders must then weigh up the various interests and come to an agreement. Waterways used for recreational touring require minimum operating hours as set out in Table 53.

type of intersection	minimum operating frequency
railway with up to 10 trains/hour	1 x per ½ hour
railway with more than 10 trains/hour	1 x per 2 hours
road with more than 1000 vehicles/hour	1 x per hour

Table 53: Minimum operating frequency in accordance with Basic Blueprint for Recreational Touring in the Netherlands 2016-2020

Vessels should pass a bridge or lock in the order of arrival to prevent irritation. The box shown in Figure 27 is a good solution. It is important that recreational touring craft be shown when the bridge or lock will next open, to ensure traffic is handled smoothly. At places where recreational touring craft can expect long delays, a sheltered waiting area of sufficient size must be provided.

8 Management and maintenance

8.1 Management

8.1.1 *Purpose of general and asset management*

The purpose of management and maintenance in a general sense is to determine and preserve the functionality of the infrastructure. Management and maintenance involves identifying the point at which the desired functionality is guaranteed in the long term, at the lowest possible cost. In the case of the waterway, this involves transporting goods and people in a safe, smooth and efficient way. Asset management takes a broader approach, focusing on the optimum use of the network in relation to the goals set, taking into account performance, risks and costs over the network's entire lifetime. Keywords include:

- reliability: reliable journey times are essential for waterway users
- availability: the minimum availability of the waterway can be defined in a performance indicator (PIN)
- maintainability: maintenance should be considered at the design stage
- safety: the waterway should be in such a state that smooth, safe travel is guaranteed at all times

Priorities need to be set. Management also includes devising and updating scenarios for incidents and disasters, and organising the response to them. Accessible databases on the infrastructure and its functions are needed to support management. Examples include *Rijkswaterstaat's* Engineering Structures Data Information System (DISK). Active use of data collection systems can also be regarded as management.

8.1.2 *Legal context*

Rijkswaterstaat's basic tasks are laid down in the Water Act (*Waterwet*), which was introduced in 2009 to replace eight other pieces of legislation, including the Public Works Act, the National Waterways (Management) Act, the Flood Defence Act and the Water Management Act. There are also many other pieces of legislation and regulations with which all waterway management authorities must comply. Table 54 lists the most relevant, though it is certainly not exhaustive.

8.1.3 *National Waterways Management Plan*

Policy on the management of national waterways is set out in the National Waterways Management Plan (BPRW, ref. 43). The BPRW translates the National Water Plan 2016-2021 (NWP) and the National Policy Strategy for Infrastructure and Spatial Planning (SVIR) into measures for the management and maintenance of national waterways. The plan also links with the plans for the construction of new infrastructure set out in the Multiyear Infrastructure, Spatial Planning and Transport Programme (MIRT). The BPRW is also the blueprint for the management of the main water system and the waterways that are under the management of central government. It defines the roles, tasks and responsibilities of *Rijkswaterstaat* and the likely developments during the period covered by the plan. It also lists planned activities in that period. The BPRW provides regional details, with a programme of measures for the management and development of national waterways.

theme	relevant legislation
safety	Water Act
transport	Inland Navigation Act Shipping Act Inland waterways police regulations Rhine Police Regulations Administrative Provisions (Navigation) Decree Mannheim Convention
environment	Water Act Environmental Management Act Building Materials Decree Convention on the collection, deposit and reception of waste generated during navigation on the Rhine and other inland waterways
management	Wrecks Act Earth Removal Act Monuments and Historic Buildings Act Spatial Planning (General Rules) Decree

Table 54: Relevant legislation and regulatoins

The BPRW applies to waterways and flood defences managed by central government and to the coastline, and provides details of:

- the functions of waterways managed by central government
- the programme of management measures
- management under normal and exceptional circumstances
- financial resources

Rijkswaterstaat manages and maintains national waterways on the basis of a vision for river basins, transport corridors and national networks. The BPRW translates management, maintenance and construction into core tasks, user functions and areas. The core tasks of *Rijkswaterstaat* are flood defence, a guarantee of sufficient clean and healthy water, smooth and safe navigation by water, and a sustainable living environment. The core task 'smooth and safe navigation by water' concerns traffic control for shipping and management and maintenance of waterways and engineering structures. By providing good accessibility, safe waterways and reliable travelling times, *Rijkswaterstaat* helps to ensure the efficient and sustainable transport of goods and passengers, while offering room for recreational navigation.

The BPRW also stipulates that in any infrastructural interventions in or along rivers or waterways, the party undertaking the intervention is responsible for ensuring that the intervention does not cause any permanent disruption to shipping.

8.1.4 *Achieving management goal*

In practice, the goal of management is generally achieved by legal and administrative means, with due regard for the current legislation and regulations. This involves awarding licences and granting exemptions with or without conditions, conducting inspections, enforcement activities (including dealing with collision damage), registering vessels etc. The management authority responds to the policy, development and infrastructural plans of third parties, lodging objections if necessary. In exercising its management duties, the waterway management authority maintains contact with other, generally neighbouring, management authorities, which can lead to management and administration agreements, route agreements or voluntary agreements.

8.2 Maintenance

8.2.1 *Type of maintenance*

Activities for the physical preservation of waterways, whether conducted annually or not, on a fixed or variable timetable, qualify as maintenance. Maintenance takes place on the basis of maintenance inspections, agreed preservation plans and maintenance schedules (multi-year or otherwise) that allocate time, manpower and financial resources. It is also important to respond immediately to any technical faults and incidents.

Depending on the waterway management authority's budget system, a distinction can be drawn between work and measures related to maintenance, improvements, use, expansion and construction. There are three approaches to maintenance from which the management authority must choose, having first considered the risks:

- condition-dependent maintenance

consequential loss is great and certainty as to the point of failure small, the condition of the parts must be inspected regularly and replaced preventively when the intervention level is reached

- regular or operational life-dependent maintenance

consequential loss is great, but there is a relative degree of certainty as to the point of failure; replacement occurs preventively after a certain period of use

- fault-dependent maintenance

consequential loss upon failure is small and functionality remains after the part fails; the part is replaced or repaired only when it is defective

A distinction can also be drawn between regular and variable maintenance (Figure 53):

- regular maintenance concerns activities needed to ensure an object functions on a day-to-day basis, such as fault maintenance and periodic maintenance
- variable maintenance concerns major replacement, renovation or reconstruction work on an object, similar in scale to a construction project, and dealt with as such

One example of condition-dependent maintenance is dredging of the fairway (Figure 54). Regular surveys indicate the state of the waterway bottom. The rate of sedimentation determines when intervention – dredging – is needed. The frequency of dredging is based on an optimisation process, and depends heavily on local circumstances.

8.2.2 *Reference Framework for Management and Maintenance (RBO)*

Rijkswaterstaat currently uses the Reference Framework for Management and Maintenance (RBO), a description of which can be found in ref. 44. Further information can be obtained from RWS Centre for Water, Transport and Environment (WVL).

The core of the RBO is defined maintenance strategies for object categories. Budgets are allocated on the basis of price x area (P x Q), or a unit price times the number of units. Uniformity and objectivisation of costs is crucial. The waterway management authority's internal costs must also be included.

