REPORT

Stakksberg Helguvík Upgrade

CLIENT

Stakksberg EHF

SUBJECT

Outdoor noise from plant to surroundings

DATE: / REVISION: March 12, 2019 / 01

DOCUMENT CODE: 10204714-01-AE-REP-043

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REPORT

PROJECT	**Stakksberg Helguvík Upgrade**	DOCUMENT CODE	10204714-01-AE-REP-043
SUBJECT	Outdoor noise from plant to surroundings	ACCESSIBILITY	Open
CLIENT	**Stakksberg EHF**	PROJECT MANAGER	Thor Martin Bjarnøe
CONTACT	Thordur Magnusson	PREPARED BY	Torbjørn Grønningen
		RESPONSIBLE UNIT	10106020 - Acoustics
COUNTRY	/ / / Iceland, Helguvík		

SUMMARY

As input for the environmental impact assessment (EIA) for the Stakksberg Helguvik upgrade project, Multiconsult has studied the plant's noise emission towards neighboring properties. The plant's noise emission has been calculated using Cadna/A software, predicting the future noise emission with one furnace and four furnaces.

None of the results exceed the noise allowance or the governmental regulation, under the given assumptions in chapter 4, and no noise reducing measures are required for compliance.

The calculations reveal that the dominating noise sources are quartz handling activity, break-out duct noise from the furnace house draft, as well as quartz-falling from the conveyor band into the hoppers at the top of the day bins.

The report suggests a few noise reducing "optimizations", even though they are not required with respect to neighborhood noise compliance.

In extreme cases, the night time noise limit, L_N, could possibly be exceeded: If a ship is in the harbor with engines on, offloading quartz throughout the night (23-07), and chiseling is simultaneously done for 30 minutes between 23-07, the calculated night time noise limit will be close to being exceeded. Extreme operations like these must be avoided during nighttime hours.

The requirement relating to the indoor maximum noise level, $L_{AF,max}$, is under no relevant circumstance in danger of being exceeded. By assuming a standard house façade sound reduction of 30 dB, the outside façade noise level needs to be 75 dB(A) $L_{p,AF,max}$ (45+30 dB). Given the distances to the closest noise sensitive land use, the sound pressure level at the plant would need to be around 140 dB at the harbor, which is highly unlikely.

REV.	DATE	DESCRIPTION	PREPARED BY	CHECKED BY	APPROVED BY
01	12.03.2018	Issued after client comments	Torbjørn Grønningen	Peter Klaveness / Harald Haarstad	Thor Martin Bjarnøe
00	18.01.2019	Issued for client review	Torbjørn Grønningen	Peter Klaveness / Harald Haarstad	Thor Martin Bjarnøe

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1 Abbreviations and definitions

1.1 Abbreviations

Table 1 Abbreviations

Abbreviation	Description
EIA	Environment Impact Assessment
EOP	Environmental Operating Permit
T	Tonne / Metric ton (1000 kg)

1.2 Definitions

Table 2 Definitions

Term	Description	Definition
dB	Decibel	A ratio expressed on a logarithmic scale
L_p (SPL)	Sound pressure level	Apparent sound pressure at a given location relative to a reference pressure of 20 μPa on a logarithmic scale.
L_w (SWL or PWL)	Sound power level	Radiated sound power relative to reference power of 1 pW on a logarithmic scale.
dB(A)	A-weighted L_p or L_w	Frequency filter A(f) that corresponds to the sensitivity of the human ear at moderate noise levels.
$L_{A,eq,T}$	Equivalent sound pressure level.	Average A-weighted SPL over a specified period of time, T.
L_{day} / L_d	Day equivalent sound pressure level	The average sound level over a 12 hour day time period
$L_{evening}$ / L_e	Evening equivalent sound pressure level	The average sound level over a 4 hour evening time period
L_{night} / L_n	Night equivalent sound pressure level	The average sound level over a 8 hour night time period

2 Background and purpose

The Norwegian engineering company Multiconsult are working with the Icelandic engineering company Verkis on upgrading Stakksberg Helguvik silicon smelter plant. Today, the plant is shut down, but work is in progress to upgrade the production process and getting the plant in production.

An environmental impact analysis (EIA) is to be prepared for governmental application. A noise evaluation is part of the EIA, and therefore, Multiconsult's Oslo department of acoustics has studied

the plant's noise emission toward the closest properties in Reykjanesbær. The report does not include an evaluation of working environment noise.

3 Noise requirements

In this chapter, the plant's emission noise limits and the (general) governmental requirements are presented.

3.1 Noise limits established for Stakksberg

The Environment Agency of Iceland, Umhverfisstofnun, has given the plant an environmental operating permit[1], dated July 4th 2018. Considerations to be observed by the operator regarding noise emission is covered in the permit's chapter 2.17. Below is a translation of the chapter:

"The operator should reduce noise and vibration from the equipment to the extent possible, for example through regular improvement projects, and ensure that noise from the operation complies with Table III and other provisions of Regulation No 724/2008 on noise. Noise area outside the work area of the operator shall not exceed 70 dB (A) L_{Aeq} in industrial areas and 55 dB (A) L_{Aeq} in residential areas in front of a building's façade. The following actions are examples of actions that may be considered as remedial tasks, cf. 1st paragraph:

- *Review procedures/methods available to reduce noise.*
- *Check noise generated by the handling of raw materials.*
- *Make subdivisions to enclose the noise.*
- *Ensure that doors and windows are closed when noise levels are highest."*

This requirement does not differentiate between the day subperiods. Which activities that are counted as part of the plant's operational activities (e.g., port operations) is not explicitly stated. Multiconsult has used experience from similar projects in this regard and have included the port activity in the assessment.

3.2 Governmental general noise requirements

Governing noise limits for noise from industrial plants are listed in table 3. This is a copy of a relevant part of Table III of the Icelandic Regulation No. 724/2008 on noise.

