Living with Flood Risk
in a Changing Climate

FLOWS report WP3Ciii-3

Multi objective flood defence plan, River Isi, Vøyenenga

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Interreg North Sea Region

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FOREWORD

This report is Bærum Municipality's contribution to the FLOWS Interreg Project (Flood-plain Land-use Optimising Workable Sustainability), Work Package 3Ciii, which deals with land-use in flood-prone areas. This EU project for the North Sea Region includes participants from the UK, the Netherlands, Germany, Sweden and Norway. On the Norwegian side, the Norwegian Water Resources and Energy Administration (NVE) is acting as project coordinator, and other members include the University of Oslo, the Hedmark County Governor, Hedmark County Council, Åsnes Municipality and Bærum Municipality. The project maintains its own Internet site: www.flows.nu.

This report has been drawn up by Siv Kjeldsen (Dept. of Water Supply and Sewerage) and Ole Roger Lindås (Dept. of Area Planning) in Bærum Municipality. Expert input to the report has been provided by Hallvard Berg and Sigrid Langsjøvold (NVE). Terje Hansen (Dept. of Area Planning), Odd Arne Smedstad (Dept. of Water Supply and Sewerage), Knut Bjarne Sætre (Dept. of Area Planning) and Morten Merkesdal (Dept. of Nature and Sports Management). Øyvind Høidal of the Norwegian Geotechnical Institute performed the hydrological analyses.

SUMMARY

This report forms Bærum Municipality's contribution to FLOWS WP 3Ciii, which deals with land-use in flood-prone areas. The Bærum demonstration project focuses on alternative means of providing flood protection for an industrial area in Vøyenenga. FLOWS is part of the EU Interreg IIIB programme, which is funded by the EU Structural Fund and which is intended to stimulate sustainable development in the North Sea region. Much of the building mass in the lower part of the River Isi's catchment is prone to flooding. Some of these buildings lie very close to the river, making it difficult in some places to build tradition flood barriers between them and the river. The River Isi is a protected river and is an extremely important spawning and nursery ground for sea trout and salmon. Conservation of the riverbank vegetation on the Isi is important as a means of ensuring the survival of these fish stocks.

Most floods in this river take place in the autumn, but spring floods also occur.

The floods develop extremely rapidly, because the catchment is small (70 square kilometres) and steep, includes rather little lake surface and has a poor retention capacity. Among the areas most liable to flooding is Vøyenenga. Within the Vøyenenga flood protection planning area, the estimated water levels of 200-year floods are two to three metres above normal levels.

Bærum Municipality is positive to the proposal to reduce the number of security classifications in new planning and development guidelines in flood hazard zones near rivers. The change would mean that the security requirement for dwelling-houses and weekend cabins would be raised from a 100-year to a 200-year level. However, we are critical to the suggestion that the security level for "small garages" should be lowered

from 50-year to 20-year floods, since many garages contain expensive cars and provide storage for various types of equipment. If the security classification for garages is lowered, it should be left open to individual municipalities to impose stricter requirements.

The report sheds light on the possibilities that are available to local authorities for controlling area use in the planning area. A number of alternative means of flood protection are described and discussed. These are as follows:

Alternative 0: no new flood protection measures
Alternative 1: embankments or walls for flood protection
Alternative 2: protecting building facades
Alternative 3: raising the ground level
Alternative 4: widening the river and lowering the ground level within the flood zone
Alternative 5: laying a new river course in the open air or in a tunnel.

Two of these have been identified as being the most relevant.

The first of these is Alternative 1: embankments or walls for flood protection. This is in accordance with the flood protection plan of NVE and Bærum Municipality, and is an alternative that would provide adequate flood protection within about two to five years. The draft plan that has been presented to the property-owners concerned needs to be modified so that less industrial area would be affected, for example by reducing the width of the top of the embankment from four to two metres.

More extensive use of walls would also be desirable where the distance to the river is short and the vegetation belt needs to be conserved. Hydrological analyses suggest that there is no need for flood protection in the lowest part of the planning area. This is because measures being taken in connection with the building of new bridges in the lower part of the planning area will improve the flood situation and lead to lower water levels.

Such a solution could well satisfy the needs of industry and property-owners, since the whole area could be protected against flooding in the course of a short time. Where the natural environment is concerned, the most important positive consequences would arrive if Stovibekken (a stream) could be opened. There would also be positive consequences for the natural environment if the river's flood channel were to be widened at locations where there are erosion problems on the river bed. However, encroachments in the riverbank vegetation during the construction phase and a reduction in the width of the vegetation at certain points would reduce the positive effect of this measure.

The other proposal of most interest is Alternative 3: raising the ground level. Raising the level of the land by changes or new construction would improve flood protection more than Alternative 1. This is because there is a residual risk of occurrence of a flood that is higher than the level against which the area is protected, with the result that the embankments would be breached. This could create a situation with large amounts of water moving at high speed as it passes through the embankments. The ground-raising proposal could be implemented over a longer period of time than Alternative 1, depending on when property-owners wished to renovate their properties, and there

would probably be several years during which individual properties would be raised to different heights.

In the long run, the ground-raising alternative would satisfy the requirements of industry, property-owners, the natural environment and recreational interests better than Alternative 1: embankments or walls, The most important objections to raising the ground level are the uncertainty regarding the time of implementation, the unlikelihood of obtaining the consent of all the property-owners concerned and that it would require a high degree of utilisation of the new building areas.

A combination of Alternatives 1 and 3 is another potential solution. Flood protection embankments or walls could be built in order to provide an adequate level of security for existing buildings. Thereafter, the level of security could be further improved by renewing buildings in the area on earth-fill terrain behind the flood barriers. This development would also eliminate the necessity for maintenance and operation of the flood prevention system in the long run.

The extent and quality of natural and recreational areas bordering the river can be increased if the embankment is simultaneously moved further away from the river by renewal of lots with buildings currently standing closer to the river than is desirable.

1. INTRODUCTION

Bærum Municipality's contribution to the FLOWS Interreg Project includes a demonstration flood damage prevention project in the Vøyenenga industrial area on the River Isi.

The river plain between Vøyenenga and Årenga, which includes a large number of properties and buildings, is highly exposed to flooding in the Isi, which forms part of the Sandvik River system.

The Sandvik River is permanently closed to hydropower development. National policy guidelines require biological diversity, nature conservation and recreational interests related to protected rivers must be taken into account. Any flood protection measures must incorporate these conservation interests.

The objectives of this contribution to FLOWS are:

- To show how Norwegian legislation and authorities can be utilised to control area use in a flood-prone area. Special focus is laid on the potential for implementing such control by means of zoning plans.

- To assess the effects of proposals for new guidelines for planning and building in flood-hazard areas near the river within the planning area on Vøyenenga and in relation to established case-handling routines in the municipality.

- To evaluate various potential flood protection schemes and illustrate the consequences they might be expected to have for area use, industry, property owners, nature conservation and recreational activities.

2. THE POTENTIAL FOR CONTROLLING AREA USE WITHIN THE PLANNING AREA

2.1 The role of the municipality

Within the planning area, the municipality is a relatively modest property owner. The municipality's ability to control area use within the planning area is therefore dependent on its administration of the Planning and Building Act.

The municipality possesses the following means of controlling area use within the planning area with the end in view of limiting potential damage:

- Changing the zoning category in the area-use part of the municipal master plan and issuing new regulations and guidelines.
- Changing current zoning objectives and zoning regulations.
- Basing the way in which it deals with planning and building applications on a strict interpretation of § 68 of the Planning and Building Act and NVE's guidelines 1/99 (ref. 1).
- Applying to NVE for assistance with flood protection measures (various measures are at the planning stage).

Paragraph 68 of the Planning and Building Act prohibits development in flood-prone areas, but the regulations are not unambiguous since the definitions of the thresholds of acceptable flooding risks exist only in the form of (non-binding) guidelines. The municipality used to issue building permits that were in conflict with the guidelines of 1999. Since the flooding zone map was drawn, the practice of the municipality has been in line with these guidelines.

When an area is zoned for renewal according to § 25, no. 8 of the Planning and Building Act, the municipality can give itself the authority under § 31, no. 4 of the Planning and Building Act to reject types of renewal that it regards as undesirable. According to § 35 of the Planning and Building Act, the municipality may issue a compulsory purchase order for land and buildings in order to implement a zoning plan. The time limit for issuing such an order is ten years from the approval of the zoning plan; § 31, no. 2 of the Planning and Building Act. As well as being the administrator of the Planning and Building Act the municipality is also the issuer of guidelines, informant, planner, and responsible contractor for flood protection measures implemented in cooperation with NVE and property owners.

2.2 Other organisations/roles

NVE: directorate, informant, surveyor of flood hazards, issuer of guidelines, manager of the Water Resources Act, planner and executant of joint flood defence systems.

Property owners/rights owners: may submit proposals for plans and building applications. Participation in planning processes via input and expressions of intent or interest. Party to agreements with the municipality regarding share of joint flood protection systems implemented in cooperation with NVE.

General public and other organisations: participation in planning processes via input and comments.

3. NEW GUIDELINES FOR PLANNING AND DEVELOPMENT IN HAZARD ZONES NEAR RIVERS

3.1 Existing guidelines for area use and protection in flood-prone areas

On the background of the flooding in Eastern Norway in 1995 and the subsequent White Paper no. 42 (1996 - 97) regarding flood protection measures, a set of guidelines was drawn up that included criteria for flood protection of various classes of property, in addition to criteria for area use in flood-prone areas. The guidelines differentiate between various flood protection criteria on the basis of whether there is a risk of material damage or hazard to human life.

The guidelines apply to the production of area use plans and to all building and construction activities mentioned in § 93 of the Planning and Building Act. When new flood protection measures are being designed and existing measures are being upgraded, these guidelines are to be followed. The guidelines discuss various types of flood protection measures, including embankments, raising the ground level, and building adaptations.

The experience of NVE is that other flood protection measures than traditional embankments or dykes are often employed. These guidelines (ref. 1) are based on the principle that the security requirements should be differentiated on the basis of what type of property need to be protected, and how large these values are. The classification is based on the rate of recurrence of flood events.

When the guidelines were issued in 1999 they represented a major improvement on the previous situation, in which there was little on which to base the handling of individual cases, other than the general requirement in § 68 of the Planning and Building Act that building ground should be safe.

The guidelines are used as a tool in planning and building procedures, both at central level by NVE and locally by local authorities and persons or bodies that submit proposals. The concretisation of the degree of hazard by differentiating between

different degree of risk and rate of recurrence is perceived by users as a move in the right direction. A number of responsible contractors regard the guidelines as "law", while others feel that they are insufficiently concrete, since they are not legally binding.

In the years during which we have had the guidelines, there has been some discussion regarding the division into various classes of material damage. Criticism has been aimed both at the number of classes and at the types of area use, buildings and constructions that have been allocated to each class. Many people have wished that flood events should be related to given water levels (contour heights).However, such levels are impossible to indicate in the absence of an analysis of the river concerned, in which water flow is related to the height of the terrain. NVE's inundation maps cover some 150 stretches of rivers where the potential for damage has been assessed as being greatest.

The fact that an area has been assessed as being adequately protected against a flood event may also induce a false feeling of security if we believe that the area is secure in every way. Sooner or later, more serious floods that the guidelines allow for will take place, and in Eastern Norway, for example, floods are expected to occur more frequently in the future as a result of climate change.

3.2 Proposals for the process of limiting potential flood hazards at municipal master plan level

In Bærum we have inundation maps for most of our rivers at risk of flooding. For this reason, this process is not so relevant for us, although we have looked at the effects of the proposal.

The guidelines for planning and building in hazard zones near rivers (ref. 2) propose that zones at risk of inundation should be set at 7 m above the normal water level in rivers that lack inundation maps. In Bærum, the greatest known difference between normal water level and a 200-year flood in local rivers is four metres, at the lowest point in the River Isi, before the confluence with the River Lomma. Within the Vøyenenga planning area, the largest difference in height is three metres. In Bærum, three metres would be an adequate height vis-à-vis the rivers, with two to three metres along streams. The principle itself is fine, but the difference in water levels should be adapted to take into account the size and fall of the river concerned.

In Bærum, it could be of interest to determine a standard height, for example of 2 m, for flooding from streams when development proposals are being considered or when documentation concerning flooding conditions is required.

For the evaluation of zones in danger of erosion, the proposal is to use the height from the bottom of the slope to the height of the alluvial plain, multiplied by two and with an addition of 10 metres, though never less than 20 m. For the Vøyenenga planning area, the height is 2 - 4 m, which would make the zone 14 - 18 m wide. In such a case, the minimum breadth of 20 m would be employed. A 20 metre-wide zone on each side of the rivers is considered to be sufficient to absorb any danger of erosion along them. On Vøyenenga the inundation area at certain points would be larger than the erosion danger

zone. By using the largest area in combination (danger of inundation 3 m above normal water level and erosion hazard 20 m) the zone in need of flood assessment would be taken care of.

3.3 Safety levels in areas in danger of flooding

The proposals for new guidelines (ref. 2) include a change in the number of security classes and safety levels. In Bærum, there are areas in danger of suffering material damage from flooding that are likely to be brought into use, and which are commented on below.

Table 1: T1 safety levels under threat of flooding (ref. 2)

SAFETY CLASS	AREA USE, BUILDING, CONSTRUCTION	LARGEST NOMINAL ANNUAL PROBABILITY
		INUNDATION, EROSION, ICING
F 1	Small garages, boathouses, sheds	**1/20**
F 2	Houses, cabins, industry, offices, important infrastructure, etc.	**1/200**
F 3	Hospitals, emergency institutions, critical infrastructure	**< 1/1000**

The change is from four to three safety classes and involves the adoption of a 200-year flood as the security level for dwellings, industry and infrastructure. This is in line with current practice in Bærum Municipality. Most buildings in danger of inundation in Bærum are commercial or industrial buildings.

Only when applications to build detached houses are being dealt with the 100-year flood safety level has been used. A number of large combined-use buildings with parking in the basement, commercial premises on the ground floor and apartments on the remaining floors have been built. If these buildings are in danger of flooding, a safety level corresponding to a 200-year flood plus a 0.5 safety margin is utilised. It is recommended not to build a cellar, but our practice has been not to prohibit cellars if they are protected up to the height of a 200-year flood plus a 0.5 m safety margin.