Where possible, the RBO is based on 'Life Cycle Costs' (LCC), which take account not only of lifetime-extending maintenance, but also the cost of replacing objects (or parts thereof) at the end of their lifetime. In this way, the method allows a balance to be struck between maintenance needs and the budget available, or enables the available budget to be prioritised. LCC also play a role in the initial investment decision, indicating the costs of construction, maintenance over the entire life cycle, and demolition and disposal.

1	nature and function of object, including boundary conditions
2	surface area and appearance, of both entire system and sub-systems
3	relevant legislation and regulations, associated specifications and standards
4	functionality and characteristics of ageing processes, deterioration, damage, lifetime
5	service levels, user requirements
6	maintenance method (cyclical, condition- or fault-dependent), regular or variable maintenance, decision points
7	intervention level, reference damage, repair standards
8	sensitivity analysis: effects of more, less, earlier, later maintenance
9	special points for attention, such as possibility of combining work, special boundary conditions, potential for innovation
10	indication of average annual costs

Table 55: The ten aspects of the object management regime

8.2.3 *Object management regime*

Several sub-categories can be distinguished within the object category 'main waterway network', a number of which are relevant in the context of these Waterway Guidelines. The categories encompass similar parts of objects or activities:

- banks, including contiguous banks, quaysides, groynes, areas between groynes, longitudinal dikes and levees, river meadows and salt marshes
- waterway bottoms, including fairway bottoms, harbour bottoms and other waterway bottoms
- engineering structures, such as lift locks, flushing and discharge sluices, fixed and movable bridges, weirs, pumping stations
- traffic services, which can include traffic control and waterway markings
- operations, the collective term for buildings, sites, vehicles, general affairs, legal management and transfers

Since the nature, structure, functionality and use of the objects varies widely, an object management regime has been drawn up for each category. The collection of object management regimes provides an overall picture of the object management regime. The object management regimes provide a direct link between policy objectives and implementation. Examples and figures relating to average costs for each of the six categories listed above can be found in ref. 44. Each object management regime sets out further details of the aspects listed in Table 55.

8.2.4 *Response and repair time*

The agreement with the supplier, who is responsible mainly for fault-dependent maintenance, should stipulate a response time – the time between the moment at which a fault is reported to the supplier and the arrival of an engineer on site. A response time of two hours is normal. An average repair time for routine activities can also be laid down in the contract.

Choosing the right moment to carry out maintenance is one of the most important factors determining the success of preservation. Carrying out maintenance too early leads to unnecessary costs, while carrying it out too late leads to loss of functionality or consequential damage.

The management authority should weigh up the extra costs of guaranteed rapid repair against the benefit of restoring functionality. The less essential the part in question is in terms of functionality, the more acceptable a longer response time, or shutdown at weekends, will be. The amount of traffic on the waterway should also be considered, of course.

8.3 Preservation plan

8.3.1 *Purpose of preservation plan*

A preservation plan describes all the factors, measures and costs involved in preserving each object or complex of objects throughout its lifetime, and ensuring it delivers the required performance. In the preservation plan, the waterway management authority will determine the extent to which each part of the system or object meets the requirements and, if it does not, what interventions are necessary, what they will cost and what maintenance and inspection measures will be required over the coming years. The plan must be updated regularly.

The preservation plan is intended for internal use by management organisations, such as *Rijkswaterstaat's* districts. It is also a working document, which can be accessed at all times to find out what needs to happen and when.

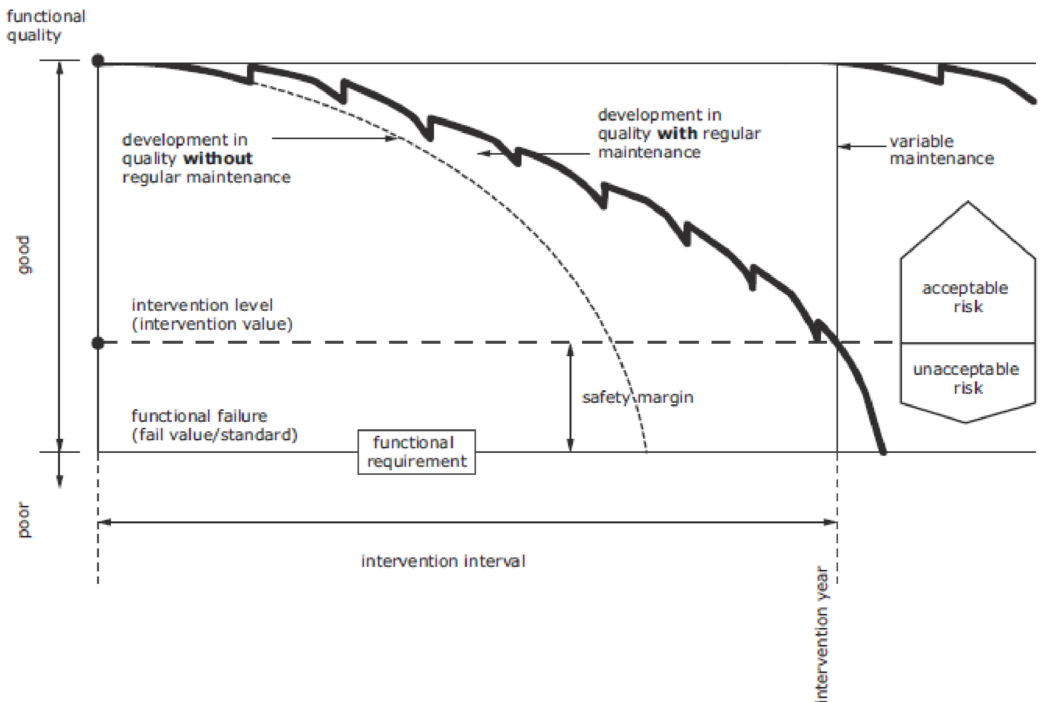

Figure 52: Principle of development in quality, intervention level and maintenance

part	preservation measure	intervention level	frequency of inspection
steel sheet piling	replace planks	thickness in mm	every two years
	stop leak	leak,including sand conveyance	every six months
fill behind sheet piling	top up	even subsidence of > 5 cm or cracks	annually
	mow bank	n.a.	annually
	prune vegetation	visibility (ch. 3)	annually
underwater slope in front of sheet piling	top up gravel in erosion pit	deepening > 20% in height of the sheet piling	at exposed places: every six months
rockfill embankment	top up rockfill	missing stones> 40% holes> 2 m2	annually
stone-faced embankment	groutand/or repair stone facing	missing stones> 40% holes> 2 m2	annually
canal bed	dredge	bottom depth in m – NAP	annually to once every 12 years
river bed	dredge	bottom depth in m – NAP	annually to once every 6 years

Table 56: Some examples of inspection and intervention

8.3.2 *Inspection parameter and intervention level*

If inspection parameters have been defined for each object, a value at which intervention is required will have to be set. This is known as the intervention level. The intervention level may be the same as the functional requirement, or a safety margin may be built in, depending on the local situation, such as in the case of sedimentation in rivers or estuaries (Figure 54). Maintenance improves the quality of the object to such an extent that its proper functioning is guaranteed. Table 56 shows some examples of inspection methods and frequency of inspection. For detailed information on canal and river beds, see ref. 45.