Table 3 Noise limits from regulation no. 724/2008, table III

Noise limits stated in regulation no. 724/2008, table III							
Type of housing	Limits to noise from commercial activities						
	L_d (07-19)		L_e (19-23)		L_n (23-07)		L_{AFmax} (night)
	In front of façade	Indoors	In front of façade	Indoors	In front of façade	Indoors	Indoors
Residences in residential areas	50	30	45	30	40	25	40
Residences in mixed development and central areas	55	30	55	30	40	30	45
Industrial and work areas	70		70		70		

[1] https://www.ust.is/library/Skrar/Atvinnulif/Starfsleyfi/Starfsleyfi-i-gildi/Verksmidjur/2018.07.04%20Færsla%20starfsleyfis%20EB0117%20ehf.pdf

The noise emission limits defined in the permit correspond to the urban areas (line 2).

4 Assessment basis

4.1 Calculation information

The calculations are made using the environmental noise software program Cadna/A, version 2019. The calculations utilize the methods specified in the Nordic Prediction Method for Industrial Noise [1]. The calculations are performed using plans and/or forecasts about future layout, available information and decisions up until the date of this report, and specific process information for the Stakksberg plant, as described in chapter 4.2.

The noise emission calculation model is based on a digital terrain model containing elevation contour lines with one meter resolution, building outlines, coastline and roads. The data was developed using registrations done by the Icelandic company Loftmyndir during the summer of 2018. The gable heights of buildings in Reykjanesbær (closest noise sensitive properties) are assumed to be approximately seven meters. The noise immission values (at distinct receiver points in front of the closest houses) are calculated as incident "free field" sound, i.e. without reflections from surrounding buildings, and the noise contours are shown at an elevation of two meters. Sea elevation is set at 0 meters, and the road-objects (included because of sound reflection, as described in next paragraph) are placed on top of the terrain. The noise sources are modelled as determined most applicable in each case at relevant positions and heights.

All ground is set to be fully absorptive (absorption factor = 1,0), except water, which is set to be completely reflective (absorption factor = 0). Road objects are considered to be fully reflective. All buildings are defined as non-reflective ("free-field"), according to Icelandic Regulation No. 724/2008 on noise. The noise contour map is built up as a grid with 10x10 m resolution. The Nordic prediction method calculates the noise with a tail-wind, i.e., from the source to the receiver, to represent a worst-case condition. Specified wind speed is 5 m/s.

4.2 Calculation basis

Multiconsult Acoustics have obtained thorough insight into the plant operations during a plant visit at the end of November, 2018. A meeting [2] was held between Multiconsult and Stakksberg, with the aim to establish an understanding about the plant process, and to gather detailed information about dominating noise sources and operation time.
Additional information and forecasts about the future changes was gathered internally in the project group and from Thórdur Magnussón from Stakksberg.

The noise evaluation deals only with noise from the plant itself, neglecting all other background noise, such as air and road traffic noise.
The studied cases are:

1. **One furnace.** Updated and improved plant with a 420 T nominal weekly production.
2. **Four furnaces.** Expansion of the plant with quadrupled capacity and production.

The following subchapters present the noisy activities included in the noise calculations and describe the additional assumptions related to extending to four furnaces. Table 5 in chapter 9 (Appendix) summarizes the sound power levels and the operation times for each noise source and activity.

4.2.1 Harbor activities. Ship idling (ship's engine exhaust noise). Offload raw material to trucks.

Raw material delivery is directly related to the plant premises and must therefore be included as part of the plant noise emission.

Ships with raw material arrive every two weeks, delivering quartz, low-ash coal, wood chips, or charcoal. This means that each type of raw material is delivered every eight weeks. Offloading happens continuously through day and evening, but will cease between 23:00 and 07:00. The calculations, however, include offloading-related activity from 06:00-24:00. It is Multiconsult's experience from numerous projects, that "related activities" continue a while after the main activity has ceased (i.e. in this case; offloading and ship idling). "Related activities" are, e.g. hatch closing on the ship, ship idling, offloading vehicle driving, among others. This is considered more realistic and conservative.

Given the use of four trucks with a load capacity of 24 T quartz and low ash coal, 16 T for wood chips and 14,4 T for charcoal, the total duration for loader driving activity is 31,3 hours for quartz and wood chip delivery, 6,9 hours for charcoal delivery, and 15,6 hours for low-ash coal.

The sound power level, L_{WA}, from quartz offloading is 116 dB, as measured at the Elkem Bremanger plant in Norway. The sound power level, L_{WA}, for the other material offloading is estimated to be 106 dB, based on experience.

Ship idling noise, primarily due to the electricity generators, is estimated to last 20 % longer than the duration of the actual offloading. A representative sound power level L_{WA}, was measured at Elkem Bremanger to be 103 dB.

In the case with **four furnaces**, it is assumed that the raw material quantities are quadrupled. The duration of offloading and ship idling is the same per ship as for one furnace. However, it is assumed that ships arrivals are more frequent, partly because of limitations of the harbor concerning ship size. This has been discussed between Multiconsult and Stakksberg.

4.2.2 Transportation of raw materials from harbor to raw material area, and dumping of raw materials.

Raw materials are transported from the harbor to the raw material storage area, where they are deposited. The activity is assumed to take place between 06:00 and 24:00.

The calculations are based on the use of four trucks with an average speed of 25 km/h. The truck weight capacity depends on the density of the loaded material, as described in chapter 4.2.1, and it is assumed that one round trip takes 30 minutes. (A round trip consists of loading, driving up to the storage area, dumping, and driving back to the harbor.)

The number of trips required to freight all delivered raw material from harbor to upper area is derived by dividing the weight of delivered material by the truck load capacity:

- For quartz: 6000T/24T = 250 trips
- Charcoal: 800T/14,4T = 56 trips
- For wood chips: 4000T/16T = 250 trips
- Low-ash coal: 3000T/24T = 125 trips

The average truck sound power level, L_{WA}, was measured at the Elkem Bremanger project to be 105 dB.

In the case of **four furnaces**, the duration of the transportation activity from each comparable ship would be the same. The difference is that the activity would happen four times as often, and thus the average noise over an eight week average will increase. The plant activities have been defined with an eight week rhythm, thus this time period is used as a reference for averaging.