Where small garages are concerned, the new guidelines propose a reduction in the safety requirements, from 50-year to 20-year flood. In Bærum, the value of garages and their contents can be high, due to high building costs and the relatively high income levels of the inhabitants. Garages may contain several expensive cars and provide storage space for various types of inventory. A lowering of the safety level appears to us to be irresponsible, and should at the very least be formulated as a minimum

requirement that allows individual local authorities to set stricter requirements. This is recommended if the guidelines are to be suitable for use in Bærum.

Another argument against lowering safety levels in general is the observed rise in the frequency of major flood events in Bærum between 2000 and 2005 (see Table 4).

3.4 Assessment of flooding hazards at zoning plan level

At this level, the real danger of flooding needs to be identified. The guidelines introduce a new aspect that involves water depth and water velocity, with the aim of identifying areas that absolutely must not be developed as a subset of those where there is a risk of flooding (water velocity multiplied by water depths of more than 1.5 m).

Table 2: Degree of hazard and restrictions. From NVE's project report (ref. 3)

	Dimensioning flood (1/200 or 1/1000, depending on process
High risk **h>1.5 m** **v*h>1.5 m^2/s**	No construction permitted
Low risk **H<1.5 m** **v*h<1.5 m^2/s)**	Construction may be permitted if protective measures can prevent damage to building and the risk of loss of human life is acceptable Damage to boathouses or garages can be tolerated as long as the risk of material damage is <1/20

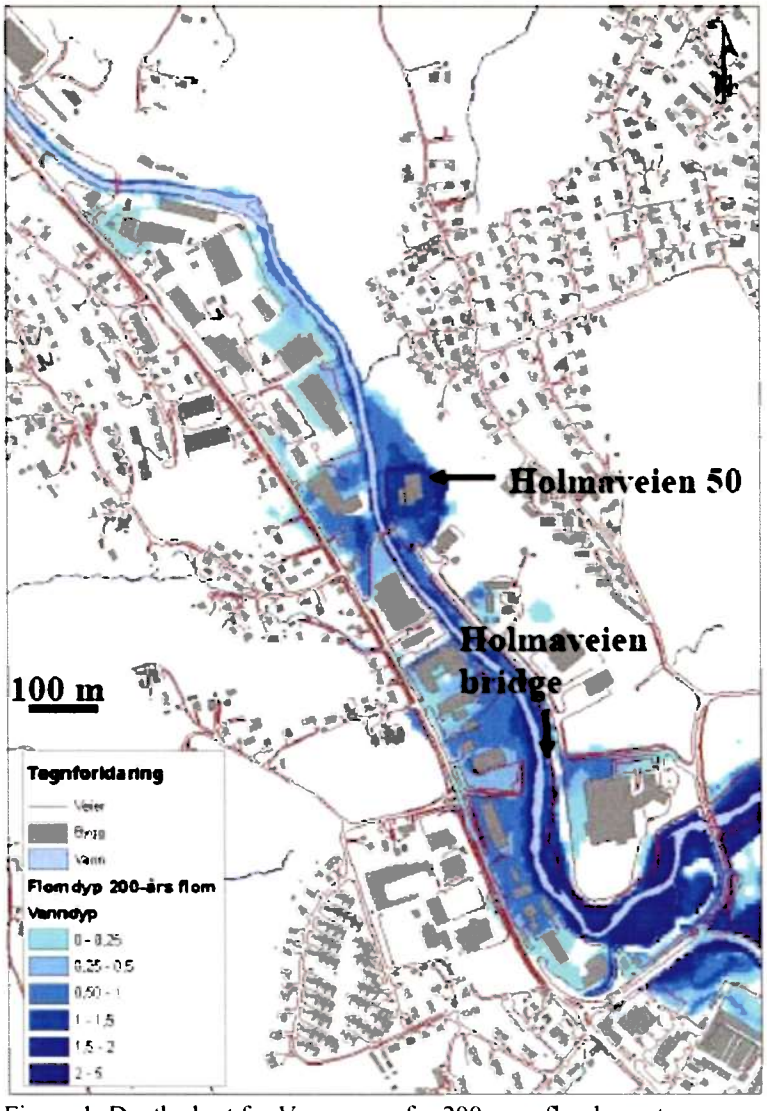

Figure 1: Depth chart for Vøyenenga for 200-year flood event

In the building areas within the planning area, water depths are usually low, i.e. from 0 – 1.0 metre for a 200-year flood. The greatest depth is 1.0 – 1.5 m at Holmaveien 50 on the east side of the River Isi. By 2007, the waterline will sink within the planning area south of Holmaveien Bridge as a result of improvements downstream of the Køla Bridges. The depth chart (Figure 1) therefore indicates greater than true depths for the future in the part of the planning area that lies south of Holmaveien Bridge.

Water flow rates outside of the course of the river are low. The hydrological model treats this as still water. Water flow rates below 1 m/s should not cause any problems.

Within the planning area, the proposed new safety classes for flooding will only need to be modified for the few existing detached houses and garages. The requirement for detached houses will be raised from 100- to 200-year floods, while for garages it will be lowered from 50- to 20-year floods.

3.5 Current practice in Bærum

The municipality operates a geographical information system (GIS) located at www.baerum.kommune.no , that makes flood zone thematic maps and associated information available to the general public. In connection with the processing of planning and building applications, the Dept. of Water and Sewerage expresses its opinion regarding floods and minimum heights for construction. The department has a good overview of flood hazards in local rivers. Where detailed flood zone maps have not been drawn up, a 1000-year flood, defined on the basis of a dam-burst, is used as an indicator of flood hazard. For several streams, no information about flood conditions is available. Observance of a zone in which construction is prohibited within 10 metres of these streams in the area-use part of the municipal master plan should provide adequate protection from flooding in many cases.

When the area-use part of the municipal master plan was updated in 2002, consideration was given to whether the area that would be affected by a 200-year flood on the basis of the flood zone maps should be included as a flood-hazard area. This was not done, as the Planning and Building Act does not include a zoning category for such a flood area, and because there are limits to how much guideline information can be included in the area-use plan.

Along the coastline, contour 2 (local height) is adopted as an acceptable level.

4. DESCRIPTION OF THE AREA

Bærum Municipality lies in south-eastern Norway and borders Oslo municipality to the east (Figure 2). The Vøyenenga planning area lies to the northwest of the municipal centre of Sandvika. The planning area (Figure 3.6) is largely built up and comprises a number of large commercial and industrial buildings. The area lies beside the River Isi, which forms part of the Sandvika River system, and which is covered by national guidelines as a protected river.

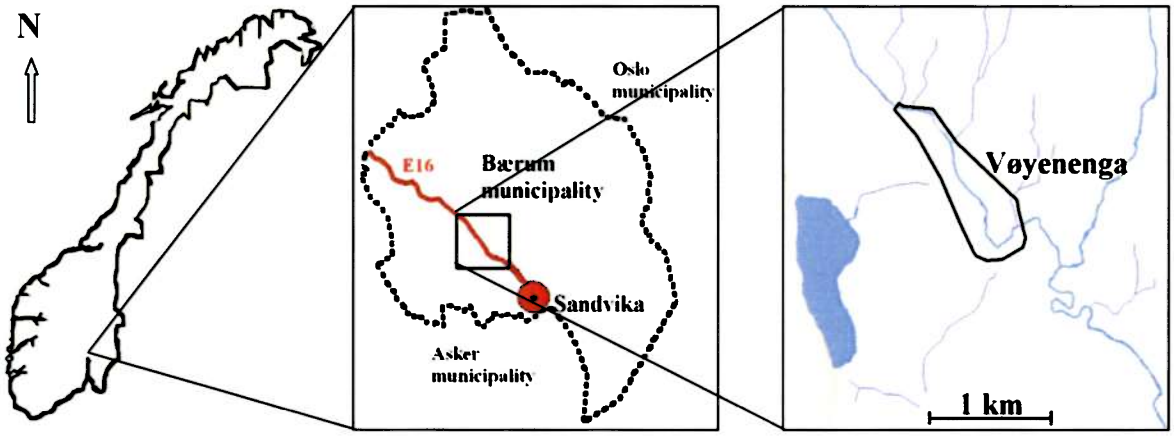

Figure 2: The Vøyenenga planning area lies in Bærum Municipality in south-eastern Norway

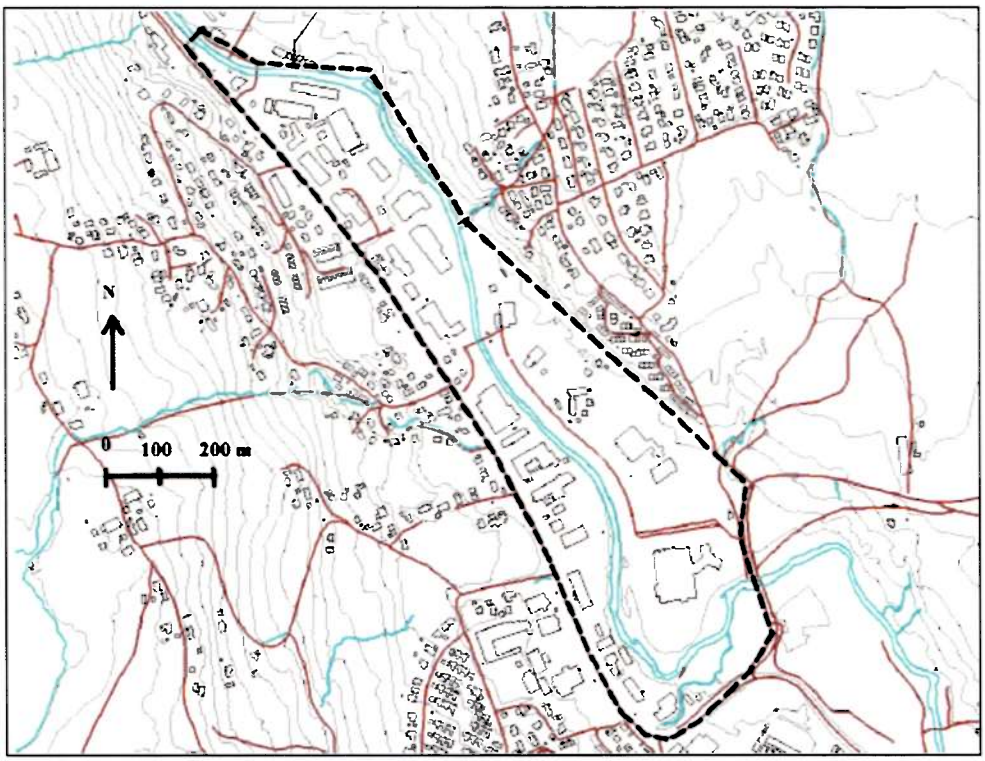

Figure 3: Vøyenenga planning area is indicated by a stippled line. Rivers (blue), buildings, roads (red) and contours (5 m) are shown.

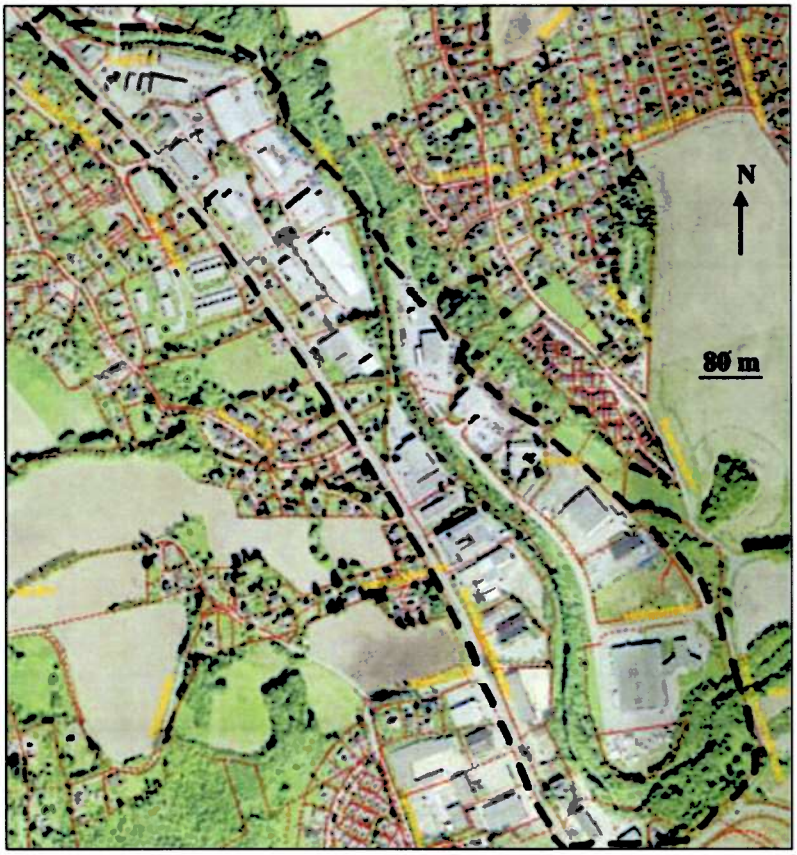

Figure 4: Orthophotograph of the Vøyenenga planning area, indicated by a stippled line. Property boundaries are shown in red.

Figure 5: Oblique aerial photo of the northern part of the planning area, facing north. The stippled line indicates the limits of the planning area.

Figure 6: Oblique aerial photo of the southern and central parts of the planning area, facing east. The continuous line indicates the limits of the planning area.

4.1 Hydrology

The catchment of the River Isi covers 70 km^2, and its longest axis is 17 km. The altitude of the catchment ranges from 21 - 540 masl. The catchment consists largely of forest. In the lowest-lying areas along the river to the south, agriculture and built-up areas cover large areas of clayey soil. The catchment contains only a limited area of lakes and small surfaces or deposits with retention volumes. The hillsides are steep, resulting in rapid

flood development with high peak flooding levels. Floods usually occur during the autumn, but spring floods also occur. Parts of the alluvial plain are affected even by 10-year floods, while 200-year floods leave large parts of the plain under water. According to the inundation map for 200-year floods, (Figure 7), water could enter the ground floor of some 40 buildings, and in view of the current inadequacy of protective measures, heavy financial costs due to damage to buildings and infrastructure can be expected in the event of such a flood.