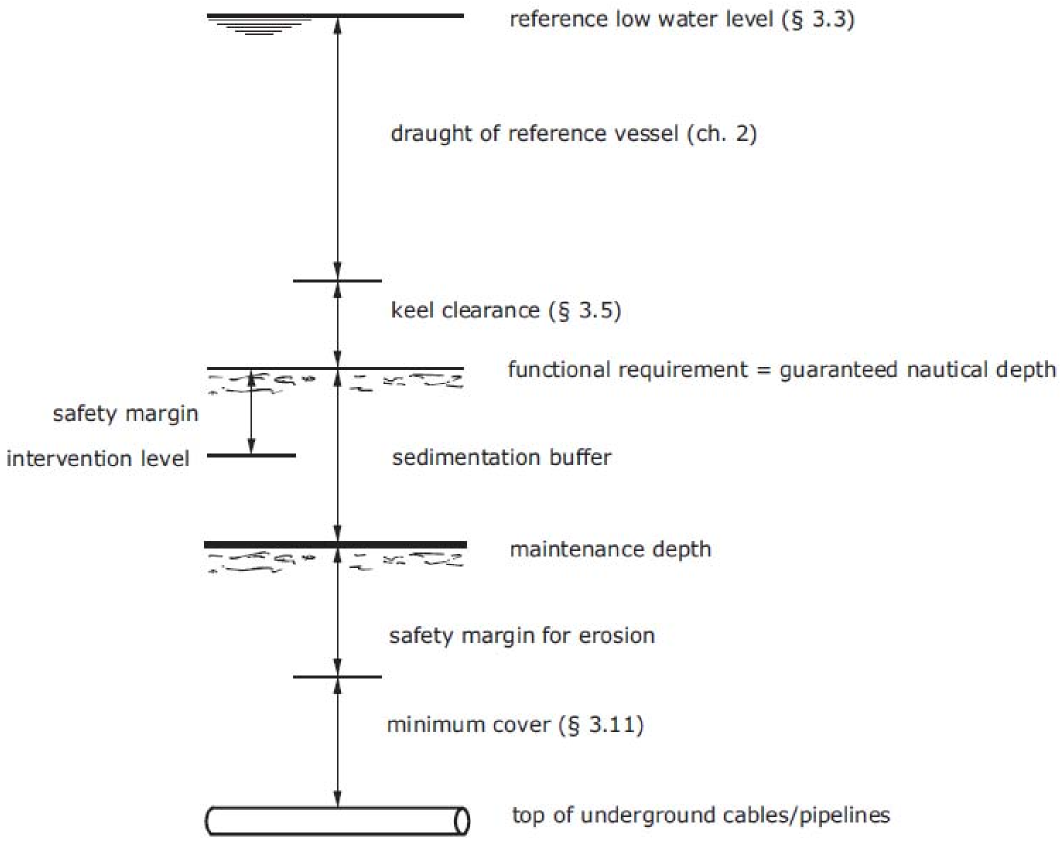

Figure 53: Diagram of waterway bottom

8.3.3 River Management Assessment Framework (RBK)

Rijkswaterstaat uses the River Management Assessment Framework (ref. 69) for the assessment of project plans and permit applications for interventions in river beds. The framework stipulates how morphological effects should be identified. If the effects are not deemed acceptable by the competent authority under the Water Act, the party carrying out the intervention is responsible for optimising the design so that the morphological effects are prevented or minimised. Aspects such as current, cross current and sedimentation in the fairway have a bearing on shipping.

Appendix 7 of the framework provides a guide to determining and presenting the representative (depth-average) cross current and the representative cross current discharge.

8.4 Reducing obstruction

8.4.1 Classes of obstruction

Maintenance work should be carried out in such a way that vessels experience the least or shortest possible obstruction and/or delay, and the safety of navigation remains guaranteed. Timely communication with users is essential. To inform users and other stakeholders in a uniform manner, the degree of obstruction is communicated using one of six classes of obstruction, each with its own notification deadline for stakeholders and waterway users (Table 57). These deadlines also apply to work by third parties and to events licensed by the waterway management authority.

class of obstruc-tion	description of obstruction	notification deadline for stakeholders	notification deadline for waterway users
0	activities that cause no obstruction to shipping	6 weeks	6 weeks
1	limited obstruction, activities necessitate change in behaviour, but cause no substantial delays, e.g. a local ban on overtaking or speed restrictions; delay less than 10 minutes	6 weeks	6 weeks
2	short delay, i.e. less than half an hour	8 weeks	8 weeks
3	delay, up to two hours no more than twice every 24 hours, free passage at other times	8 weeks	8 weeks
4	long delay, up to 48 hours	26 weeks	12 weeks
5	exceptionally long delay, i.e. longer than a consecutive period of 48 hours	52 weeks	26 weeks

Table 57: Classes of obstruction and notification deadlines

Classes 2 to 5 may never occur on trunk routes; classes 3 to 5 may never occur on main waterways.

Some obstruction is unavoidable when maintenance dredging is carried out, even when free sailing dredgers are used. The obstruction should be limited to one location on each waterway. On waterways in classes I, II and III, the obstruction must reasonably comply with the above instructions. Obstruction due to dredging may not exceed that caused by the shallows.

A complete block as a result of maintenance work on engineering structures should be avoided using the measures in the ‘Less Obstruction’ (*Minder Hinder*) programme. If one of the lock chambers at a lock with two or more is out of use, this is not regarded as a complete block, although delays can occur at busy times. The same applies when vessels can still reach their destination via another route, albeit with some delay.

8.4.2 *Less obstruction*

Rijkswaterstaat's 'Less Obstruction' programme (ref. 46) identifies seven universally applicable steps:

1. Clever planning

Maintenance work that leads to a blockage is best performed at night or at quiet times and/or on a shift system. Sometimes a short complete blockage is better than a long period of partial blockage. The waterway management authority must strike a balance between the extra costs of carrying out maintenance work at night or at weekends and the costs to shipping, shippers and shipping agents.

2. Clever design

Measures can be taken at the design stage to reduce obstruction caused by maintenance work, such as lock gates that can be replaced quickly and easily. Standardised design also makes it easier to replace structural elements.

3. Operational traffic management

If some obstruction cannot be avoided, operational traffic management can reduce the impact of the obstruction, by organising single-lane traffic, for example, or encouraging vessels to use alternative routes.

4. Coordinating with stakeholders

It is always necessary to coordinate the times and duration of any blocks with representatives of users and other stakeholders, and to inform the general public in good time. Early coordination enhances acceptance.

5. Regional collaboration

Consultations with other waterway management authorities in the corridor should prevent navigation routes from being blocked unnecessarily often or for unnecessarily long periods, and prevent simultaneous blockages on alternative routes.

6. Targeted information

Targeted information during obstructions, particularly the current delay, allow waterway users to alter their travel plan, and perhaps use an alternative route.

7. Contracts

Maintenance contracts can include financial incentives to reduce the period of obstruction, in the form of a bonus for early delivery or reimbursement of the costs of measures taken to reduce the obstruction, or penalties for exceeding deadlines.