4.2.3 Dumping of raw materials to conveyor using a wheel loader.

Raw materials are transported from the storage areas to the conveyor band using a wheel loader.

Each round trip duration is estimated to be two minutes, i.e. loading the bucket, driving to the loading ramp or the wood chip feeding area, and driving back for another load. The number of round trips is derived from the weight of raw material during the eight week period divided by a bucket capacity of 8 T.

The quartz dumping sound power level is assumed to have the sound characteristic as quartz offloading, thus the noise source in the model is given a sound power level, L_{WA}, of 116 dB. Dumping of coal and wood chips is not as noisy as quartz, and the sound power level was estimated to be 106 dB(A).

In the case of **four furnaces**, the number of events per hour is assumed to remain the same, but the duration of the activity within the eight week average is multiplied by four.

4.2.4 Noise inside the furnace building.

The noise inside the furnace building consists of a steady background noise from exhaust fans, the furnace electrodes, and general activity of vehicles and material handling. More intermittent noise is generated by the pouring of melted metal from the furnaces, by casting and by the moving of ladles.

The noise in the furnace building at Elkem Bremanger was measured during that project, and sound data from that measurement has been used to model new, virtual sources at the gate openings. The gates are assumed to be open most of the time.

4.2.5 Transportation of silicon plates from furnace building with wheel loader (with fork) to cooling storage area, further to the crusher building with a front wheel loader.

Transportation of hot silicon plates to cooling storage, and after cooldown, to the crusher house, is done with a wheel loader. Silicon is produced continuously, thus the wheel loader runs regularly between the furnace house and the cooling storage, at a rate of 8-10 times per day. The cold metal is collected for crushing and screening three days per week, 10 hours per day, assumed restricted to the day period (07:00 – 19:00). Two crushers and two screens are used as input to the noise calculation.

The wheel loader has a sound power level, L_{WA}, of 106 dB. The crushing and screening activities have sound power levels of 104 and 100 dB, respectively. All three sources were measured at the Elkem Bremanger plant.

Four furnaces and a quadrupled production will require a larger capacity for transporting hot silicon from the furnace house to cooling. This is assumed to require one additional wheel loader, as well as doubling the number of trips per day. Cooled metal is then assumed to be collected for crushing and screening five days per week, 12 hours per day, between 07:00 and19:00.

4.2.6 Chiseling inside cooling storage house

The silicon is chiseled inside the cooling storage house, south of the furnace house. This is the building that was earlier used for crushing, The building has two meters high concrete walls. Above

this elevation, it has a structural steel framework carrying a canvas superstructure. The canvas has poor sound reduction properties, especially at frequencies below 250 Hz (R_w approximately 10 dB). The majority of the sound energy will radiate through the canvas. The gate openings are assumed to be closed when chiseling happens.

From experience with the Elkem Bremanger project, it is assumed that the duration of the chiseling activity is 30 minutes per day. This occurs three days per week, as for the crushing and screening, within the day period (07:00 – 19:00).

Sound measurements from previous projects indicate that the sound power level, L_{WA}, from chiseling activity is approximately 131 dB.

With **four furnaces** in operation, the chiseling duration is quadrupled.

4.2.7 Crushing and screening of silica in crusher house. Transport of crushed material (in bags / bulk loaded into containers) to the harbor.

The crushing and screening house is a part of the new, upgraded plant. Details about this was provided by the project engineering group. It will be built with insulated metal sandwich construction, such as Paroc or similar. A sound reduction of R_w = 26 dB for the crusher house walls and roof was used in the calculations. This corresponds to a 100 mm Paroc construction.

The plan is to run crushers and screens 10 hours per day, three days per week. Measurements indicate a sound power level, L_{WA}, of 104 and 100 dB for crushers and screens, respectively. The crusher house gates are assumed to be closed when there is much noise inside.

50% of the crushed silicon is filled into bags which are loaded into bag-containers, and 50% is loaded into bulk containers. When filled up (20 bags / 20 T), the containers are moved to the quay, using a container mover. This requires seven trips to the harbor three days per week, with the production goal of 420 T per week.

Measurements at a container mover indicate a sound power level, L_{WA}, of 116 dB.

The crushers and screens have capacity to handle the production quantities from **four furnaces**. With four furnaces, it is possible is to run the crushing equipment 12 hours per day, five days per week. The crusher house is assumed unchanged in the situation with four furnaces. A production of 1680 T silicon per week requires almost 17 containers per day five days per week.

4.2.8 Air handling related sources: air inlets, air suction (dust filters), exhaust fans.

The reverse fan outside the Bag House and the induced draft fan ("ID fan") between the Day Bin and the distribution station were measured during the Multiconsult visit to the plant. The sound power levels, L_{WA}, were determined to be 100 dB and 97 dB, respectively. They are running continuously, day and night.

The steel ducts connected to the above-mentioned fans radiate a lot of noise ("break-out noise"). Measured sound power from the accessible ducts was 103 dB per meter duct. The duct network is included in the noise calculation model.

Outside the crushing and screening house there are plans for a fan with bag-filter, to extract the dust and fumes. The fan has a capacity of 65.000 m^3/h.

Outside the furnace building on the southwestern corner there is an air cooled HP Compressor that was measured by Multiconsult during the visit. Measured sound power level, L_{WA}, was 87 dB outside the louver. On the same corner of the furnace house it there are plans for a large exhaust fan with filter, related to tapping and casting exhaust. Planned capacity for the fan is 200.000 m^3/h. This is a

large fan, which experience shows generate 105-110 dB(A) sound power level (corresponding to about 95 dB(A) sound pressure level at 1 meter distance). For the calculations, a sound power level, L_{WA}, of 108 dB is used.

In the **four furnace** situation, the furnace exhaust system is quadrupled. One larger and one smaller bag house is added next to the existing bag house (positioned according to preliminary layout drawings), and three reverse fans and ID fans with connected ducting are added. Sound data from existing fans has been used for these fans.

4.2.9 LP and HP Compressors outside Bag House and Furnace building.

The HP compressor outside the furnace building was measured when Multiconsult visited the plant. The sound power level, L_{WA}, outside the louver was determined to be 83 dB. The compressor runs continuously.