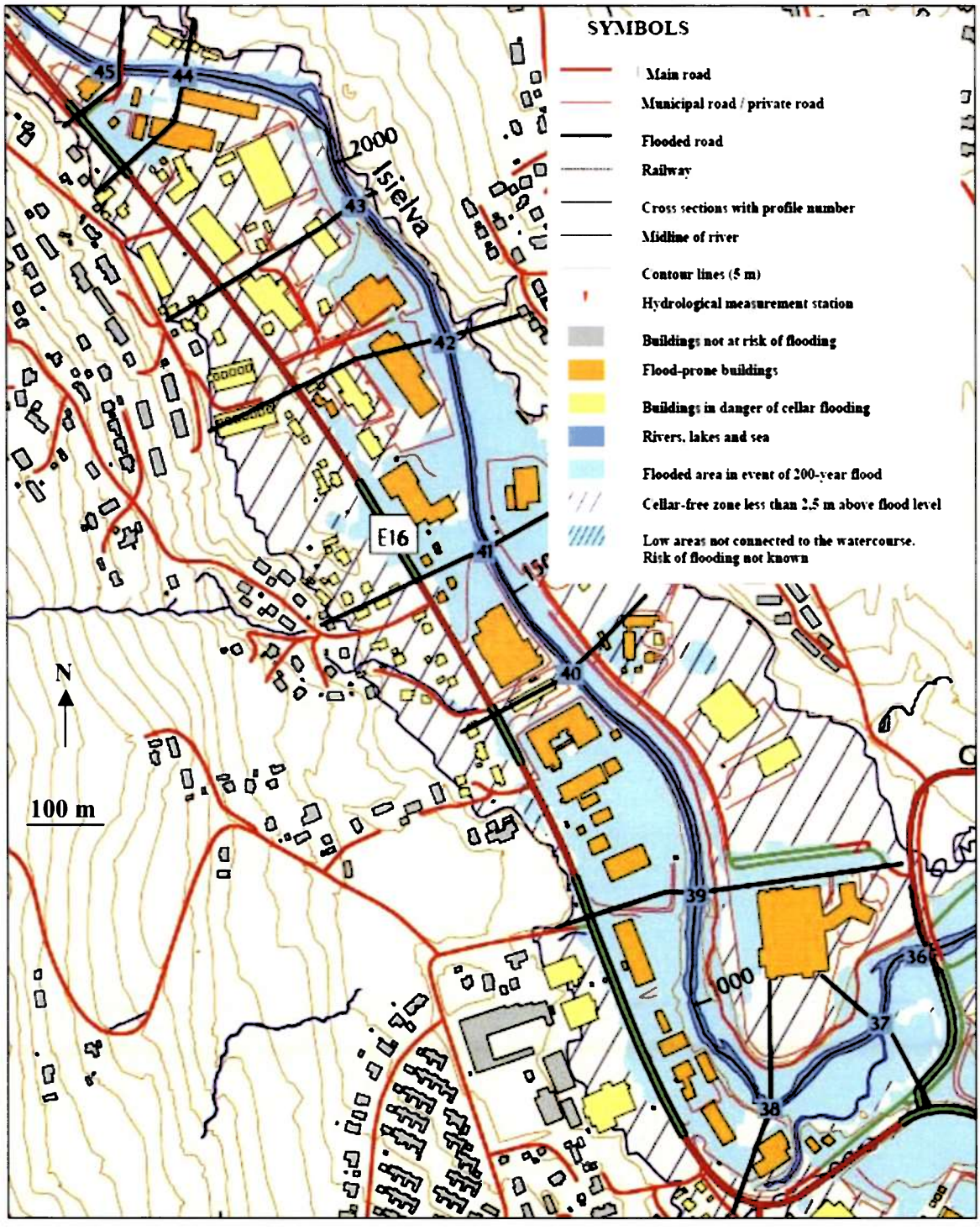

Figure7: Flood inundation map dated 01.12.2003 for 200-year flood (ref. 4). More details are available at www.nve.no

The very rapid changes in the rate of flow of the river during a flood can be illustrated by values measured at Bjørnegårdssvingen (Table 3). People who have experienced flooding in the river confirm that the flood situation can change extremely rapidly.

Table 3: Instantaneous values for autumn and spring floods at Bjørnegårdssvingen. Qm = mean flood, Q5 = five-year flood, etc. Data from NVE, hydrological database and ref. 5.

Date	Q_m: 63 m^3/s	Q_5: 81 m^3/s	Q_{10}: 97 m^3/s	Peak	Observations
7.Oct 2001	At 12: 65 m^3/s	At 13: 89 m^3/s	At 14: 101 m^3/s	At 15: 104 m^3/s	3 hours from Q_m to Q_{15}
1.May 2002		At 08: 81 m^3/s	At 10: 97 m^3/s	At 13: 112 m^3/s	5 hours from Q_5 to Q_{20} (raw values)

During the flood in 2001 there was a three-hour interval between mean flood and 15-year flood flow rates. In 2002, the interval between the five-year and 20-year rates was five hours.

4.2 Floods and flood development

The 1987 flood was the highest flood ever observed at Bjørnegårdssvingen. The observation period for Bjørnegårdssvingen is from 1968. Before 1968 there were major floods in September 1965 and August 1951. Floods that caused damage also occurred in October 1997.

NVE bases its statistics on daily mean values and highest annual values. Floods that led to damage are best reflected by the peak value, as it is high water level that causes damage. At the peak value of a five-year flood there appears to be little damage, while at 10-year flow rates damage begins to occur.

Table 4: Floods and flood dimensions at Bjørnegårdssvingen in the River Sandvik during the past six years, and for the 1987 flood. Qm = mean flood, Q5 = five-year flood, etc. Data from NVE, hydrological database and Bærum Municipality.

Year	Date	Flood days	Daily average (m^3/s)	Instantaneous peak flow rate (m^3/s)	Peak flow	Comments
1987	16.Oct	Q_{100}	101	145 at 17	Q_{100}	Greatest flood for which data are available
2000	11.Oct	Q_{15}	65	83 10.Oct at 18	Q_5	
2000	31.Oct	Q_5	55	102 30.Oct at 23	Q_{10}	
2001	7.Oct	Q_m-Q_5	47,5	104 at 15	Q_{15}	
2002	1.May	Q_{15}	68	97 at 13	Q_{10}	Q_{50} Bærums Verk
2002	26.Oct	Q_5-Q_{10}	57	85 at 03	Q_5	
2003	1.Des	Q_m	43,3	58 at 06	Below Q_m	
2004	5.Oct	Q_m	42,5	85 4.Oct at 23	Q_5	
2005	4.Nov			72 at 8	Q_m-Q_5	Bærum's observations 84 m^3/s at 08

In Bærum, during the six-year period 2000 - 2005, we have experienced floods with "excess rates of recurrence" relative to expected rates. There have been six years with one average flood and seven floods whose recurrence rates should have been five to

fifteen years. If we look at annual floods and culmination flow rates, we have had one average flood and four with 5 - 15-year recurrence rates. Does this indicate a trend in the direction of greater floods, or is it simply a statistical accumulation of high values? The uncertainty in our flood estimates, changes in the catchment in the course of the period covered by the statistics and climate change, all seem to be important challenges in planning flood defences.

Table 5: Peak flow, size of floods and precipitation ahead of selected flood events. Precipitation measured at Dønski, 1997- 2002, Horni, 2004 and Gjettum, 2005. Data from NVE, hydrological database, ref. 5, ref. 6, DNMI and Bærum Municipality. Qm = average flood, Q5 = five-year flood, etc.

Year	Date	Peak flow (m^3/s) and time	Size of flood	Approx. precipitation (mm) in week before peak flow	Approx. precipitation previous 36 hours
1987	16. October	145 at 17	Q_{100}	110	60
2000	11. October	83 10.Oct at 18	Q_5	82	62
2000	31. October	102 30.Oct at 23	Q_{10}	85	50
2001	07. October	104 at 15	Q_{15}	85	50
2002	01. May	97 at 13	Q_{10}	60	30
2002	26. October	85 at 03	Q_5	80	12
2004	05. October	85 04.Oct at 23	Q_5	65	40
2005	04. November	72 at 08	Q_m-Q_5	102	50

There was only one spring flood on May 1, 2002 (Figure 8) in which rain and snow-melt were dominant. The autumn floods are pure rain floods. It rains significantly less in May than in October. For Asker, normal rainfall is 66 mm in May and 111 mm in October. On July 15, 1999 a record daily rainfall was measured at Dønski and Gjettum, with 71 and 75.9 mm respectively. Such rainfall rates are estimated to have a rate of recurrence of about 100 years. The highest daily rainfall in October was registered on October 10, 2002 at Dønski and Gjettum, with 47.8 and 47 mm respectively. The highest daily rainfall in May was registered on May 29, 2002 at Dønski, with 36.4 mm.

Figure 8: Floods in the planning area, on May 1, 2002

4.3 Flood damage in Bærum Municipality and within the zoning area

General statistics regarding flood damage to buildings are available from the Norwegian Nature Damage Pool. The insurance companies report damage caused by acts of nature

to the pool, which maintains statistics from 1980 until the present for Bærum Municipality. These statistics give the number of cases of damage and their cost per year. For more information, see the Flood and natural damage report (ref. 7).

Table 6 shows the number of cases of damage in 2002 - 2002. These years were selected because it is possible to obtain more detailed information about them from the insurance companies, and to relate this information to the relevant flood events.

Table 6: Damage caused by acts of nature in Bærum Municipality. Source: Norwegian Nature Damage Pool. Amount = amount paid out in MNOK.

Year	Flood		Storm high tide		Landslide	
	Number	Amount	Number	Amount	Number	Amount
2000	31	15,27	7	0,21	2	0,93
2001	56	9,98	1	0,3	2	1
2002	8	1,43	0	0	1	0,26
Sum	95	26,68	8	0,51	5	2,19

Data were obtained from two insurance companies, A & B, which insure many companies in the municipality and the planning area. The quality of the data from company A is good, and includes type of building, post-code and partial address. Data from company B comprise only damage data and the sums paid out.

Table 7: Flood damage registered by two insurance companies (A & B) on the dates of floods in Bærum Municipality, by industrial/commercial and private property (mostly dwelling houses). Amount = amount paid out in MNOK.

Date of damage	Companies A and B		Company A				Company A in the planning area	
			Private		Industry		Industry	
	Number	Amount	Number	Amount	Number	Amount	Number	Amount
30-31.Oct 2000	29	12,0	5	0,13	10	4,2	6	4
7.Oct 2001	43	10,3	22	3,5	12	4,9	6	3,2
1.May 2002	4	1,3	0	0	3	0,7	3	0,7
Sum	76	23,6	27	3,63	25	9,8	15	7,9

A comparison of annual data for flood damage registered by the Norwegian Acts of Nature Damage Pool with data supplied by the two insurance companies for the relevant days shows that we have captured a large proportion (76 of 95 cases of flood damage, or 80%) of the total number of cases, and MNOK 23.6 of MNOK 26.7 of the compensation paid (88%).

Company A, paid MNOK 7.9 out of a total of MNOK 13.43 for commercial/industrial buildings within the planning area, for the three floods that took place in 2000 - 2002. These payments were significantly larger per unit for industry than for private buildings. Within the planning area, three commercial/industrial properties suffered flood damage during every one of the floods, and one had flood damage in two of the floods. The data are not complete, but they confirm that within the planning area, considerable sums were paid out as a result of flood damage.

4.4 Danger of landslides within and in the vicinity of the zoning area

In 2005, Bærum Municipality carried out a pilot project on surveying risks of land-slides and rock-falls in the municipality. The pilot project showed that there are areas in and around the planning area that are liable to suffer mud-slides (Figure 9). These areas need to be studied in more detail in order to verify and clarify the degree of risk. Areas liable to suffer rock-falls have not been identified within or around the planning area.

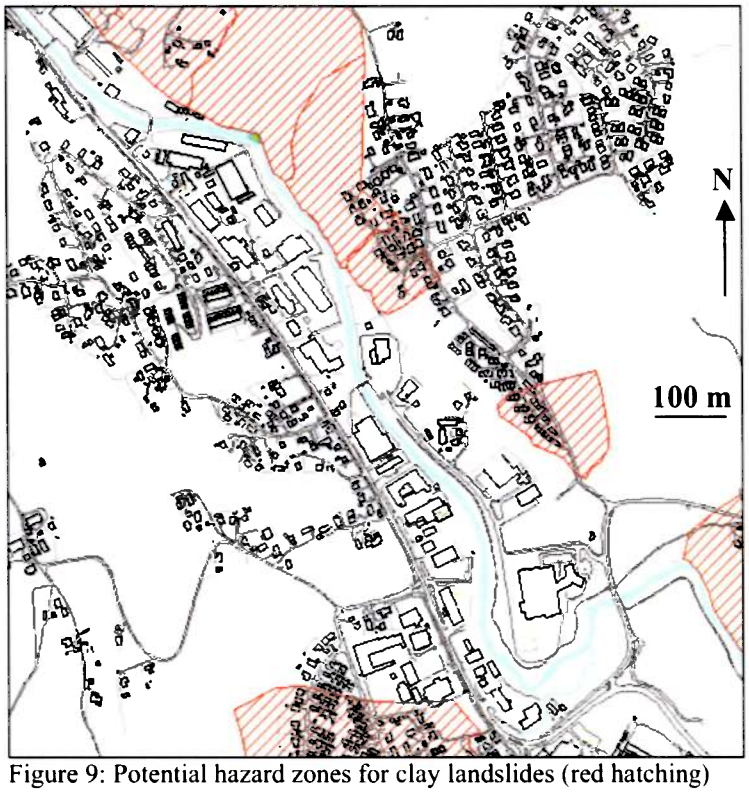

Figure 9: Potential hazard zones for clay landslides (red hatching)

4.5 Encroachments on the river

Within the planning area, there have been encroachments on the river in the shape of land-fills, supporting walls, bridges, canalisations and changes in the course of the river. Tributary streams have been enclosed. A main highway (E16 Oslo - Bergen) that follows the river plain to the west is liable to flooding. A rerouted main highway is being built (2005 - 2008) to the east of the river and at a greater distance from it than the current route. The new main highway will cross the River Isi at the southern limit of the planning area via a four-lane bridge. The highway will also have a turn-off via the new Holmaveien Bridge (Figure 1) across the river within the planning area. During the winter, snow is dumped from industrial/commercial properties into and alongside the river (Figure 10), damaging riverbank vegetation and increasing the danger of flood damage in the event of early spring flooding.