8.4.3 *Managing the impact on safety when work is carried out*

When work is being carried out in or alongside the waterway, it might not conform to its original design temporarily. Safety risks may arise which should be explicitly highlighted – at least within *Rijkswaterstaat* – and managed. Risk management measures are also needed for

- collision and interaction between passing vessels and structures, work vessels and workers

- accident risk to vessels as a result of reduced space for shipping, and restricted lines of sight and reduced visibility of waterway facilities and signs, and work traffic

When conditions on the waterway are non-uniform, it is must be ascertained whether they make navigating the waterway more difficult for users. If this is the case, the waterway management authority must, given its duty of care, provide extra signs and other information for waterway users. Extra supervision might be required to ensure that the work does not have an undesirable impact on safety.

8.4.4 Blockages for events

Partial or complete blockage of the waterway in connection with events is acceptable only in highly exceptional circumstances, after solutions to minimise obstruction to navigation have been sought in consultation with stakeholders. A blockage on a Sunday, for example, will generally be more acceptable than a blockage on a weekday. The duration of the blockage must be kept to a minimum, the start and end defined and, if possible in terms of safety, should not affect the entire width of the waterway. A blockage may then be approved:

- on a trunk route: if the event is of international or exceptional national importance
- on a main waterway: if the event is of national or exceptional regional importance
- on other waterways: if the event is of regional or exceptional local importance

9 Bibliography

The references and background reports listed below can be accessed via *Rijkswaterstaat's Kennisplein* intranet site. Most of them can be downloaded in PDF format.

9.1 References

1. Ministerie van Verkeer en Waterstaat (Ministry of Transport, Public Works and Water Management): *Vaarwegennota - ontwerp*, The Hague 1975

2. Ministerie van Verkeer en Waterstaat (Ministry of Transport and Public Works): *Structuurschema Vaarwegen*, The Hague 1977

3. Commissie van Ingenieurs van den Rijkswaterstaat en van den Provinciale Waterstaat van Noord-Holland, van Zuid-Holland en van Utrecht: *Normalisatie van de Nederlandse vaarwegen in het algemeen en van die in de Hollandse laagvlakte in het bijzonder*, The Hague 1932

4. Commissie Vaarwegen Noorden des Lands: *Afmetingen van de sluizen en bruggen voorkomende in de vaarwegen in de provincies Groningen, Friesland, Drenthe en Overijssel en in de Noordoostpolder*, The Hague 1950

5. PIANC, the World Association for Waterborne Transport Infrastructure: *Standardization of Inland Waterway's Dimensions*, Brussel 1990

6. PIANC, the World Association for Waterborne Transport Infrastructure: *Factors involved in Standardising the Dimensions of Class Vb Waterways (Canals)*, Brussel 1999

7. European Conference of Ministers of Transport (ECMT): *New Classification of Inland Waterways, CEMT/CM(92)6 Final*, Parijs 1992

8. Waterrecreatie Nederland: *Basisvisie Recreatie Toervaart Nederland 2015-2020*, November 2016

9. Rijkswaterstaat Adviesdienst Verkeer en Vervoer: *Classificatie en kenmerken van de Europese vloot en de actieve vloot in Nederland*, Rotterdam 2002

10. Maritime Research Institute Netherlands (MARIN): *Herziening inventarisatie manoeuvreermiddelen*, Wageningen 2008

11. Maritime Research Institute Netherlands (MARIN): *Scheepskarakteristieken van nieuwe grote schepen*, Wageningen 2010

12. Economic Commission for Europe, Inland Transport Committee: *European Recreational Inland Navigation Netwerk*, *Resolution no. 52*, *TRANS/SC.3/164/Rev.1*, Geneva 2004

13. Watersportberaad: *Beleidsvisie Kleine Waterrecreatie Nederland 2001-2020*, Bunnik 2001

14. PIANC, the World Association for Waterborne Transport Infrastructure: *Standardization of Ships and Inland Waterways for River/Sea navigation*, Brussel 1996

15. Ministerie van Verkeer en Waterstaat (Ministry of Transport, Public Works and Water Management): *Nota Mobiliteit, naar een betrouwbare en voorspelbare bereikbaarheid*, The Hague 2004

16. Ministerie van Verkeer en Waterstaat (Ministry of Transport, Public Works and Water Management): *Varen voor een vitale economie, een veilige en duurzame binnenvaart*, The Hague 2007

17. Economic Commission for Europe, Inland Transport Committee: *European Agreement on Main Inland Waterways of International Importance (AGN)*, *ECE/TRANS/120*, Genève 1996

18. Ecorys & Euromapping: *Classification of European recreational waterways, maps and current recreational waterways*, Rotterdam 2006

19. Ministerie van Verkeer en Waterstaat (Ministry of Transport, Public Works and Water Management): *Beleidslijn voor de invoering van scheepvaartbeperkingen of stremming bij hoogwater op de Rijn en de Maas*, The Hague 1999

20. CUR Onderzoekcommissie C59: *Natuurvriendelijke oevers*, Gouda 1994

21. Rijkswaterstaat Dienst Weg- en Waterbouwkunde : *Faunauitstapplaatsen*, DWW wijzer 1995 nr. 67

22. Rijkswaterstaat Dienst Verkeer en Scheepvaart: *Richtlijnen Scheepvaarttekens*, Rotterdam 2008

23. Rijkswaterstaat Adviesdienst Verkeer en Vervoer: *De langs de vaarwegen benodigde vrije ruimte*, Rotterdam 2004

24. Ministerie van Verkeer en Waterstaat (Ministry of Transport, Public Works and Water Management): *Circulaire risiconormering vervoer gevaarlijke stoffen*, The Hague 2010

25. Ministerie van Verkeer en Waterstaat (Ministry of Transport, Public Works and Water Management): *Beleidsregel voor het plaatsen van windturbines op, in of over rijkswaterstaatswerken*, The Hague 2001

26. Rijkswaterstaat Bouwdienst: *Ontwerp van schutsluizen*, Utrecht 2000 (2 delen)

27. Rijkswaterstaat Bouwdienst: *Advies Richtlijnen Afmeervoorzieningen*, Utrecht 2004

28. Rijkswaterstaat Bouwdienst: *IJsbestrijding bij kunstwerken*, Utrecht 2000

29. Rijkswaterstaat Dienst Verkeer en Scheepvaart: *Handboek ijsbestrijding vaarwegen 2010*, Delft 2010

30. Rijkswaterstaat Adviesdienst Verkeer en Vervoer: *Radarhinder van bruggen voor scheepvaart*, Rotterdam 2000

31. Rijkswaterstaat Dienst Verkeer en Scheepvaart: *Corporate uitvoeringskader ligplaatsen RWS*, Delft 2011

32. Koninklijke Schippersvereniging Schuttevaer: *Binnenvaarthavens, inventarisatie van inrichtingsaspecten*, Rotterdam 1996

33. Nationale Havenraad: *Richtlijn walstroom binnenvaart*, The Hague 2009

34. PIANC, the World Association for Waterborne Transport Infrastructure: *Guidance on facility and management specification for marine yacht harbours and inland waterway marinas with respect to user requirements*, Brussel 1991

35. PIANC, the World Association for Waterborne Transport Infrastructure: *Disability Access Guidelines for Recreational Boating Facilities*, Brussels 2004

36. Rijkswaterstaat Dienst Verkeer en Scheepvaart: *Basisbeschrijving werkproces bediening en werking schutsluis en beweegbare brug*, Delft 2011

37. Rijkswaterstaat Dienst Verkeer en Scheepvaart: *Zicht bij bediening van beweegbare bruggen en schutsluizen*, Delft 2011