On the upper level, south of the bag house, a LP Compressor is planned. At this point, it is not clear if it will be an air cooled or water cooled compressor, but it will be enclosed. For the modelling, we have assumed a similar sound spectrum and sound power level as for the HP Compressor on the lower area, with louvers in the enclosure/building.

4.2.10 Micro silica handling

Micro silica dust is collected in bags, which are placed in containers and shipped from the harbor. One container can hold 20 bags, or 20 T weight.

During the above mentioned meeting between Multiconsult and Stakksberg [2], the number of micro silica bags per day was estimated. Pouring/casting and crushing/screening was estimated to generate a total of two bags per day. Larger particles from the cyclone are approximated to fill four bags per day. Containers for the micro silica bags are deposited at each source area and, when filled, transported to the harbor.

With **four furnaces**, the above quantities are expected to quadruple.

4.3 Presentation of Results

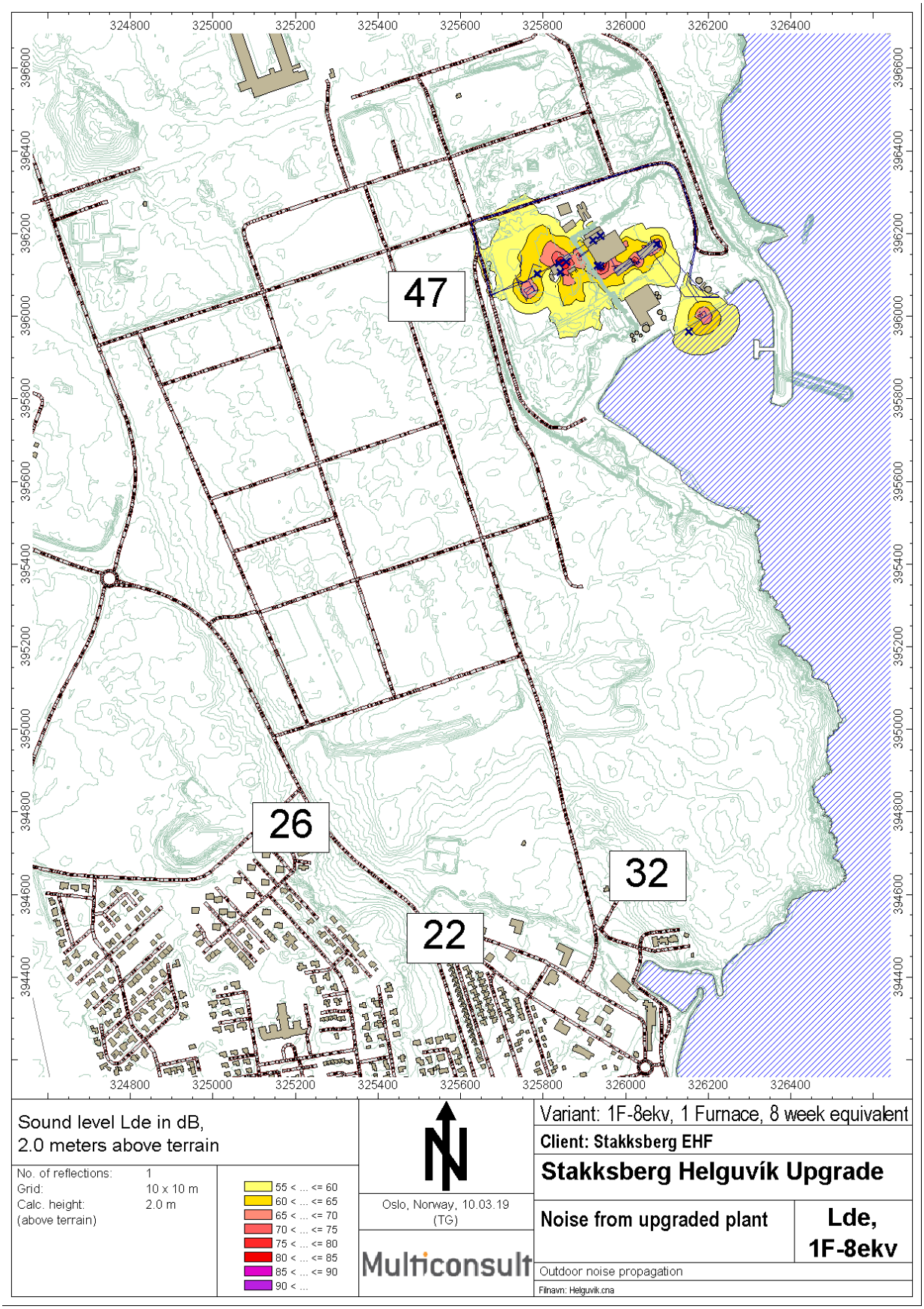
The noise limit in the pollution permit states the emission limit as an equivalent level ($L_{A,eq}$) , which is an energetic average over a period of time. The time period is not defined in the permit text. One task of this study is to represent the plant's noise emission over one or more representative time periods to describe it as a whole. As discussed above, the noise sources vary over time (hours, day periods, days, and weeks). To include all work operations, we have chosen an averaging time period of eight weeks. This represents approximately the cycle of raw material delivery (the four raw material types are delivered about every second week) with one furnace. The equivalent noise level over the eight week period will thus include offloading activity from all raw material types and ship idling noise. The plant's equivalent noise level repeats in eight week cycles and the emission is thus representative for other time periods longer than this (for EIA purposes, noise emission is commonly calculated as an annual average emission).