Figure 10: Cleared snow dumped in the riverbank vegetation zone and in the river, March 2006

4.6 The natural environment

The River Isi forms part of the Sandvik River system, which is a regionally important salmon and sea-trout river (Figure 11) and is regarded as the most important salmon and sea-trout river in the County of Akershus (ref. 8).

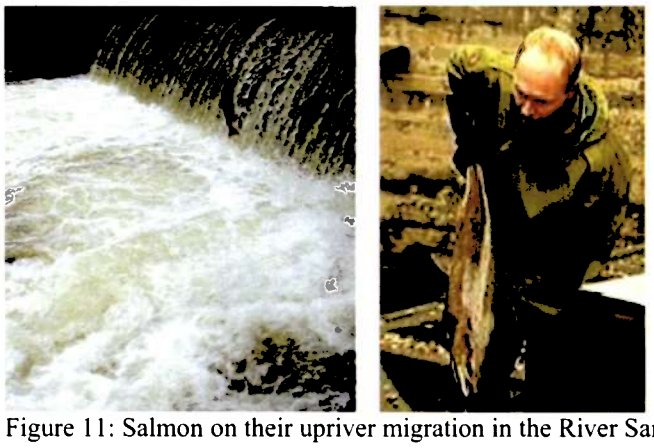

Figure 11: Salmon on their upriver migration in the River Sandvik. Wild salmon caught for stock enhancement purposes in the broodstock facility at Hamang. Photo: Dept. of Nature and Sports Management

There is extremely good angling in the river, which also contributes a great deal to the excellent sea-trout fishing in the Oslo Fjord. Stocks of sea-trout and salmon are maintained by catching local broodstock fish for insemination of roe at the broodstock facility and releasing unfed fry. The planning area lies within the most important spawning and nursery grounds for salmon and sea-trout in the Sandvik River.

The vegetation on the banks of the Rivers Sandvik and Isi is an important area for birds and flowering plants/fungi that inhabit humid woods.

4.7 Area use

The planning area includes the largest continuous built-up flood-prone area in Bærum.

The area is largely occupied by industrial buildings and warehouses, with some commercial premises. Most of the building mass dates from between the 1950s and the present day.

Since 1995, the land-use part of the municipal master plan has included a general prohibition on construction less than 30 metres from either side of the river. Since 1985, the municipal master plan has overridden older zoning plans on this point. Buildings, roads, parking places, outdoor storage, etc., however, do lie closer than 30 metres from the river on parts of the river plain. The municipality has allowed a number of exceptions from the prohibition, permitting the construction of new buildings and extensions to existing buildings within the 30-metre zone since 1995. The prohibited zone has been based on normal water levels, i.e. more or less what is shown on the technical map.

Three tributary streams on the west are partly culverted, a situation that can cause problems during floods due to blockages of gratings and limits of the capacity of the pipes.

5. DESCRIPTION OF ALTERNATIVE MEANS OF PROTECTION

5.1 Alternatives

The following alternatives have been evaluated:

Alternative 0: no new flood protection measures
Alternative 1: embankments or walls for flood protection
Alternative 2: protecting building facades
Alternative 3: raising the ground level
Alternative 4: widening the river and lowering the ground within the flood zone
Alternative 5: laying new river course in the open air or in a tunnel

There is a close relationship between area use in the areas close to the river and the choice of flood protection method. As well as developing optimal flood protection measures based on current area use, the project will also evaluate flood protection for a future situation in which area use is changed. Underlying our evaluations is a desire to satisfy NVE guidelines 1/1999 (ref. 1), national policy guidelines for protected rivers, general interests related to the river and the EU's Water Frame Directive.

Flood protection measures are described for each of the alternatives. The project adopts a viewpoint with respect to whether there should be restrictions on the use of area behind the flood defences. It also describes the consequences for area use, industry, property owners, the natural environment and recreational interests.

One alternative that would eliminate the potential for damage and create a nationally important natural area would be to return the whole planning area to the condition of natural area and flood-plain. This alternative was not taken into consideration because it would have extremely negative consequences for property owners and would mean unjustifiably high costs for the municipality.

5.2 Alternative 0: no new flood protection measures

This alternative would mean the municipality taking no active steps to deal with the problem of flooding. Without any form of flood protection measure, buildings, roads and outdoor storage areas would be relatively frequently affected by floods. Floods of the size of the 1987 autumn flood or greater would be expected to result in serious financial damage.

5.3 Alternative 1: embankments or walls for flood protection

The area can be protected from flooding by means of embankments or walls. At a meeting on June 13, 2005 a preliminary plan for flood barriers drawn up by NVE was presented to property owners (Figure 12). The proposal is based on the construction of an embankment or levee raised to a height of one metre above the estimated level of a 200-year flood.

The extra height is necessary in order to ensure the stability of the embankment during a flood of the dimensions it is designed to withstand, and with regard to the uncertainty of the calculations and the possibility that objects carried by the floodwater would have the effect of "piling up" the water locally. In wider rivers, which cannot be blocked by trees, NVE usually calculates a safety margin of 0.5 m.

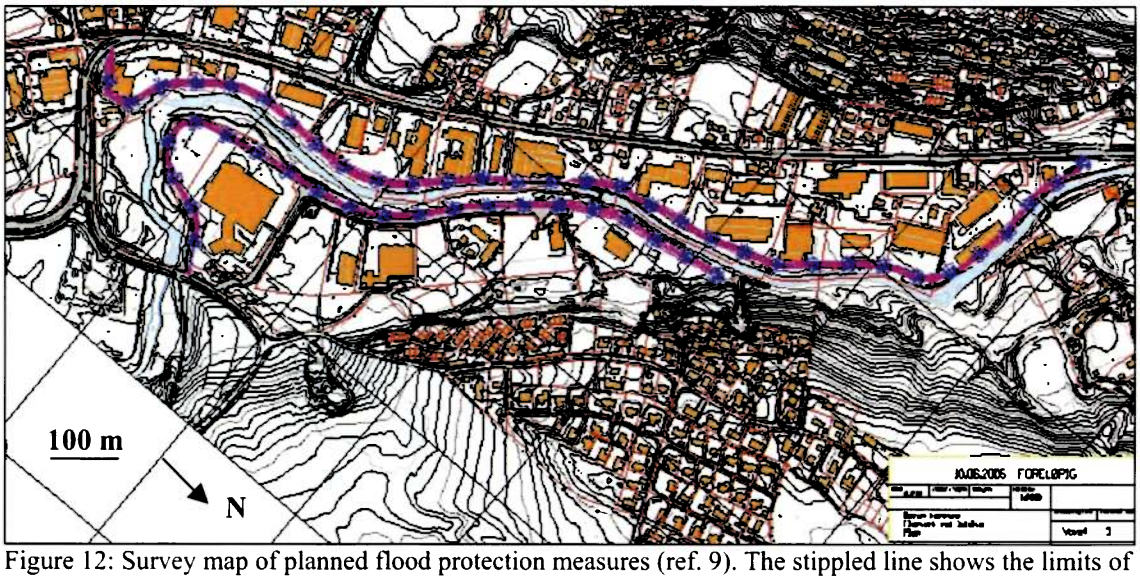

Figure 12: Survey map of planned flood protection measures (ref. 9). The stippled line shows the limits of the planned measures.

5.4 Alternative 2: protecting building façades

Permanent physical flood protection measures can be installed (designed to cope with 200-year floods + 0.5 m) on façades. However, such installations may create occasionally insuperable hindrances for goods transport, etc. This flood protection method may require a significant amount of rebuilding and involve a high level of costs.

Walls without doors, ports or windows that can be opened can provide a high level of safety for façades. This requires protection designs that make the building watertight both above and below ground. The greatest costs of protection measures of this sort must be assumed to be associated with the below-ground part of the watertight structure.

Where ports, entrance doors and windows are concerned, mobile flood installations can be installed when there is a danger of flooding. The disadvantage of installations of this sort is that there may be extremely little time available for their installation, because floodwaters tend to rise rapidly and without advance warning.

Specially modified permanent ports, doors and windows with more or less watertight seals are available. These items are expensive and require regular inspection and maintenance.

5.5 Alternative 3: raising the ground level

A new zoning plan for the whole area can be drawn up. Such a plan could open up the possibility of raising the ground level and setting out the lowest permissible contour heights for the lowest floor in all extensions, buildings and changes of use, etc., for which applications must be submitted. Regulations can be drawn up with greater or lesser degrees of flexibility with regard to changes of use or reconstruction of existing buildings. If the plan is designed within a very restrictive framework, it might be capable of initiating a gradual raising of the ground level. However, the level of conflict with property owners may be expected to rise in line with the strictness of the limitations that it introduces.

In areas in which it would be desirable to renew the building mass, the renewal area zoning category may be used (§ 25, no. 8 of the Planning and Building Act). This gives the municipality authority under § 31, no. 4 of the Planning and Building Act) to refuse renewal that it regards as undesirable. Renewal can be combined with the provisions of § 25, nos. 1 – 6 of the Planning and Building Act. On the basis of the authority provided by these regulations, the municipality may issue a compulsory purchase order for any areas and buildings over which it has been unable to reach satisfactory agreement with their owners.

5.6 Alternative 4: widening the river and lowering the ground level within the flood zone

The river has been made narrower at several points within the planning area as a result of landfills, as for example in the areas shown in Figure 13. A 1951 map shows the river (area covered by water at normal water level) as being from 8 -18 metres wide, while the river is 7 – 10 m wide at present according to current maps. According to the waterlines on the inundation map, the area around the footbridge in Figure 13 is a bottleneck during floods.

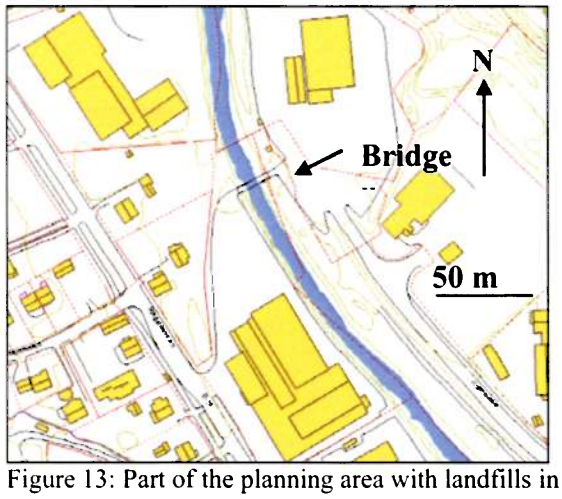

Figure 13: Part of the planning area with landfills in the river-bed. According to the hydrological analysis (ref. 10), the bridge and the landfill material hinder the passage of water during flood events.

Another bridge further north within the planning area also piles up the water during major floods according to the hydrological analysis (ref. 10). This bridge is at profile 45 (Figure 7). In practice, flood conditions in the river could be improved by large-scale removal of river-bank vegetation. However, this is not regarded as a suitable large-scale measure because of the important biological diversity of the river-bank zone, as well as the fact that its trees provide shade and prevent temperatures from rising to dangerously high levels for young sea-trout and salmon.

Alternative 5: laying new river course in the open air or in a tunnel

Skui Neighbourhood Association has proposed that tunnels should be studied as a potential means of carrying off high levels of floodwater.

Another potential means of avoiding having to protect the planning area from flooding would be to open up a new course for the river to carry off floodwaters.

6. DISCUSSION

Climate-change scenarios for the forthcoming decades suggest that autumn and winter precipitation in Eastern Norway will increase, with more occurrences of extreme precipitation events. Since the planning area is already highly flood-prone under the current precipitation regime, it would be irresponsible not to implement measures capable of reducing the potential for damage in the planning area.

Since many buildings within the planning area are located very close to the river, none of the alternative flood-protection measures alone would be capable of meeting the needs of property owners, industry, the natural environment and recreational interests satisfactorily, i.e. meeting the ultimate objectives of all these interests simultaneously appears to be unattainable. The objective for nature conservation and recreation would be best met by removing all flood-prone buildings and returning the area to a natural state. This possibility has not been considered because of its negative consequences for property owners and industry.

The following sections evaluate the various alternatives suggested, in addition to the re-opening of Stovibekken.

6.1 Alternative 0: no new flood protection measures

There is a possibility that the area will continue to be built up even without flood protection. This is because of the high pressure of development, scarcity of commercial/industrial area and uncertainty regarding how § 68 of the Planning and Building Act should be interpreted in individual cases. However, it is not certain that the potential for damage would increase, since the municipality has introduced as a practical rule that new buildings must be protected against floods with rates of recurrence of up to 200 years.

The municipality is at risk of claims from insurance companies and ground-owners/rights owners who suffer financial loss as a result of flooding. Such claims would have to be based on the municipality having given permission to build in conflict with § 68 of the Planning and Building Act. Whether the responsible contractor was aware of the flood problem when he applied for building permission has no relevance for the municipality's financial responsibility.

The risk of serious flood damage occurring in the planning area is so great that Alternative 0 is regarded as undesirable.

The advantages of Alternative 0 (no flood protection) compared with Alternative 1: embankments or walls for flood protection are as follows:

- A wider belt of river-bank vegetation could be retained and it could also be extended where it is currently narrowest, if the municipality prioritises work on this aspect.
- There would be no risk of increased erosion of the river bed.

The disadvantages of Alternative 0 are as follows:

- High risk of wide-spread flood damage: danger of financial losses for private persons, rights-owners and insurance companies. Possibility of recourse claims against the municipality.
- Cleared snow could continue to be dumped in and beside the river, with resultant destruction of riverbank vegetation and increased danger of damage caused by spring floods.

Alternative 0 would result in the objectives for the natural environment and recreational interests being rather poorly met, and those of property owners and industry being very badly met.

6.2 Alternative 1: embankments or walls for flood protection

If this solution is to be realised, one condition must be that those who benefit by the flood protection measures will have to contribute financially.