38. Rijkswaterstaat Dienst Verkeer en Scheepvaart: *Veilig stoppen van landverkeer bij brugopeningen*, Delft 2011

39. Rijkswaterstaat Dienst Verkeer en Scheepvaart: *Uniform MMI ontwerp voor (centrale) bediening van beweegbare bruggen en sluizen*, Delft 2011

40. Rijkswaterstaat Dienst Verkeer en Scheepvaart: *Taken, verantwoordelijkheden en bevoegdheden van bediening van beweegbare bruggen en schutsluizen*, Delft 2011

41. Rijkswaterstaat Dienst Verkeerskunde: *Bedieningsplan sluizen en bruggen Rijksvaarwegen*, Rotterdam 1991

42. PIANC, the World Association for Waterborne Transport Infrastructure: *Guidelines and Recommendations for River Information Services*, Brussels 2004

43. Ministerie van Verkeer en Waterstaat: *Beheer- en ontwikkelplan voor de Rijkswateren 2010-2015 (BPRW), werken aan een robuust watersysteem*, The Hague 2009

44. Rijkswaterstaat WVL: *Referentiekader Beheer en Onderhoud (RBO)*, Rijswijk 2015

45. Rijkswaterstaat Waterdienst: *Informatiebehoefte en programmering bodemhoogte (HWS en HVWN)*, Lelystad 2011

46. Rijkswaterstaat Dienst Verkeerskunde: *Werkwijzer MinderHinder*, Delft 2011 (2 parts)

47. Rijkswaterstaat Dienst Verkeer en Scheepvaart: *Topkader gebruik, bediening en besturing schutsluis en beweegbare brug Rijkswaterstaat*, Delft 2013.

48. Rijkswaterstaat Dienst Verkeer en Scheepvaart: *Stop en noodstop bij beweegbare bruggen en sluizen*, Delft 2013.

49. Ministers van I & M resp Veiligheid (Minister of Infrastructure & Water Management and Minister of Justice & Security: *Besluit algemene regels ruimtelijke ordening (Barro)*, The Hague, 22-8-2011.

50. Staatssecretaris V&W resp. Minister van Justitie (State Secretary for Transport, Public Works & Water Management and Minister of Justice): *Wet van 29 januari 2009, houdende regels met betrekking tot het beheer en gebruik vanwatersystemen (Waterwet)*, The Hague, 2009.

51. Marin: *Uitbreiding Richtlijnen Vaarwegen – fase 1*, Wageningen, January 2013.

52. Marin: *Uitbreiding Richtlijnen Vaarwegen – fase 2*, Wageningen, February 2013.

53. Rijkswaterstaat Water, Verkeer en Leefomgeving: *Supplement Richtlijnen Vaarwegen 2011*, Delft, November 2013.

54. Marin: *Versobering remmingwerken in de voorhavens van sluizen*, Wageningen, december 2014.

55. Ministerie I&M (Ministry of Infrastructure and the Environment): *Structuurvisie Infrastructuur en Milieu*, The Hague 2012.

56. Deltares: *Gronddekking op kabels en leidingen in Rijkswateren*. Delft, 2014.

57 Minister I&M (Minister of Infrastructure and the Environment): *Wijzigingswet Wet vervoer gevaarlijke stoffen, enz. (Wet basisnet)*, The Hague, 2013.

58. Staatssecretaris I&M (State Secretary for Infrastructure and the Environment): *Regeling basisnet*, The Hague, 2016.

59. Minister I&M (Minister of Infrastructure and the Environment): *Beleidsregels EV-beoordeling tracébesluiten*, The Hague, 2015.

60. Rijkswaterstaat West-Nederland Zuid: *Beleid verlenen ontheffingen voor ligplaatsen Binnenvaartpolitiereglement en Rijnvaartpolitiereglement 1995*, Staatscourant Nr. 46267, 17-12-2015.

61. TNO: *Effecten van windturbines op binnenvaartscheepsradars - Een voorstel tot een nieuwe nationale regelgeving*, The Hague, 18-07-2016.

62. Rijkswaterstaat Dienst Verkeer en Scheepvaart: *Rapportage containerhoogtemetingen*, Delft, May 2013.

63. Rijkswaterstaat Water, Verkeer en Leefomgeving: *MKBA aanpassing doorvaarthoogte kunstwerken*, Rijswijk, May 2016.

64. Rijkswaterstaat Water, Verkeer en Leefomgeving: *Richtlijnen Vaarwegen – Rivieren, Onderzoeksagenda*, Deltares report no. 1210586-000-ZWS-0013, Delft, 10 November 2015.

65. Rijkswaterstaat Water, Verkeer en Leefomgeving: *Richtlijnen Rivieren – Fase 1.2, MARIN Eindrapport* Nr. 29242-2-MSCN-rev.2, 8 December 2016.

66. Rijkswaterstaat Water, Verkeer en Leefomgeving: *Interactie beladingsgraad – vaarwegprofiel, MARIN memo* 29242.601_memo_v2, 24 November 2017.

67. Rijkswaterstaat Water, Verkeer en Leefomgeving: *Richtlijnen Rivieren – Windtoeslag, MARIN Eindrapport* Nr. 29242-4-MSCN-rev.2, 15 December 2017.

68. Rijkswaterstaat Water, Verkeer en Leefomgeving: *Referentievlakken en stroomklassen, MARIN Report No.* 29242.600-1-MSCN-rev.2, 2 December 2016.

69. Rijkswaterstaat Water, Verkeer en Leefomgeving: *Rivierkundig Beoordelingskader voor ingrepen in de Grote Rivieren*, Version 5, 4 June 2019.

70. Rijkswaterstaat Water, Verkeer en Leefomgeving: *Richtlijnen Rivieren – Dwarsstroomcriteria en Stroomtoeslagen Bochten, MARIN Report* No. 29242-5-MSCN-rev.3, 24 April 2018.

71. PIANC World Congress: *Modeling and Simulating Traffic Flow on Inland Waterways*, Fisher, N., Treiber, M., Söhngen, B., , San Fransico, 2014.

72. University of Alberta, Dept. of Civil Engineering: *A study of flow in curved open channels*, Yee-Chung, J., , 1990.

73. Rijkswaterstaat Water, Verkeer en Leefomgeving*: Richtlijnen Rivieren – Fase 1.3, MARIN Final report* No. 29242-3-MSCN-rev.2, 14 December 2016.

74. Rijkswaterstaat Water, Verkeer en Leefomgeving: *Richtlijnen Rivieren – Splitsingspunten, MARIN Report No*. 29242-8-MSCN-rev.2, 6 december 2018.

75. Rijkswaterstaat Water, Verkeer en Leefomgeving: *Richtlijnen Rivieren – Dwarsstroomgradiënten, MARIN Report No.* 29242-9-MO rev.2, 17 December 2019.

76. Rijkswaterstaat Water, Verkeer en Leefomgeving: *Richtlijnen Rivieren – Vormgeving van en inrichting rond stuwen, MARIN Report No.* 29242-10-MO-rev.2, 12 December 2019.

77. Rijkswaterstaat Water, Verkeer en Leefomgeving: *Richtlijnen Rivieren – Crossings, MARIN Report No.* 29242-11-MO-rev.02, 13 December 2019.