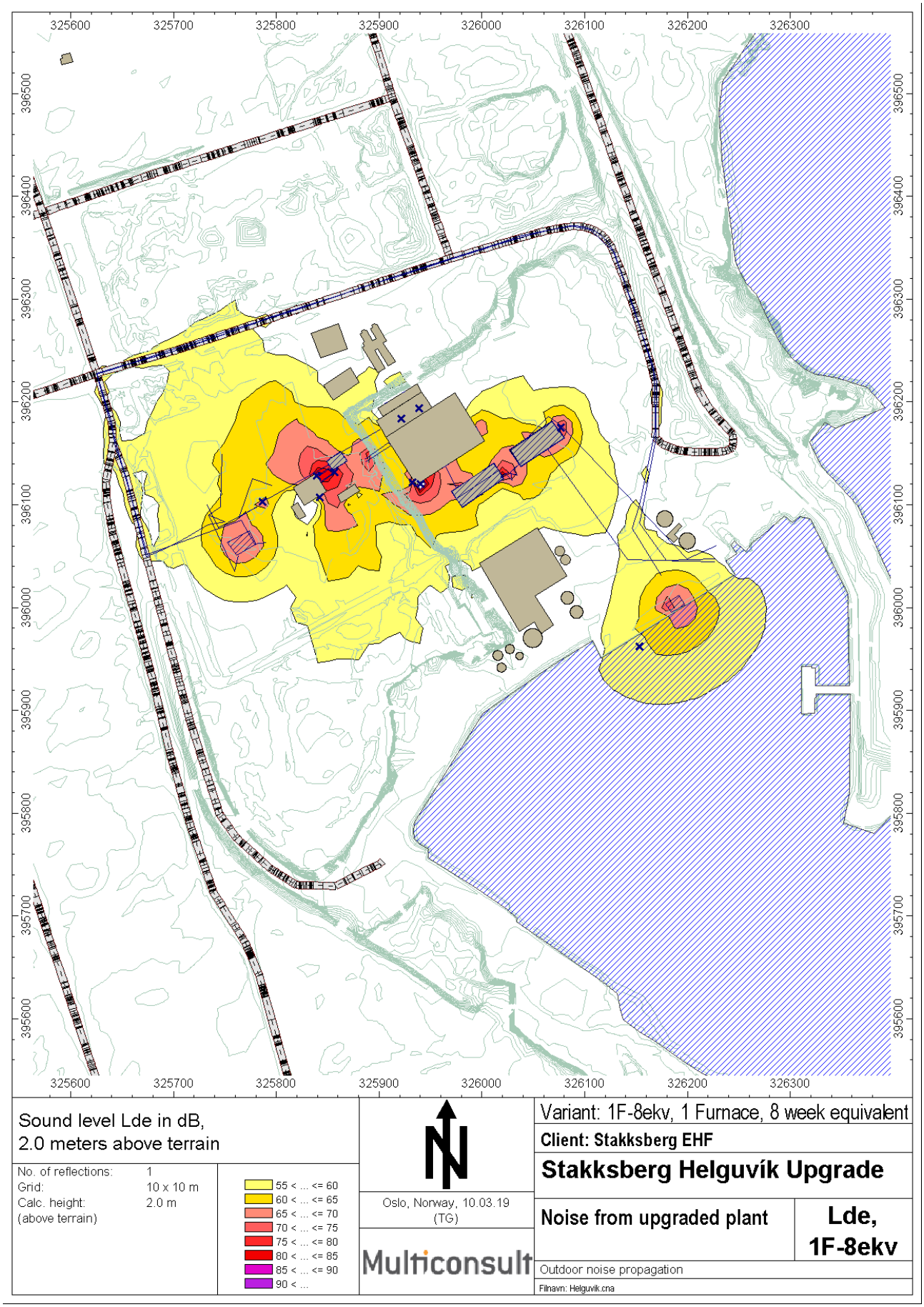
Strictly speaking, the noise limit is stated such that one could argue that it should never be exceeded. Therefore, we have calculated a hypothetical "worst day". In this scenario, all work operations that may possibly happen within one day, are included.

The results are presented for direct comparison with the regulatory requirements, i.e. over the period of 07:00 – 23:00 (day/evening), 23:00 – 07:00 (night), and in terms of maximum levels, $L_{A,max}$.