The challenges involved in constructing flood-protection measures on the River Isi are:

- At some points there is very little room between the river and existing buildings. Traditional flood embankments would be 5 – 12 m wide, which means that there would not be room for flood barriers everywhere.
- The flood barriers must not destroy the riverbank vegetation.
- There would be an encroachment zone between the barrier and the river in connection with construction and maintenance of the structure.
- A contingency plan for floods greater than those for which the barrier is designed will have to be drawn up.
- The consequences of a breach of the barrier will have to be evaluated.
- The flood barrier will have to be regularly inspected and maintained.
- Land-owners will have to be willing to cede ground for flood barriers.

The advantages of building flood barriers are as follows:

- Much more rapid completion than e.g. raising the level of the ground(alternative 3).
- The solution can be identical for much of the area.
- Provides a higher degree of security than protecting façades (for façades with ports and doors).
- The vegetation belt along the riverbank can be more clearly defined than it is today, and it would be easier to manage.
- The destruction of riverbank vegetation and filling the river with cleared snow can be reduced.
- Parts of the embankment can perhaps be used as a footpath, thus improving public access to the river.
- This solution would probably be less expensive for property owners than Alternative 3: raising the level of the ground.

The disadvantages of building flood barriers are as follows:

- Embankments and walls take up large commercial/industrial areas that are currently used for driving on, parking, storage and dumping snow.

- The operation and maintenance of embankments, walls, and pumping systems for excess water are expensive.
- Embankments must be kept free of trees because of the danger of roots penetrating them.
- In some places, embankments or walls will reduce the width of the vegetation belt.
- Dealing with tributary streams, excess water and any water leakages behind the flood barrier will require a separate set of measures.
- It seems that it would not be possible to construct a continuous footpath along the whole length of the planning area on the embankment on the west bank of the river.
- During floods, the water velocity may rise and increase the danger of erosion.

The hydrological analysis suggests that on most of the reach of the river involved, planned flood control measures would have little effect on water velocities or levels. This is because virtually all the water produced by an estimated 200-year flood would lie below and at the existing ground level. On the inundation map around profile 42, according to calculations, building flood barriers would have an effect in that the water level at profile 42 would rise by about 12 cm in the event of a 200-year flood. The land-fills and embankments already implemented have had a significant effect, in that they have produced a lower level of protection on the opposite side of the river (ref. 10).

Water velocities would be expected to rise upstream of profile 41 and as far as profile 42 (see Figure 7) from 1.87 to 1.95 m/s and from 1.69 to 2.04 m/s respectively for a 200-year flood (ref. 10). This would result in a significant increase in the kinetic energy of the water.

Palliative measures might include raising the level of the footbridge at profile 41 and modifying the cross-section of the river corridor between profiles 41 and 42 by lowering the river edge to a level equivalent to that reached by an average flood (ref. 10). The part of the river course that is normally covered by water would not be affected.

The hydrological analysis suggests that there is no need for flood protection measures in the lowest part of the planning area (ref. 10), since measures in connection with new bridges currently under construction will improve the flood situation and lower water levels.

The need for restrictions on area use behind the flood barriers will have to be evaluated. A building prohibition area could be zoned behind the barrier, where the water velocity would be highest in the event of a breach. This possibility would be taken care of to some extent by extending the current building limit in the area part of the municipal master plan to a minimum of 30 m from the river edge, as well as the building limits in such existing zoning plans as have prohibited building zones greater than 30 m.

Consideration should be given to sectioning the flood barrier in order to reduce the extent of damage in the event of a breach. If the flood barrier consisted of several sections the danger that a large number of properties would be affected by a breach would be reduced.

Consideration should also be given to identifying a series of breach-points for floods with recurrence rates greater than 200 years. It would be necessary to zone the areas behind any such points, where water velocities would be highest, as hazard areas.

Landslides may be triggered by floods and precipitation. Landslides that end up in the river can affect floodwater height. This possibility has not been taken into account in the mapping of the flood zone. If future studies confirm that there is a real possibility of landslides occurring, these areas should be protected against landslides. Increasing the height of embankments in order to attempt to capture waters dammed up by landslides is not regarded as a relevant alternative.

If adaptation to existing buildings means that embankments need to be constructed locally closer to the river than is desirable from the point of view of general interests, the requirement that the embankment should be moved if the building is renewed can be integrated into a new zoning plan.

If those who would benefit by the flood protection measures are positive to the new measures, they could be implemented in the course of two to five years. A preliminary draft which has been presented to property owners should be modified so that less commercial/industrial area is affected, for example by reducing the width of the top of the embankment from four to two metres. It would also be desirable to use more walls rather than embankments where the distance to the river is short and the vegetation belt needs to be protected.

All in all, a solution based entirely on flood barriers such as embankments or walls to protect existing buildings seems to offer an improvement over existing conditions for property owners and industry because of the major positive effect of reduced risk of flooding. The effect on recreational interests would appear to be slight since it would be difficult to construct a continuous footpath along the top of the embankment. The overall effect on the natural environment appears to be negative in that it would reduce the width of the riverbank vegetation belt and increase the danger of erosion because of the increase in water velocity. Opening Stovibekken (a local stream) would counteract the negative consequences for the natural environment to a certain extent.

6.3 Alternative 2: protecting building façades

There would be little point in basing the main solution on expensive ways of protecting façades since many buildings would still have doors, ports and windows, etc. at high risk of water ingress.

There is a high degree of uncertainty associated with seals etc., installed on doors, ports and windows.

If methods of this sort were used throughout the planning area there would still be a danger of significant flood damage due to faults and weaknesses in the seals. On walls without doors, ports and openable windows, however, a good degree of protection could be obtained.

Façade protection is not regarded as a suitable flood protection strategy, but could be combined with other measures such as embankments, etc.

If the building areas within the planning zone are rezoned from industry/commerce to housing, or combined housing/commercial, implementation would probably be simplified, because such a move would raise the value of land. Such a situation would have to be evaluated in the process of updating the municipal master plan.

Disadvantages of Alternative 2

- The level of safety afforded by façade protection as a principal measure would be much lower than by means of flood barriers or raising the ground level. The uncertainty is particularly great with respect to doors, ports and openable windows.
- These measures would be very expensive, particularly with respect to the watertight below-ground structures needed to prevent water ingress through façades and floors.

Advantages of Alternative 2

- Riverbank vegetation would scarcely be affected.
- There would be no danger of increased water velocity and riverbed erosion.

Overall, the chances of meeting the objectives of industry and property owners by relying purely on Alternative 2 are regarded as rather poor because of the difficulties of obtaining adequate flood protection, while the effects as far as the natural environment and recreational interests are concerned would be slight.

6.4 Alternative 3: raising the ground level by means of a new zoning plan

This alternative would involve large-scale demolition and rebuilding of the building mass at risk of flooding. It is not certain whether such a level of investment could be a paying proposition. It is possible that rezoning some building areas as housing or combined commercial/housing zones could make such a process more interesting in financial terms.

When the measures have been fully implemented the planning area could be better protected against flooding than via any of the other alternatives. Buildings that stand too close to the river could be removed and rebuilt at a responsible distance from the river. This would have important positive effects on the riverine environment.

Since compulsory purchase used as a zoning measure often leads to high levels of conflict, any new zoning plan should attempt to arrive at new area-use categories in cooperation with property owners in order to ensure their voluntary participation in building renewal.

However, the dilemma of the municipality in this case is partly a matter of safety and partly of economics (risk of recourse claims). If it proves to be impossible to cooperate with certain property owners, the municipality's current safety and financial risks must

be weighed against the stresses of implementing the zoning plan against the wishes of the property owners.

The current zoning plans for the building areas of the planning area do not include regulations that would prevent raising the ground level. On certain limited areas, the maximum cornice height is given in terms of the contour height. This could theoretically act as a hindrance to land-filling, but it would probably be of little practical importance since the necessary land-fill height would be less than a single floor.

In some areas, the building limit in the current zoning plans is stricter than 30 metres. For the most part, the regulated building limit is currently about 70 m from the river. Most buildings that lie closer than 30 m to the river are located on its west bank. A total of 15 buildings lie within the 30 m limit, eight of them within 290 m of the river bank. Further thought will have to be given to the considerations on which the new building limits in the new zoning plan should be based.

Advantages of Alternative 3

- In terms of protection this is the best long-term alternative.
- The problems of Alternative 1: embankments or walls, regarding dealing with overflows, tributaries and water leakages behind the flood barriers would be eliminated within the entire planning area once the ground level had been raised.
- The measure would not require maintenance, unlike Alternative 1: embankments or walls, or Alternative 2: protecting building façades.
- Buildings can be kept further away from the river where there is currently least space.
- This alternative can be designed in such a way that it would be more advantageous for biological diversity and recreational interests than Alternative 1: embankments or walls.
- All types of vegetation, including trees, can be established on the slope down to the river, as they could not under Alternative 1.

Disadvantages of Alternative 3

- The costs for property owners would be higher than for Alternatives 1 or 2, because many buildings would have to be demolished and rebuilt.
- An excessively long time would probably pass before the whole area was protected if it were left to the initiative of individual property owners.
- The municipality could be left with unsolved problems of safety and financial risk for a long period of time.
- A new zoning plan that prohibited building or changes of use, etc. below given contour heights could be regarded as an intrusion on the rights of property owners.
- Compulsory purchase is an expensive option for the municipality and can involve high levels of conflict.

All in all, the potential of an exclusive focus on Alternative 3 as a means of meeting the objectives of property owners, industry, the natural environment and recreational interests is regarded as good. A prerequisite for this solution to be interesting for property owners would be a high quotient of utilisation of the remaining building areas. As far as the natural environment is concerned, the most important positive effect would

be a rise in the width of the riverbank vegetation belt, while the most important positive consequence for recreation would lie in improved access to the river via new footpaths.

This alternative could function as a follow-up to protection by means of embankments or walls. Basing a flood defence system on embankments or walls can provide sufficient protection for existing buildings. Protection could subsequently be improved over a period of time by renewing the building mass in the area on land-filled ground behind the flood defences. Such a development could eliminate the need to maintain and operate the flood barriers in the long run. The size and quality of natural and recreational areas near the river could be raised if the embankment was also moved further from the river by renewal of lots with buildings currently lying nearer the river than is desirable.

6.5 Alternative 4: widening the river and lowering the ground level within the flood zone

In order to improve the removal of floodwater, the footbridge at profile 41 can be raised and the profile of the river corridor be changed, for example between profiles 41 and 42, by lowering the river edge to the level of an average flood (ref. 10). Downstream of the footbridge there is a large area of soft clay riverbed, which is probably due to erosion caused by high water velocity, a result of the bridge and the narrowing of the river produced by land-fills.

The bridge at profile 45 will also tend to pile up water under conditions of 100-year floods or greater (ref. 10). Consideration should be given to raising the bridge in order to prevent this situation.

In the very south of the planning area, on the inner edge of the southernmost sharp bend in the river (see profile 38, Figure 8), there exists a short parallel river course which is partially overgrown by vegetation. It is proposed that two groin dikes should be laid on the western side in order to direct the flow towards the east side, and that the wood should be cut down on the ness on the east side in order to allow the river itself to make a new course that would improve water transport. The sharp bend at profile 38 should be seen as a result of the fact that the Køla bridges have long piled up water in large floods. The level of the river is likely to fall upstream of the Køla bridges, thanks to the improved flow capacity of the new bridges (ref. 10).

On long stretches of the River Isi woodland is dense, with many fallen trees. Trees can block the passage of water during major flood events. A plan for woodland management in the river corridor would be desirable as a means of reducing the danger of blockages without damaging the biological value of the woodlands.

Unless other methods of flood protection are also adopted, Alternative 4 would not be sufficient to protect the whole planning area. If the whole of the planning area were to be protected by means of encroachments in the river and the riverbank, the process would destroy a great deal of riverbank vegetation and lead to unacceptably serious effects on the protected river. However, Alternative 4 appears to be a perfectly

acceptable supplement to other flood protection measures, and would have the effect of reducing the negative effects of high water velocities during floods.

6.6 Alternative 5: laying a new river course in the open air or in a tunnel.

The river is subject to national policy guidelines regarding protected rivers. Flooding is a natural process in rivers. We do not know the long-term consequences for the riverine environment of eliminating all major floods. Measures that lead major floods away from rivers may to a certain extent come into conflict with river protection, but this is not certain. Since the river used to have several parallel courses in the planning area, it can also be argued that diverting the waters could bring the current course of the river somewhat closer to its original condition. Downstream of the planning area, in places where there has been only one course, diverting the biggest floods could hinder the natural processes that form the course of the river.

Skui Neighbourhood Association has proposed that the possibility of building a tunnel should be investigated. This would be an expensive solution, since it would require a long tunnel from above the flood-prone area of the River Isi, and probably all the way down to the sea, in order to avoid worsening the flood situation further downstream. The length of tunnel needed is estimated to be about 8 – 10 km. The design of both the inlet and outlet would be problematic in technical, safety and aesthetic terms, while the costs of such a measure would be high. We do not recommend further study of this proposal.

Before the river plain in the planning area began to be built on, the river had several parallel courses which transported water when flow rates were high. In the process of building on the area the river was channelled. There are now very few parallel courses within the planning area.

There would not be room for new waterways (flood courses) on the surface in the planning area would not be possible without large-scale clearance of landscaped outdoor areas containing parking places and outdoor storage, rerouting of roads and demolition of buildings. Any new waterways on the surface would also cover such large areas of ground that little building ground would be left This alternative would result in considerably less building area than Alternative 3: raising the ground level. We therefore recommend that the municipality should not proceed with further study of this alternative, due to its very high cost and conflict with natural environment, industrial and property-owner interests.

6.7 Possible opening of Stovibekken

The area-use part of the municipal master plan contains guidelines that require that in all planning cases that concern enclosed streams, the re-opening of such streams should be considered. Within the planning area lie three tributary streams: Stovibekken,

Tanumbekken and Brennebekken, the latter two of which are open within the planning area.

Stovibekken runs through a culvert between Ringeriksveien and the River Isi (Figure 13). The stream used to be an important spawning stream for sea-trout and was also a major upriver migration stream for eels. Since its closure the stream has become of minor importance for fish. Reopening is concerned as desirable for the fish stocks. When flood protection measures are being implemented, Stovibekken could be dealt with in one of the following ways:

- Re-opening and flood protection of the stream by means of embankments and walls.
- The stream stays enclosed and is laid in a pressure pipe. Its closed section would have to be lengthened.
- Re-opening of the stream and raising the height of adjacent area to flood-proof height.