78. Rijkswaterstaat Water, Verkeer en Leefomgeving: *Uitkomsten project Vaarwegbeeld Sluis & Stuw Complexen*, memo, 28 May 2018.

79. Centrale Commissie voor de Rijnvaart: *Minimumeisen en aanbevelingen voor de technische uitvoering van werken aan de Rijn*, Straatsburg, 19 October 2016.

80. Rijkswaterstaat Water, Verkeer en Leefomgeving: *MKBA doorvaarthoogte kuntswerken in relatie tot containervaart - Een verdiepende analyse*, 22 July 2018.

81. Minister I&W: *Kamerbrief Vervolg Kosten-batenanalyse brughoogtes (4 kansrijke vaarwegcorridors)*, The Hague, 6 June 2019.

82. Koninklijk Nederlands Meteorologisch Instituut: *Klimaatscenario's voor Nederland*, De Bilt, 2014.

83. Centrale Commissie voor de Rijnvaart: *Herziene Rijnvaartakte*, Mannheim, 17 October 1868.

84. Centrale Commissie voor de Rijnvaart: *Procedure voor bepalen van voorwaarden en verplichtingen voor bouwerken aan de Rijn in het kader van de Centrale Commissie voor de Rijnvaart*, Straatsburg, 8 december 2016.

85. Koninklijke Nederlandsche Roeibond*: Handboek Roeiaccomodaties – Normen en aanbevelingen*, versie 2.2, Amstelveen, June 2017.

86. Centrale Commissie voor de Rijnvaart, Werkgroep I&M: *Basis voor het bepalen van de behoefte aan ligplaatsen en rusthavens aan de Rijn*, 19 September 2019.

87. Rijkswaterstaat Directie Gelderland: *Een toekomstvisie voor de Waal als hoofdtransportas*, Nota I Interimerapportage, Arnhem 1990.

88. Rijkswaterstaat Water, Verkeer en Leefomgeving: *Richtlijnen Rivieren – Bruggen*, *MARIN Report No*. 29242-12-MO-rev. 3, April 2020.

89. Rijkswaterstaat Water, Verkeer en Leefomgeving: *Richtlijnen Rivieren – Interim Richtlijnen*, *MARIN Report No*. 29242-7-MSCN-rev. 3, November 2018.

9.2 Backgroud reports

Stichting Projecten Binnenvaart: *Containerbinnenvaart 2010*, Rotterdam 2011

PIANC, the World Association for Waterborne Transport Infrastructure: *Innovations in navigation lock design*, Brussels 2009

Rijkswaterstaat Adviesdienst Verkeer en Vervoer: *Bedienen op afstand van bruggen en sluizen*, *bouwstenen voor vorming en inrichting van bediencentrales*, Rotterdam 2002

Rijkswaterstaat Adviesdienst Verkeer en Vervoer: *Functionele eisen hoofdvaarwegen*, Rotterdam 1999

Rijkswaterstaat Adviesdienst Verkeer en Vervoer: *Kolkhoogte en schorthoogte van de tweede sluis Lith*, January 1994

Sdu Uitgeverij: *Vervoer gevaarlijke stoffen over de binnenwateren VBG/ ADNR*, The Hague 1994

Waterloopkundig Laboratorium: *Klasse V vaarwegen; dwarsprofielen, richtlijnen voor afmetingen en vormgeving; deel VI*, *Eindrapport*, April 1994

Waterloopkundig Laboratorium: *Klasse V vaarwegen; sluizen, richtlijnen voor afmetingen en vormgeving; deel IX, Interim rapport*, April 1993

Rijkswaterstaat Adviesdienst Verkeer en Vervoer: *Radarhinder van hoogspanningsleidingen; notitie 93.310*, Rotterdam, October 1993

Waterloopkundig Laboratorium: *Breedte van klasse V vaarwegen; manoeu-vreereigenschappen van klasse V schepen; inventarisatie van meetgegevens van de Commissies van Onderzoek*, part I, November 1991

Waterloopkundig Laboratorium: *Breedte van klasse V vaarwegen; invloed van vaarwegbreedte op verkeerssituaties en reistijd; simulaties en berekeningen*, November 1991

Waterloopkundig Laboratorium: *Breedte van klasse V vaarwegen; invloed van dwarsstroom op de vaarstrookbreedte; band A en B; deel IV, verslag onderzoek*, November 1991

Waterloopkundig Laboratorium: *Breedte van klasse V vaarwegen; dimen-sionering van de bermstrook op basis van scheepsbestuurbaarheid; verslag bureaustudie, deel V*, November 1991

Commissie Vaarwegbeheerders: *Richtlijnen voor de afmetingen en vormgeving van vaarwegen en bruggen voor de recreatievaart*, June 1990

Werkgroep Sluizen van de Commissie Vaarwegbeheerders: *Richtlijnen en aanbevelingen voor de afmetingen, vormgeving en inrichting van sluizen van de CEMT-klassen I t/m IV; Eindrapport*, September 1990

Commissie Vaarwegbeheerders: *Richtlijnen voor de afmetingen en vorm-geving van vaarwegen van de CEMT-klassen I t/m IV*, April 1987

Werkgroep Vaarwegvakken van de Commissie Vaarwegbeheerders: *Dimensionering van bochten en nevenaspekten, deelrapport IV*, February 1986

Werkgroep Rooilijnen Vaarwegen: *Rooilijnen vaarwegen*, April 1985

Commissie Vaarwegbeheerders: *Richtlijnen voor de afmetingen en vormgeving van vaste en beweegbare bruggen over vaarwegen van de CEMT klassen I t/m IV*, March 1985

Werkgroep Vaarwegvakken van de Commissie Vaarwegbeheerders*: Normen voor het dwarsprofiel van rechte vaarwegvakken van de klasse I...IV, deelrapport III*, May 1982

Werkgroep Bruggen van de Commissie Vaarwegbeheerders*: Invloed van het disconteringspercentage bij de bepaling van de optimale doorvaartwijdte van beweegbare bruggen; Nota S 82.15.01*, February 1982

Werkgroep Bruggen van de Commissie Vaarwegbeheerders: *Basisonderzoek nautische richtlijnen CEMT-klassen I t/m IV; Nota S 77.47.4*, December 1981

Rijkswaterstaat, werkgroep HOBU: *Rapport hoogspanningslijnen, pijpleidingen en kabels in en nabij Rijkswerken*, Utrecht, September 1981.

Werkgroep Vaarwegvakken van de Commissie Vaarwegbeheerders: *Verslag inventarisatie van bestaande Nederlandse vaarwegen van de klassen I...IV*, March 1980

Rijkswaterstaat Dienst Verkeerskunde: *De bevaarbaarheid van de vaarweg Maastricht-Weurt voor tweebaksduwstellen*, June 1980

Commissie Vaarwegbeheerders: *Maatgevende schepen ten behoeve van richtlijnen vaarwegen CEMT-klassen I t/m IV*, July 1980

Rapport Onderzoek remmingwerken Zeeland. RWS-DVS, July 2011

10 Appendices

10.1 Symbols

Where applicable, the symbols comply with Council Directive 82/714/EEC and the amendment thereto of April 1998.