5 Results for upgraded plant with one furnace

5.1 One furnace – 8 weeks equivalent. Day-/ evening noise (07-23), L_{de}

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Sound level Lde in dB,
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No. of reflections: 1
Grid: 10 x 10 m
Calc. height: 2.0 m
(above terrain)
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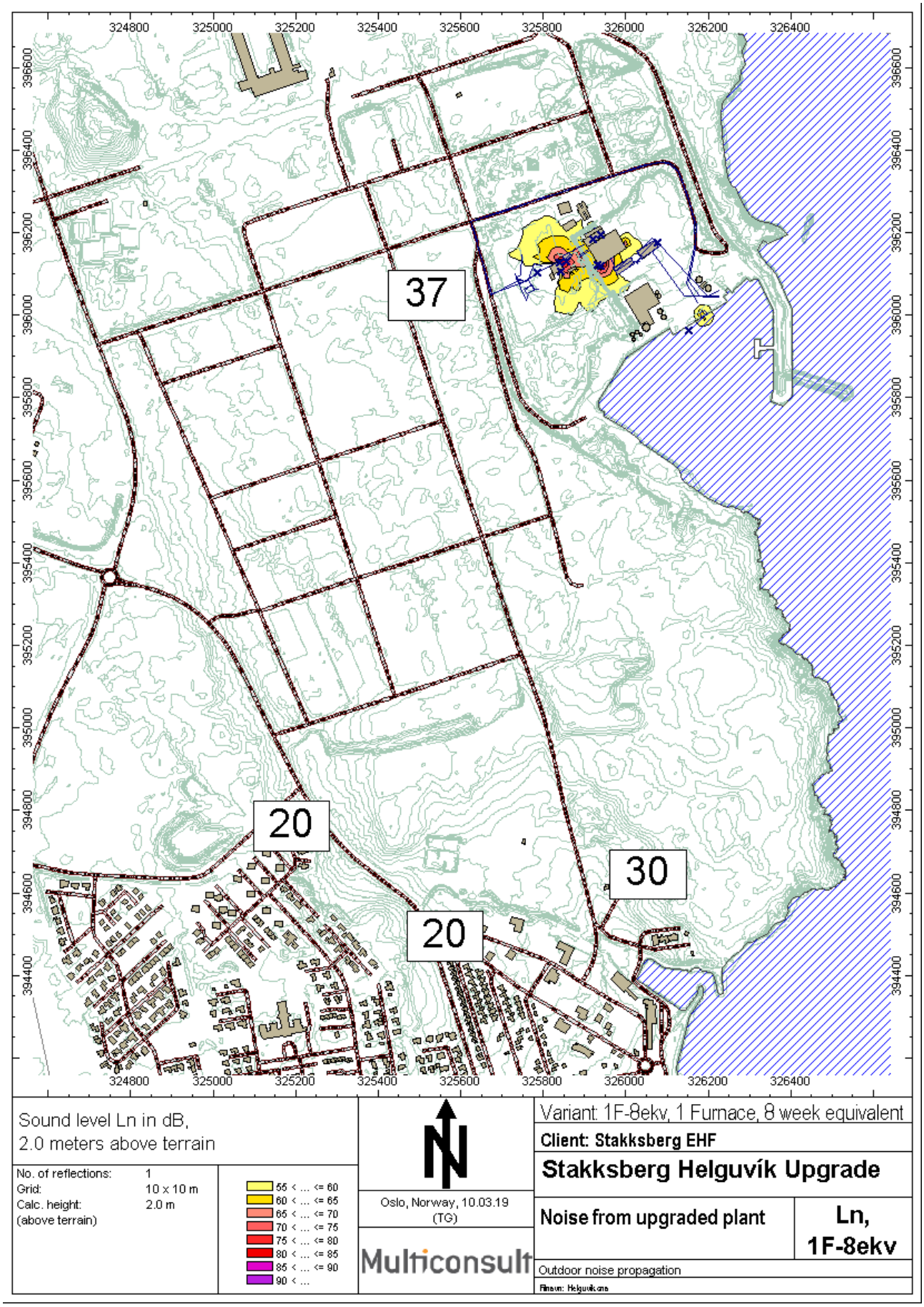
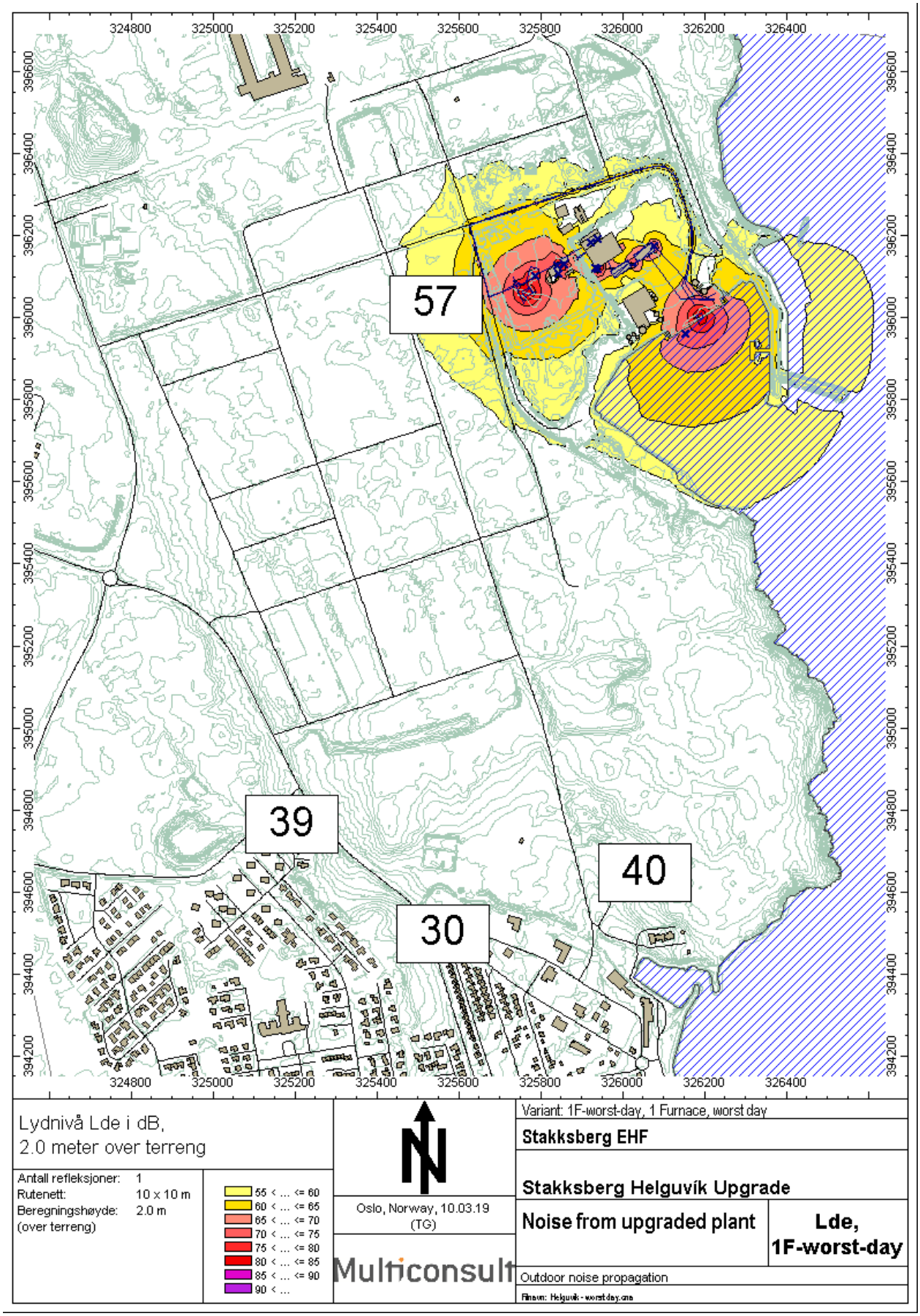
65 < ... <= 70
70 < ... <= 75
75 < ... <= 80
80 < ... <= 85
85 < ... <= 90
90 < ...
Oslo, Norway, 10.03.19
(TG)
Multiconsult
Variant: 1F-8ekv, 1 Furnace, 8 week equivalent
Client: Stakksberg EHF
Stakksberg Helguvík Upgrade
Noise from upgraded plant
Lde,
1F-8ekv
Outdoor noise propagation
Filnavn: Helguvik.cna