If the stream is kept enclosed in connection with Alternative 1: embankments or walls, the most suitable solution would be to lay it in a pressure pipe. In this case, the enclosed section of the stream would have to be lengthened, and the fish spawning area would be reduced even further. However, the potential for upriver migration could be improved if a pipe were laid at an inclination suitable for the upriver migration of fish.

Another possibility for the opening of Stovibekken would be to follow parts of the course of the stream, according to Tanum map 1951 (Figure 13).

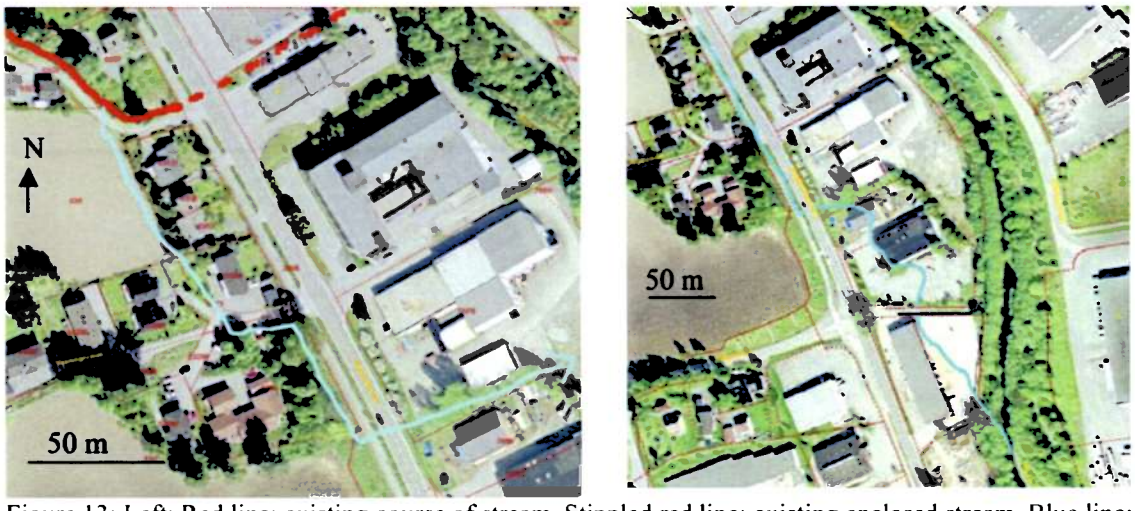

Figure 13: Left: Red line: existing course of stream. Stippled red line: existing enclosed stream. Blue line: an alternative for opening of Stovibekken. Parts of the stream's original course would be utilised (see Tanum map 1951). Right: Course of stream from Tanum map 1951, drawn over orthophoto.

Opening Stovibekken as shown in Figure 13 could offer the following advantages and disadvantages in comparison with leaving the stream enclosed:

Advantages

- Around 500 m of the stream would become a spawning area for sea trout, compared with the current 200 m.

- Increase in upriver migration of sea trout thanks to the open solution in the lower reaches of the stream.
- Prolongation of the enclosure of the stream would be avoided.
- Upriver migration of eels would be a possibility. It is uncertain whether eel larvae would migrate up through a pressure pipe.
- Aesthetic improvement, with new surface water in the planning area.
- Stovibekken makes up about 4% of the Isi's catchment where the two streams join. Opening and rerouting as suggested in Figure 13 would therefore provide a slight reduction in floodwater flow in the Isi for the properties affected, by taking the stream into the river further downstream.
- It might be possible to eliminate a pumping station in Alternative 1: flood protection by means of embankments or walls.

Disadvantages

- Rise in construction costs.
- Building area reduced to some extent.
- The stream would have to be protected against flooding if buildings are protected by embankments or walls.
- Some buildings would find themselves closer to the stream than they are today, and might therefore be more prone to flooding (needs further study).
- The risk of drowning would increase (depending on design). A new course for the stream should be designed to cope with a 200-year flood in the catchment.

The preferred new course for Stovibekken can be secured by means of zoning plans and regulations for Alternative 1: flood protection by means of embankments or walls and Alternative 3: raising the ground level. In the case of Alternative 3, implementation is uncertain due to the uncertainty concerning the time horizon for implementation of such a zoning plan. The municipality should be responsible of implementation and for the costs of re-opening the stream.

7. PLANNING PROCESSES FOR FLOOD PROTECTION MEASURES

Alternative 0: no new flood protection measures
Alternative 1: embankments or walls for flood protection
Alternative 2: protecting building facades
Alternative 3: raising the ground level
Alternative 4: widening the river and lowering the ground level within the flood zone
Alternative 5: laying new river course in the open air or in a tunnel.

Whether these alternatives need to be clarified in the municipal master plan will depend on whether they involve major changes in area use. Protection by means of Alternative 3: raising the ground level could involve major changes in area use, and this is the alternative which is in greatest need of being clarified in the partial plan.

The following alternatives would be major measures which, according to § 23 of the Planning and Building Act, would require a zoning plan to be drawn up: Alternatives 1, 3 and 5.

Where Alternatives 2 and 4 are concerned, a zoning plan might be necessary if the measures are covered by the concept of "major", see § 23 of the Planning and Building Act.

Alternatives 2 and 3 could theoretically be implemented without new zoning since there is no authority for refusing such measures in current zoning plans. However, we regard it as unlikely that these alternatives would be implemented to any great extent without a new zoning plan that would initiate such measures, e.g. via regulations regarding the sequence of works.

NVE is the licensing authority designated by the Water Resources Act, and determines whether the general interests of society are affected to such a degree that the measure is covered by § 8 of the Act (measures requiring licence). Alternatives 1, 3 and 5 would need to be considered under the provisions of the Water Resources Act.

For those alternatives that require the issue of permits under the Water Resources Act, this process could comprise the same requirements regarding participation and open case treatment as in planning treatment according to the Planning and Building Act. In such cases, the municipality could employ § 7 of the Planning and Building Act to dispense with the planning requirements for major building and construction works mentioned in § 23 of the Planning and Building Act. However, NVE may decide that a measure that is permitted in the zoning plan or building plan does not require a permit under § 20 of the Water Resources Act (coordination of permits in accordance with the Planning and Building Act and the Water Resources Act). This assumes that the measure has been adequately investigated and clarified as in the case of dealing with a permit, and that NVE has been given the opportunity to participate in the whole planning process.

Of the suggested alternatives, the requirement to carry out a consequence assessment would have to be considered for Alternative 1: embankments or walls for flood protection; Alternative 3: raising the ground level; widening the river and lowering the ground level and Alternative 5: laying new river course in the open air or in a tunnel.

The regulations for environment impact assessments of April 1, 2005, § 3, no. 2, letter c) cover "major constructions for channelization and flood protection". These are measures that must be evaluated in accordance with § 4 of the regulations, according to which the consequences of any measures carried out in accordance with § 3 must be assessed if, for example, they are performed in particularly valuable environments or in areas of importance for biological diversity, or if they could lead to severe contamination of the soil, water or sediments, or carry a risk of serious accidents, radiation, land-slides or flooding.

It is unclear whether Alternative 1 would be covered by this requirement, given the lack of a detailed definition of what constitute "major constructions".

According to Appendix 1 of the regulations, Alternative 3 would be covered by this requirement, if the cost of the investment was higher than NOK 500 million or covered a gross zoning area of more than 15 000 m^2. This alternative would also fall under these provisions according to § 3 if the gross zoning area was more than 5000 m^2 and was located in a particularly valuable environment or an area of importance for biological diversity.

Alternative 4 would be covered by the requirements if, according to § 3 of the regulations, it was regarded as a "major construction for channelization and flood protection". Since Alternative 4 is hardly likely to encompass a large area, and since the background for the proposal is a desire to bring the river back to an earlier course, the requirement is regarded as unlikely to apply here.

Alternative 5 would be covered by the requirement according to § 3, no. 2, letter c) of the regulations.

After the measures have been clarified in the municipal master plan, zoning plan and in accordance with the Water Resources Act, they would have to be dealt with in accordance with § 93, letter a) of the Planning and Building Act: "Construction, extension, additions, underground construction or location of building, structure or plant".

8. RECOMMENDATIONS

8.1 Alternative 1: flood protection by means of embankments or walls

We recommend that the ongoing planning of flood protection measures by means of embankments or walls should be continued in collaboration with NVE. This measure should be combined with such elements as raising bridges, widening the course of the river on reaches where water "piles up", protecting the façades of individual buildings, and a more detailed study of the possibility of re-opening Stovibekken. Since recent studies have shown that ongoing works in connection with the construction of new bridges will mean that there is no need for flood protection in the southerly part of the planning area, the proposal will have to be modified.

A solution such as outlined above could meet the objectives of industry and property owners very well, as the whole area could be provided with a satisfactory level of protection against flooding within a short time. Where the natural environment is concerned, the most important positive consequence would be obtained if Stovibekken could be opened. The natural environment would also enjoy a positive outcome if the river were widened at places where there are erosion problems on the river-bed. However, encroachments on the riverbank vegetation during the construction phase and a reduction in the width of the vegetation belt in some places would reduce the positive effects.

This solution could be implemented in the course of two to five years if property owners are positive. The solution will require a zoning plan for flood embankments and rivers, and would have to be approved by the municipal government in order to guarantee the local authority's share of the financial package (minimum 20%).

The preliminary draft that has been presented to the property owners should be modified so that less commercial/industrial area is affected, for example by reducing the width of the top of the embankment from four to two metres. It would also be desirable to augment the use of walls rather than embankments where the distance to the river is little and the vegetation belt needs to be protected. If the proposal to construct flood embankments and walls in the wake of further studies is not accepted by property owners, the municipality or other authorities involved, the following alternative should be given further study.

8.2 Alternative 3: raising the ground level by means of a new zoning plan

A zoning plan can be drawn up with the objective of renewal of the flood-prone building mass in the area. Land-filling would have to raise the ground level to the height of a contour corresponding to at least a 200-year flood, plus 0.5 m. New terrain should be given a slight slope in the direction of the river. Cellars are not recommended, since they would have to be protected against flooding and to have flood-proof access.

The building limits towards the river for new buildings, annexes, etc., will have to be evaluated in more detail on the basis of local conditions when a zoning plan is being drawn up. In certain areas, raising the ground level should be permitted closer to the river than the limits of the building construction prohibition area. Access roads and parking areas may be permitted somewhat closer to the river than the limits of the building construction prohibition area.

Planed ground facing the river may be finished in the form of a wall or slope. The solution chosen must be evaluated taking into consideration natural environment, recreational and fishing interests. A slope may be planted with trees, unlike the slope on the outside of a flood barrier. Close to the river the area should be zoned as recreational area and nature conservation area up to the boundary of the area in which access roads and parking are permitted. The possibility of opening Stovibekken and widening the river where it has been narrowed can be legally based on the zoning plan and regulations. It may be possible to issue new regulations concerning the order in which works are carried out, which would ensure that Stovibekken is re-opened before new buildings can be erected.

Such a regulation would allow existing buildings to remain standing and to be maintained as long as their owners wish. The zoning plan can be drawn up in such a way that changes of use, extensions, etc. is forbidden. Existing flood-prone buildings that will not be rebuilt can be protected by means of measures applied to the building itself. Flood protection is the responsibility of the building owner.

Raised ground that finishes with a 1:2 slope towards the river as for the flood embankment proposals is acceptable with respect to hydrology, stability and the possibility of vegetating the slope.

The zoning process must decide whether buildings with high foundations can be permitted, offering a flood-proof ground floor and dry access even if the rest of the plot is at risk of flooding.

An alternative could be a current further development of Alternative 1: flood protection by means of embankments or walls, which may be regarded as an instant solution, while subsequent raising of the ground level would provide a permanent solution with a higher degree of protection than flood barriers can provide.

In the long term, the ground-raising alternative would better meet the objectives of industry, property owners, the natural environment and recreational interests than Alternative 1: flood protection by means of embankments or walls. The most important objections to this alternative centre on the uncertainty regarding the time required for implementation, the fact that it will scarcely be possible to get all the property owners to support the proposal and the high degree of exploitation of the new building areas that would be required.

9. REFERENCES

1. NVE: Area use and protection in flood-prone areas, guidelines 1/1999
2. NVE: Guidelines for planning and building in hazard areas near rivers. Draft version, April, 2006
3. NVE: Project report: Acceptable safety levels in hazard areas near rivers. Draft version, March 23, 2006
4. NVE: Inundation maps; sub-project for Sandvika and Vøyenenga. Document no. 6/2003
5. NVE: Flood estimates for River Sandvik. Document no. 8/2003
6. Lars Jenssen: Water-level estimates for Rivers Sandvik and Isi, Franzefoss – Flebu, Statkraft Grøner, Trondheim. Contract no. 557591, October 2001
7. Bærum Municipality: Flood and acts of nature damage project group, final report, November 2003.
8. County Governor of Oslo and Akershus, Dept. of Environment. Registration of sea-trout rivers, Oslo and Akershus 1996 – 97. Report 1/1999
9. NVE Eastern Region: Preliminary drawings of flood barriers, June 2005
10. Øyvind A. Høydal. FLOWS – River Isi. Effects of flood protection measures for Vøyenenga, NGI Report 2005 1118-1, March 20, 2006.

APPENDIX 1 EXAMPLES OF POSSIBLE NEW ZONING OBJECTIVES AND REGULATIONS FOR ALTERNATIVES 1 – 4

Alternative 1: flood protection by means of embankments or walls.

For the implementation of this alternative, water, riverbank vegetation and flood barriers should be subject to zoning regulations.