Symbol	*Unit*	*Description*
A	m^2	diameter of inlet or outlet
B	m	beam of reference vessel
B_k	m	chamber width
B_r	m	distance between the line of the chamber wall and the fender
B_{vs}	m	width of traffic lane
C	-	constant for bend widening, for example
D	m	waterway depth relative to reference water level
E_h	lux	illumination of horizontal surfaces
E_v	lux	illumination of vertical surfaces
F	kN	hawser force
H	m	height above waterline of reference vessel
H_B	m	headroom relative to reference water level
L	m	length of reference vessel; for coupled units: total length of unit
L_f	m	funnel length
L_k	m	chamber length
L_o	m	length of line-up area
L_r	m	length of straight section of funnel to lock head

L_{uit}	m	run-out zone
L_w	m	length of waiting area
Q	m^3/s	cross current discharge
R	m	bend radius
s	m	spare headroom
S	m	width of safety strip
T	m	draught of laden reference vessel
T_b	m	draught of unladen reference vessel
v_c	m/s	cross current flow
W	m	width of fairway at average water level
W_d	m	bottom width
W_t	m	width in keel plane of reference vessel
W_u	m	width of outflow
α	°	tangent of transition curve
ß	°	bow angle
γ	°	angle between intersecting pipeline and waterway axis
Δ_b	m	bend widening
Δ_i	m	high-volume increment
Δ_w	m	side wind increment

10.3 Abbreviations

ADN(R)	Regulations for the Carriage of Dangerous Substances on the Rhine
AIS	Automatic identification system
AGN	European Agreement on Main Inland Waterways of International Importance
ARBO	Working Conditions Act
AVMS	Vessel Traffic Management Advisory Group
AVV	RWS Transport Research Centre
BON	Basic maintenance level
BPR	Inland waterways police regulations
BPRW	National Waterways Management Plan
BRTN	Basic Blueprint for Recreational Touring in the Netherlands
CCD	Charge-coupled device
CCNR	Central Commission for the Navigation of the Rhine
CEMT	Conférence Européenne des Ministres de Transports
CEN	Comité Européen de Normalisation
CEVNI	Code Européen des Voies de Navigation Intérieure
CVB	Waterway Management Authorities Committee
DGLM	Directorate-General for Aviation and Maritime Affairs
DRIP	Dynamic Route Information Panel
DVS	RWS Centre for Transport and Navigation
ECE	United Nations Economic Commission for Europe
ENW	Expertise Network on Flood Protection
EU	European Union
GPO	Centre for Major Projects and Maintenance (part of *Rijkswaterstaat*)
GPS	Global positioning system
IALA	International Association of Lighthouse Authorities
KGA	Small-scale hazardous waste
LAT	Lowest Astronomical Tide
LCC	Life-cycle costs
LED	Light-emitting diode
MHWS	Reference high water level for shipping
MLWS	Reference low water level for shipping
NAP	Amsterdam Ordnance Datum
NEN	Dutch standard
OBR	Object management regime
OLR	Agreed low river level
OLW	Agreed low water level
PAE	Private car units
PIANC	World Association for Waterborne Transport Infrastructure
RIS	River Information Services

RPR	Rhine Police Regulations
RVV	Traffic Rules and Signs Regulations
RVW	Waterway Guidelines
RWS	Rijkswaterstaat, the Directorate-General for Public Works and Water Management
SAV	CDNI Shipping Waste Treaty
SIGNI	Signalisation des Voies de Navigation Intérieure
SIVAK	Simulated traffic handling at civil engineering structures
SLA	Service level agreement
SVIR	National Policy Strategy for Infrastructure and Spatial Planning
SVV	Transport Structure Plan
TAW	Technical Advisory Committee on Flood Defences
TEU	Twenty-foot equivalent units
VHF	Very high frequency
VOBB	Regulations on the design of movable bridges
VWS	Advance warning phase
WVL	Centre for Water, Transport and Environment (part of *Rijkswaterstaat*)

10.4 Definitions

admissions policy
The entire body of measures and requirements that determine the conditions under which the waterway management authority admits a vessel to a particular waterway.

agreed low river level (OLR)
River level that is not exceeded on 20 days on which the temperature is above zero, i.e. that occurs approximately 5% of the time.

agreed low water level (OLW)
The chart datum on the lower reaches of the river determined in such a way that it represents a smooth transition from the LAT (Lowest Astronomical Tide) at Hoek van Holland to the OLR.

availability requirements
These requirements determine whether an object can be used safely, i.e. whether it is available for use. It is vital that availability requirements be defined in order to determine intervention levels and management measures.

beacon line
Line of beacons along the ends of groynes or beacons along a stretch of riverbank.

'brown fleet'
See: charter traffic

car boarding facility
A mooring place specially equipped and solely intended for loading or disembarking a car.

cargo capacity
The maximum load that may be transported by a vessel.

CEMT classification
Categorisation of inland navigation vessels into a limited number of standard types, drawn up by the Conférence Européenne des Ministres de Transports (CEMT), as last adopted in 1992.

Central Commission for the Navigation of the Rhine (CCNR)
International administrative body based in Strasbourg, charged with preserving the free and safe navigation of the Rhine and its distributaries, pursuant to the Mannheim Convention (1868). On Dutch territory, the Convention applies to the Rhine, the Waal, the Nederrijn, the Lek and the Pannerden Canal.

chamber length
The effective chamber length is the distance between the stop lines in a lock chamber.

charter navigation

Former commercial vessels that have been recommissioned. This includes both charter boats and the biggest category of pleasure craft in private ownership. Also often referred to as the 'brown fleet'.

conventional Rhine
The Rhine and its distributaries, in so far as they are covered by the Rhine Police Regulations; in the Netherlands this includes the Rhine, Waal, Lek, Nederrijn ('Lower Rhine') and the PannerdenCanal.

corridor
Set of waterways that start and end at the same point.

coupled unit
Motorised cargo vessel attached to a cargo vessel positioned alongside or in front, or to one or more push barges.

eccentricity
The eccentricity of a passage opening is the distance between the axis of the waterway and the axis of the bridge opening.

fairway
The part of the navigation area that is kept at a guaranteed width and depth for through shipping.

fairway bottom
The base area of a river, canal, lake, harbour etc. lying below the water surface, excluding the slopes of the bank.

fender
Structure alongside the line-up area and waiting area, intended for mooring vessels.

fixed points
Fixed points are points in the cross-section of a waterway that define the required minimum passage profile.

free zone
Strip alongside the waterway that must be kept free of buildings and vegetation, in order to maintain the function of the waterway.

function
The designated and therefore desired use of a water system and objects located within it.

functional requirements
Requirements imposed on the design of a water system or managed object in order for it to fulfil its usage functions and to translate them into quality requirements (including technical specifications).

groyne line
An imaginary line running over the groyne heads, at a certain flow rate, generally the mean flow rate.

guide fender
Funnel-shaped structure positioned at the head of a lock or before a bridge to provide both mechanical and visual guidance for sailors entering the lock chamber or passing under the bridge.

hazardous goods vessel
Vessel that can be seen to be carrying hazardous goods because it is flying 1, 2 or 3 mandatory blue triangles (or signal lights at night).

headroom
Headroom is the vertical separation between the reference high water level and the underside of any full laden object spanning the waterway, such headroom being available for vessels at all times.

height above waterline
The height of a vessel above the waterline is the vertical distance between the waterline and the highest point of the stationary vessel, with all easily lowered items (radar, masts, antennas, flagpole, etc.) lowered as far as possible.

high cube container
Container with a height of 2.90 m, and thus taller than the standard container, which is 8½ feet or 2.60m in height.

holding time
Period that starts when the entrance gates of the lock close and ends when the transit time for the vessel in question begins.