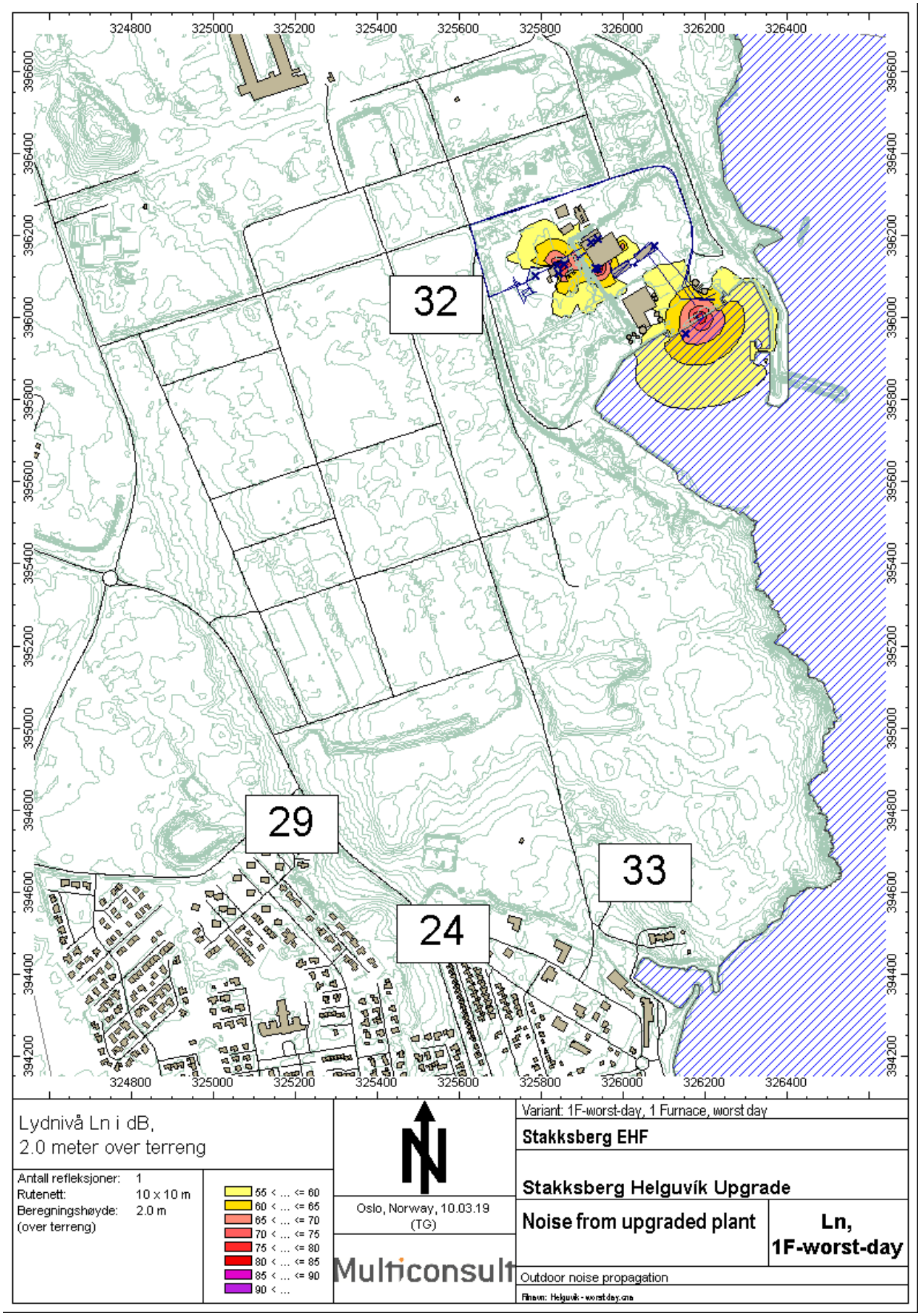
5.2 One furnace – 8 weeks equivalent. Noise level at night (23-07), L_n