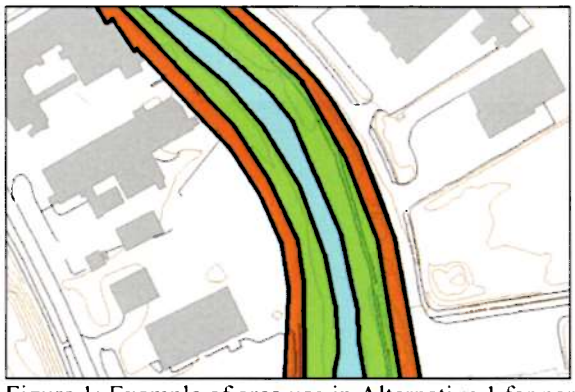

Figure 1: Example of area use in Alternative 1 for part of the area on Vøyenenga.
Key to graphic symbols:
Blue: Special area; nature conservation area in water
Green: Special area; nature conservation area/hazard area/flood-prone area
Brown: Other special area (flood barriers)

Examples of regulations:

- Within the "Special area; nature conservation area/hazard area/flood-prone area", removal of vegetation and terrain encroachments in a zone of up to x metres from the boundary with the flood barrier zone may be permitted in connection with the construction, operation and maintenance of flood barriers.
- Within the "Special area; nature conservation area/hazard area/flood-prone area", it may be permitted to widen the river by up to five metres in order to reduce water velocities during flood events.
- In the area zoned as "Nature conservation area", the dumping of cleared snow is forbidden.
- In the area zoned as "Nature conservation area", riverbank vegetation may be managed in order to improve conditions during flooding. Intended measures should be submitted to the Dept. of Nature and Sports Management, and should be carried out in such as way as not to reduce the value of the area for biological diversity.
- Within the area ": Other special area (flood barriers)" the construction of flood barriers designed to cope with a 200-year flood according to the current flood zone map may be permitted. The flood barrier may be built with a safety margin of up to one metre over the estimated floodwater level. The area may be kept free of higher vegetation. In this area, it is forbidden to implement any measures that might damage the function of the area as a flood protection system. The footbridge over the river at Gnr. 78 Bnr. 51 may be moved, raised and lengthened or removed in order to improve the removal of floodwater. The footbridge over the river between Gnr. 77 Bnr. 184 and Gnr. 77 Bnr. 262 may be

moved, raised and lengthened or removed in order to facilitate the removal of floodwater.

Alternative 2: protecting building façades

As far as we are aware, this alternative does not require changes in area use categories in the zoning plan.

The following zoning regulations can be integrated into existing zoning plans as a sequence regulation:

- For all reports and applications in accordance with §§ 86a, 86b and 93 a, b, c, e, f and h of the Planning and Building Act, the following are required: Flood protection against a 200-year flood of all façades of all flood-prone buildings on the property must be provided before any new construction activities may be carried out.

Alternative 3: raising the ground level by means of a new zoning plan

This alternative will require a new zoning plan

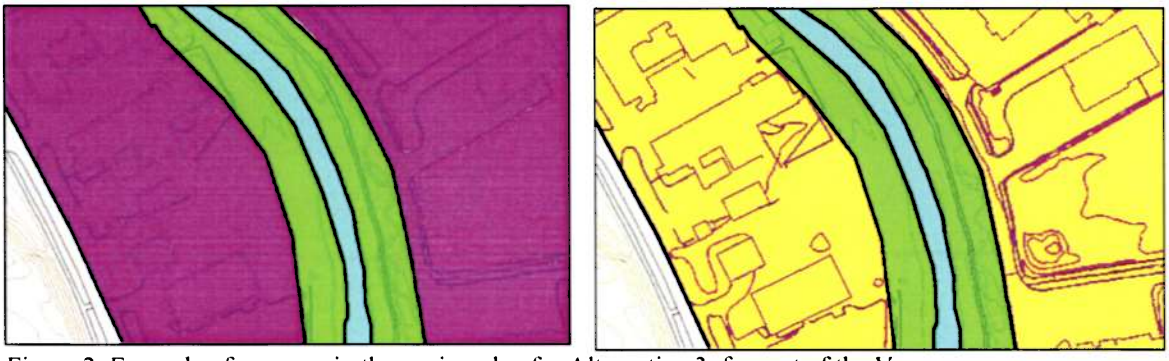

Figure 2: Example of area use in the zoning plan for Alternative 3, for part of the Vøyenenga area.
Key to graphic symbols:
Blue: Special area; nature conservation area in water
Green: Special area; nature conservation area/hazard area/flood-prone area
Violet: Building area; commercial/industrial
Yellow: Building area; housing

Examples of regulations that would apply to the whole of "Building area; commercial/industrial" or "Building area; housing":

- Raising the ground level to flood-proof height can be permitted. The building authorities will decide by how much the ground level can be raised.
- When the ground level is raised, the inclination vis-à-vis "Special area; nature conservation area/hazard area/flood-prone area" should be no greater than 1:2
- When the ground level is being raised, the part facing "Special area; nature conservation area/hazard area/flood-prone area" may be completed in the form of a wall. Any such wall must be clad in natural stone and be given a very good aesthetic design.

- Reports and applications in accordance with §§ 86a, 86b and 93 a, b, c, e, f and h of the Planning and Building Act cannot be granted before the height of the ground on all area zoned for building on the property which the application concerns is sufficient to cope with a 200-year flood on the relevant flood zone map, plus a safety margin of 0.5 metres.
- New buildings, extensions and expansions may not be located closer than 30 m to "Special area; nature conservation area in water". Significant changes or significant repairs to buildings or parts of buildings according to reports and applications in accordance with § 93b of the Planning and Building Act may not be carried out closer than 30 m to "Special area; nature conservation area in water".

Alternative 4: widening the river and lowering the ground level within the flood zone

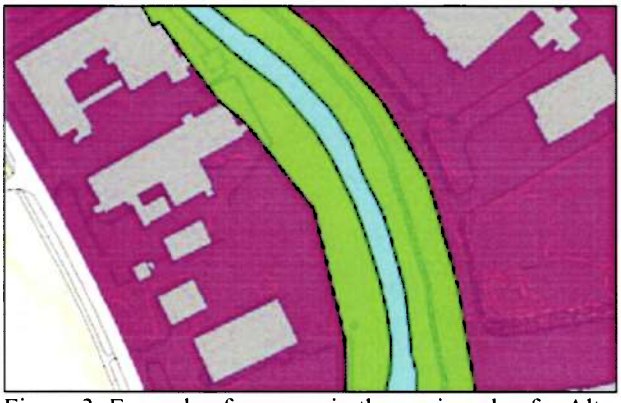

Figure 3: Example of area use in the zoning plan for Alternative 4, for part of the Vøyenenga area.
Key to graphic symbols:
Green: Special area; nature conservation area/hazard area/flood-prone area
Violet: Building area; commercial/industrial

Examples of regulations:

Within "Special area; nature conservation area in water" and "Special area; nature conservation area/hazard area/flood-prone area" it may be permitted to widen the river in order to reduce the risk of flooding. Any such measures must be approved by NVE, the County Governor and Bærum Municipality, and must be performed by NVE or some other qualified company. Within "Building area; commercial/industrial" lowering the ground level may be permitted in order to reduce the risk of flooding.

APPENDIX 2: CURRENT ZONING PLANS AND REGULATIONS IN THE PLANNING AREA

In the area-use part of the municipal master plan, the following uses are shown on the river plain:

- Agricultural, natural and recreational area (LNF)
- Free area
- Water area for general recreational purposes
- Commercial/industrial
- Area for future zoning for the E16 highway, etc.
- Future important landscape, walking/green areas on which building and construction may be permitted (in combination with commercial/industrial)

In current zoning plans, the following uses are shown on the river plain:

- Industry/warehouse
- Footpath
- Park
- Free area in river
- Nature conservation area
- Nature conservation area in river
- Temporary traffic area
- Agriculture and forestry (Holma – set aside in the area-use part of the municipal master plan 2002)
- Road/ground for roads

Some of the areas of water in the River Isi and the Tanumbekken stream to the south have not been zoned. The LNF area in the area-use part of the municipal master plan 2002 – 2020 is only a few metres wider in some places than the free area/nature conservation zones by the river. Long stretches to the west of the river have zoned free areas with widths of 8 – 12 m. These zones have not been implemented everywhere. The free areas include buildings, roads, parking areas and outdoor storage areas in the areas in which existing zoning plans have not been implemented.

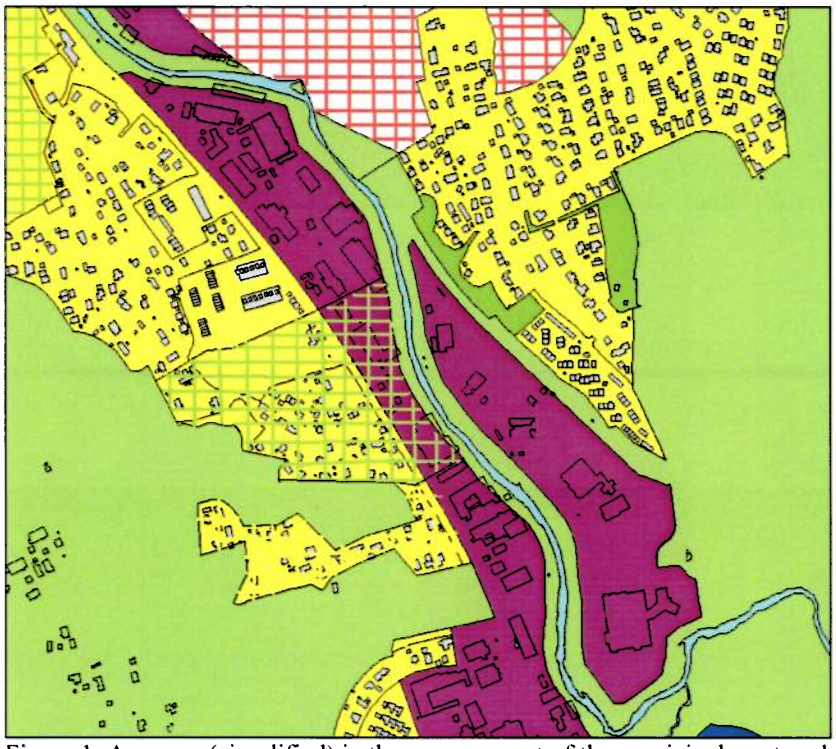

Figure 1: Area use (simplified) in the area-use part of the municipal master plan 2002 – 2020
Key to graphic symbols: Light blue: water, Light green: LNF, Green: Free area, Violet: Commercial/industrial, Yellow: Housing, Yellow with green hatching: Housing with guidelines for green areas, White with red hatching: Restricted use for future zoning for roads.
Further details: map data at www.baerum.kommune.no

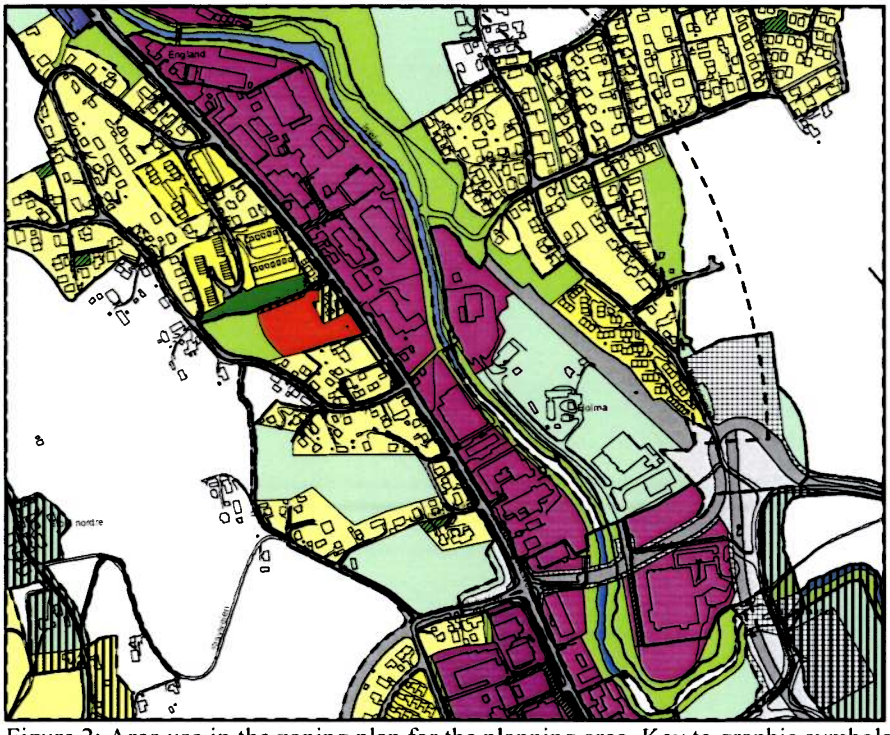

Figure 2: Area use in the zoning plan for the planning area. Key to graphic symbols:
Blue: Free area in water, Green: Free area, Light green: Agriculture and forestry, Violet: Industry and warehousing, Yellow: Housing, Grey: Ground for roads, White: Not zoned.
Further details: map data at www.baerum.kommune.no

Current zoning plans in the planning area

The zoning plan (no. 1979021) for Ringeriksveien, Horniveien and Brenneveien covers a large part of the area north of the new Holma Bridge, on both sides of the river. The limits of the plan are shown in Figure 3, and its regulations are shown below. The plan sets an approximately 20 m building limit vis-à-vis the river, and approximately 10 m-wide free areas.