Inland waterways police regulations (BPR)
System of traffic regulations applying to public inland waterways in the Netherlands, in so far as they are not subject to the Rhine Police Regulations (RPR).

intervention level
The borderline between acceptable and unacceptable risk in terms of loss of function, i.e. the threshold at which the system (or system component) no longer complies with the functional requirements.

keel clearance
Smallest distance between the underside of a vessel's keel plane and the top of the barrier, lock floor or waterway bed. Gross keel clearance: when the vessel is stationary. Net keel clearance: when the vessel is moving

keel plane
The keel plane is the imaginary horizontal plane tangential to the part of the vessel that is deepest underwater.

line-up area
Mooring area at a lock where vessels must wait for the next passage.

lock passage water level
Maximum lock passage water level: water level above which passage is no longer permitted.
Minimum lock passage water level: water level below which passage is no longer permitted.
To be determined by the waterways management body.

Lowest Astronomical Tide (LAT)
The minimum low water level forecast in the current hydrological conditions.

main waterway
Waterway along which more than 5 million tonnes of freight or 25,000 TEU per year are transported. They include key waterways and other main waterways.

management
Being responsible for and ensuring enforcement or achievement of a predetermined level of quality in the object or function managed.

management plan
The management plan presents a clear picture of the management process, both for the organisation concerned and for third parties.

minimum capacity lock
A lock complex consisting of a single chamber that is able to accommodate one reference vessel at a time.

mooring
Place where a vessel can moor up.

motorboat
A pleasure craft designed and equipped to be propelled virtually exclusively by its own engine or engines.

motorboat route (M route)
A navigational route intended for motorboat traffic and for which motorboats are the reference vessel.

navigation area
The part of a waterway that can actually be used for navigation.

network
See: waterway network.

open waterway
An open waterway is a waterway with headroom of 30 metres or more, intended for tall cargoes or for sailing vessels with raised masts.

overnight stay area / harbour
Mooring or harbour where vessels can stay overnight. These are berths or harbours that are not intended for the transhipment of goods.

passage time
The time a vessel requires to pass through a lock, comprising the waiting time plus the transit time and any holding time.

passage width
The passage width is the smallest width under a bridge or in a lock that remains fully usable by the reference vessel at the reference water level, measured perpendicular to the direction of travel.

permitted navigation area
Area that a commercial vessel may navigate on the basis of its tonnage certificate.

push barge
A lighter with no independent means of propulsion, other than a limited capacity for steering, which is designed to be pushed by tugs.

push boat
Motorised vessel that is intended only for push barges, i.e. not able to transport a load of its own.

pushed convoy
Composite unit of a push boat plus one or more barges.

quay
Moorings situated parallel to the waterway.

radar-blind zone
The area in which it is not possible to detect vessels and other objects in the water sufficiently well due to the presence of a bridge over the waterway.

raised mast route
Designated route along waterways with a minimum headroom of 30 m, intended for sailing boats with a raised mast and other high vessels.

recreational craft
A vessel that is suitable for a trip lasting one or more days beyond the immediate vicinity of its home harbour.

recreational navigation
Water-based recreation or water sports using pleasure craft.

reference high water level (MHWS)
The reference high water level for commercial traffic is the water level that is exceeded on average only 1% of the time, measured over at least ten years. The norm is 2% for recreational craft in the warmest half of the year.

reference low water level (MLWS)
The reference low water level for commercial traffic is the water level that is not exceeded on average only 1% of the time, measured over at least ten years. The norm is 2% for recreational craft in the warmest half of the year.

reference vessel
The largest vessel that is able to navigate the waterway in question smoothly and safely, which determines the CEMT classification of the waterway and engineering structures located in and along it. The waterway management body defines the dimensions of the reference vessel.

Rhine Police Regulations (RPR)
System of traffic regulations applicable to the waters covered by the revised Rhine Navigation Treaty (the Mannheim Convention), as drawn up by the CCNR.

run-out zone
Transitional zone between the normal waterway passage profile and the holding basin, which must be free of obstacles such as bridge piers and harbour entrances.

sailing boat
A pleasure craft that is designed and equipped for propulsion by wind power.

sailing boat and motorboat route
A navigational route intended for sailing boat and motorboat traffic and for which sailing boats and motorboats are the reference vessels.

sheltered waters
All Dutch inland waters, with the exception of the major Delta waters, IJsselmeer/Markermeer lake and the Wadden Sea.

shipping lane
Part of the waterway intended for vessels travelling in one direction. Fairways generally have two lanes; at places where there are high volumes of traffic there will be more.

shoreline
The shoreline is the line dividing water and land, also known as the waterway edge.

shoreline (theoretical)
The theoretical shoreline is the imaginary continuation of the shoreline of the adjacent stretch of waterway at places where the passage has been locally widened, for example at a wharf.

sill depth
The shallowest point of the sill between the lock heads.

small-scale water sports
Water sports using relatively small vessels (canoes, rowing boats, surfboards and sailing and motorised vessels shorter than approx. 5 m).

spare headroom
The spare headroom is the safety margin between the top of the reference vessel and the underside of the bridge.

target
Concrete, measurable objective.

towed vessel
Cargo ship with no independent means of propulsion.

trunk route
Main waterway that connects a major sea port with the international hinterland.

turning basin
A turning basin is a circular widening of the waterway or harbour where vessels can turn.

Twenty-foot equivalent units (TEU)
Standard container that is 20 feet long, 8 feet wide and 8½ feet high. The TEU is used as a calculation unit for the capacity of container ships and to indicate the scale of container transport.

waiting area
Mooring area at a lock where vessels heading into the lock that are unable to go with the next passage are able to moor and wait.

waiting place
Place where a vessel can moor for a short period while waiting for passage through a lock, a bridge to open, or for loading and unloading.

waiting time
The period that starts when the vessel arrives at the lock and/or moors at the fender, ending when the transit time or holding time starts.

waiting vessel
A vessel that cannot go with the first passage after its arrival at a lock and must therefore wait one cycle.

water system
A geographically defined contiguous system of surface waters, groundwater, beds, banks and technical infrastructure, including the ecological systems present there, plus all associated physical, chemical and biological features and processes.

waterway
Any waterway that is open to public use by shipping.

waterway class
The waterway class indicates the largest standard craft (according to the CEMT classification) that can navigate the waterway smoothly and safely.

waterway depth
The waterway depth is the vertical distance between the reference low water level for shipping and the highest point of the waterway bed, measured along the axis of the waterway.

waterway marking
The use of marker objects such as buoys and beacons to indicate the route of the fairway, or to mark obstacles or hazards in the fairway.

waterway network
An entire set of interconnected waterways.

waterway profile
The waterway profile is the part of the cross-section of a waterway that is freely available for shipping traffic to use.

waterway upgrade
Making the waterway and the engineering structures associated with it suitable for vessels in a higher CEMT classification.

wharf
Moorings situated parallel to the waterway, intended for the loading or unloading of cargo.

yacht lock
Lock primarily intended for the passage of recreational craft. Can also be used by (small) commercial vessels if necessary.