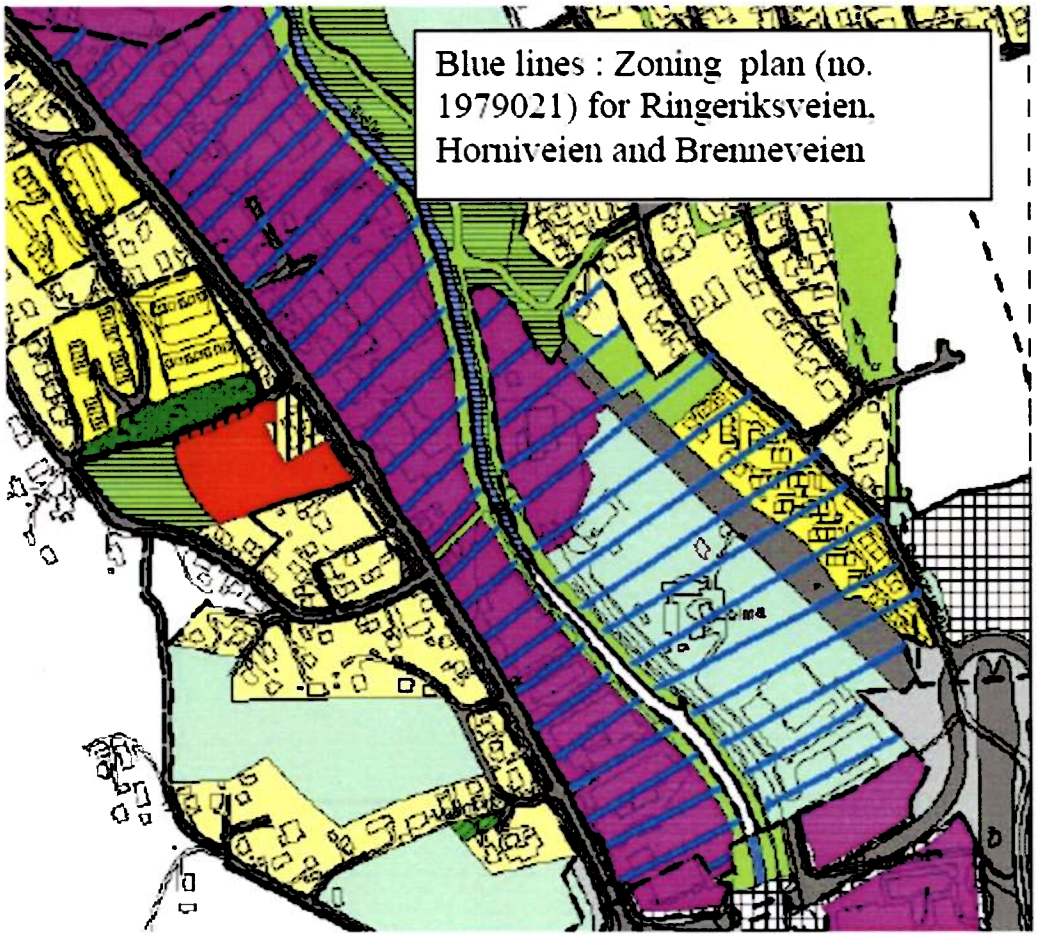

Figure 3: Planning area for the current (as of December 2005) zoning plan for Ringeriksveien, Horniveien and Brenneveien

REGULATIONS FOR THE ZONING PLAN FOR RINGERIKSVEIEN, HORNIVEIEN AND BRENNEVEIEN

§ 1 Within the zoned areas the following regulations apply, in addition to the Planning and Building Act and decisions adopted by Bærum Municipality. Exceptions from the regulations may be allowed by the building committee within the same legal framework.

§ 2 Existing valuable vegetation should be conserved.

§ 3 Before a building permit is issued, the building committee may require a building plan and outdoor use plan for the whole or parts of the building plot or field to be submitted, in accordance with § 69.3 of the Planning and Building Act.

A detailed plan for noise-screening measures should accompany building plans for fields B1 and B2. The plan should show noise screens as well as their design and height, and should be based on limiting the noise level in the housing area to 55 dBA. This measure should be implemented in the course of developing the housing area.

§ 4 Activities that cause pollution, or that produce fire or explosion hazards, may not be located in commercial/industrial areas. The area between the boundary of a plot and the building limit vis-à-vis the river should be treated as park. The building committee may require fencing to be installed as screening vis-à-vis free area. The height and design of such fencing may be determined by the committee.

§ 5 A drivable road to field I 2 will be laid from the existing Ringeriksvei, via field I 3. The building committee may permit the construction of a bridge on public free area in order to furnish a connection between I2 and I3.

§ 6 Car/parking places should be laid out at the same time as buildings, in accordance with the norms set out by the building committee. Garages for field B 4 should preferably be built as a single structure.

§ 7 Pedestrian tunnels west of area B 2 and the place where the new Ringeriksvei crosses the River Isi will be built at the same time as the road. Where the road meets the river, at the northernmost point of the plan, the road will be constructed as a bridge.

§ 8 Before the construction of traffic areas commences, the building committee should have approved the detailed plan for noise/screening measures. The plan will identify noise embankments, noise screens, etc., as well as their design and height, and will be based on limiting the noise level in adjacent areas to 55 dBA. The building committee may reduce this requirement somewhat where the road meets areas used by industry, etc. The measures should be implemented as part of the road/building programme.

The zoning plan (no. 1996010) for the stretch of the E16 Wøyen – Økri cover a large part of the area to the south of the new Holma Bridge, on both sides of the river, as well as a plot of land north of the bridge. The limits of the plan are shown in Figure 4, and its regulations are shown below. The plan sets an approximately 20 - 50 m building limit vis-à-vis the river, and approximately 10 – 50 m-wide free areas.

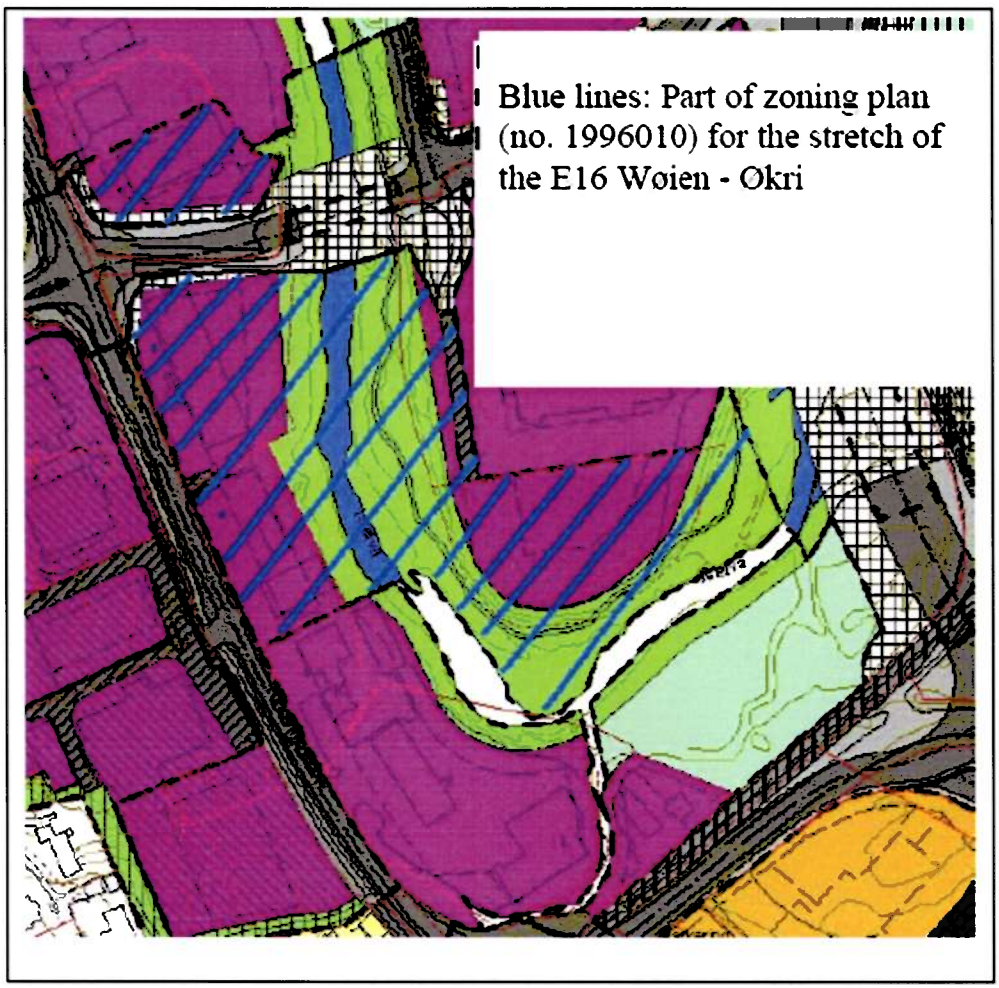

Figure 4: Planning area for the current (as of December 2005) zoning plan for the stretch of the E16 Wøyen – Økri.

REGULATIONS FOR THE ZONING PLAN FOR E16 FOR THE STRETCH OF WØYEN – ØKRI

§ 1 OBJECTIVES

The objective of the zoning plan is to identify a new route for the stretch of the E16 between Wøyen and Økri with an access road between Lommedalsveien/E16 and Vøyenenga, and new access to the Holma industrial area.

The objective of the new route for the E16 plus ancillary road constructions such as bridges, tunnel openings, land-fills and cuttings is to adapt to and conserve important cultural remains and the cultural and natural landscape.

§ 2 MIXED PURPOSE, TEMPORARY TRAFFIC AREA

REGULATIONS REGARDING SEQUENCE OF WORKS

A temporary traffic area may be utilised as a construction area as long as road works are in progress. The rig area R will function as a rig area and for related activities. The area may be used as a rig area only for the stretch of the E16 between Wøyen and Økri and related construction activities. The designation as temporary traffic area R and equivalent areas on L1-S and L2-S will cease to apply no later than the date on which the relevant stretch of the E16 is opened to traffic. Before that date, the area L1-S and other temporary traffic areas of F4-S and L2-S should be landscaped as a completion of the Wøyen Gård cultural landscape, with suitable vegetation, etc., in the edge zone vis-à-vis the E16. Other temporary traffic areas will cease to be designated as such at the latest one year after the relevant stretch of the E16

is opened to traffic. Before that date, these area will be landscaped with vegetation and planting in accordance with the approved plan.

Before construction in connection with the zoning plan can begin, an archaeological study of automatically protected cultural remains (traces of dwellings R1) on Vøyen 78/1 must be carried out. Once the plan has been approved, the municipality must contact the County Council's cultural heritage management department and the University of Oslo's Museum of Cultural Heritage in good time and at the latest, three months before any measures are undertaken. The University of Oslo's Dept. of Archaeology, Art History and Numismatics will thereafter determine what conditions should apply for dispensation with respect to the Cultural Heritage Act of July 9, 1978. The cost of the survey will be met by the responsible contractor in accordance with § 10 of the Act. The implementation plan will form part of the landscaping plan in accordance with § 8, second paragraph.

§ 3 AESTHETICS

The design guide for E16 and Bærum Municipality's "Aesthetic guidelines for planning and building applications" should be followed. The riverscape and the riverbanks should not be disturbed more than is absolutely necessary when bridge foundations are being laid. Any landscape features/riverbanks that have been disturbed must be returned to good condition in collaboration with the municipality, and should be adapted to the existing cultural landscape. An aesthetics plan that also illustrates how the whole road system is to be planted out will be drawn up. Lighting on bridges that cross the river, and along the river itself, must be designed so that light does not fall directly on the surface of the river. All structures should be given an aesthetic design that meets reasonable aesthetic criteria in themselves and with respect to their surroundings, and which makes a good impression at a distance. Aesthetic evaluations, and evaluations with regard to the riverscape, fish stocks, etc., should be sent to the planning authorities for approval.

§ 4 BUILDING AREAS

A stream will be culverted through the temporary traffic area in the north-eastern corner of industrial area I-4 from the west side of Brenneveien to the retention reservoir that forms part of the road zoning plan.

The utilisation quotients and cornice heights for the industrial areas are as follows:

I-1:T-BRA = 1500 m^2, cornice height 10 m.
I-2:T-BRA = 4000 m^2, cornice height 10 m.
I-3:T-BRA = 2200 m^2, cornice height 10 m.
I-4:T-BRA = 9500 m^2, cornice height 10 m.
I-5:T-BRA = 4500 m^2, cornice height 10 m.
I-7:T-BRA = 2200 m^2, cornice height contour 32.

§ 5 AGRICULTURE

Part of the agricultural area L 4 north of the new E16 may be land-filled with suitable aggregates and made suitable for agricultural purposes.

§ 6 FREE AREAS

There should be vehicle access as far as the existing municipal pumping station on free area F5, between industrial area I-3 and the River Isi.

§ 7 SPECIAL AREA, CONSERVATION

Existing valuable trees in the area GS-V must be conserved.

The removal of the Køla Bridge and its foundations and the construction of a new bridge should be carried out in a way that avoids damage to the oak trees at both ends of the bridge.

Areas L1-S, L2-S, F3-S, F4-S, F8-S and GSV-S will be zoned for the conservation of historical, antiquarian or other cultural values. These areas will be conserved as part of the natural landscape of Wøyen Gård; see also § 8.

§ 8 TRAFFIC AREA

Access from the prolongation of Lommedalsveien to the nursery properties is permitted. The exact location of the access road will be determined in a future zoning plan for these properties. A landscaping plan for the road infrastructure between the Sandvik River and the southern entrance to the Brenne Tunnel will be drawn up in agreement with the head of the County's Dept. of Culture and the Bærum planning authorities. This plan will be used as a basis for dealing with building applications. Future terrain must be illustrated.

Tunnel: the following works must not be undertaken within a distance of 12 m from the outer walls of the tunnel (about 18 m radius from the centre of the tunnel profile) without special permission from the National Highways Administration:

- Blasting
- Pile-driving into rock
- Drilling into rock
- Drilling wells or other holes in rock
- Foundations designed to support additional loads on rock.

§ 9 COMMON AREAS

The common access road shown in the plan will be common to the industrial areas I1 and I2, and I4 and I7.

§ 10 NOISE AND VIBRATION

The lowest threshold in the Ministry of Environment's guidelines for traffic noise in planning according to the Planning and Building Act, circulars T-8/79 and T-1/86 will be observed in the implementation of the zoning plan. For structural noise, the maximum threshold values must not exceed 30 – 35 dBA "slow". The
lower of paired values must be met. For vibrations in rooms with long-term occupation, the threshold values must not exceed 0.4 – 1.0 mm/s maximum weighted vibration velocity. The lower of paired values must be met. For construction activities, the threshold values corresponding to the Regulations regarding limits on noise, adopted by Oslo Health Council on August 28 1973, by Oslo City Council on January 24, 1974 and confirmed by the Ministry of Social Security as a special appendix to the health regulations for the City of Oslo on October 9, 1974 will apply.

Other zoning plans

Individual properties and buildings in the flood protection planning area are zoned in other plans than the two mentioned above. This is the case for the northernmost part of the planning area, the area around the new Holma Bridge and to the very south of the planning area. All details concerning these zoning plans can be found via the interactive map located at www.baerum.kommune.no.

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