5.3 One furnace – worst-day noise at day and evening (07-23), L_{de}

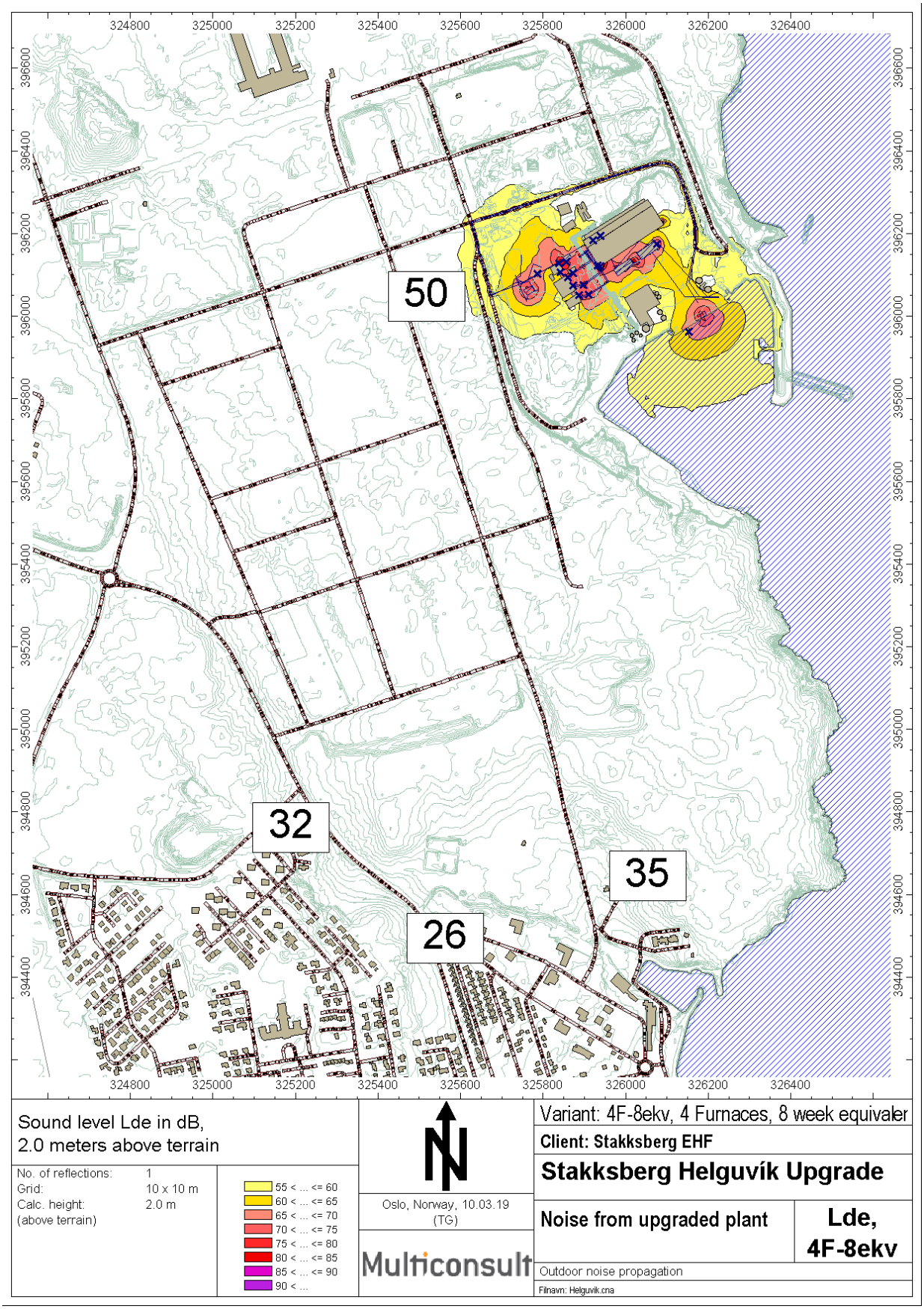


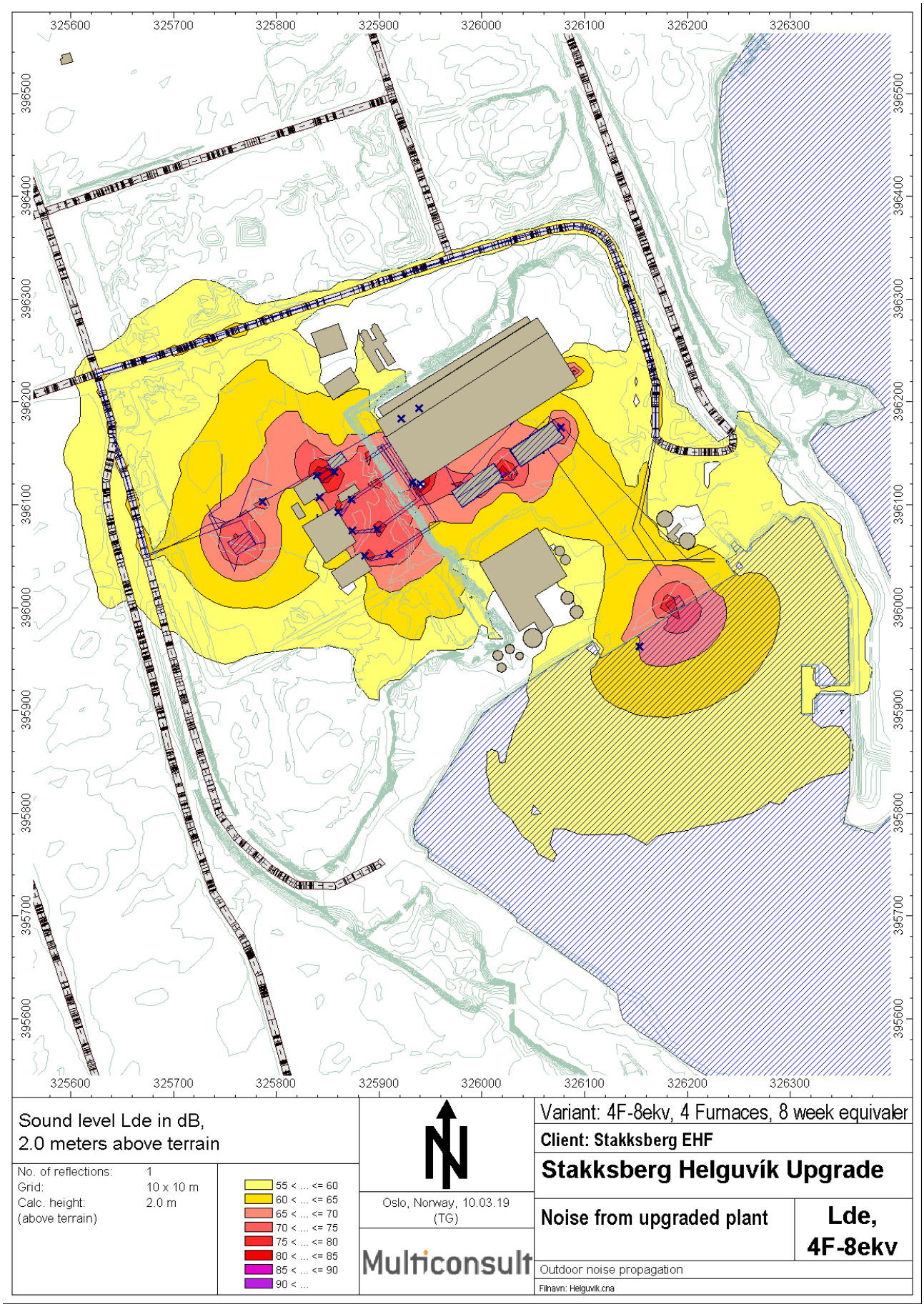
5.4 One furnace – worst-day equivalent. Noise level at night (23-07), L_n



6 Results for upgraded plant with four furnaces

6.1 Four furnaces – 8 weeks equivalent. Day-/ evening noise (07-23), L_{de}

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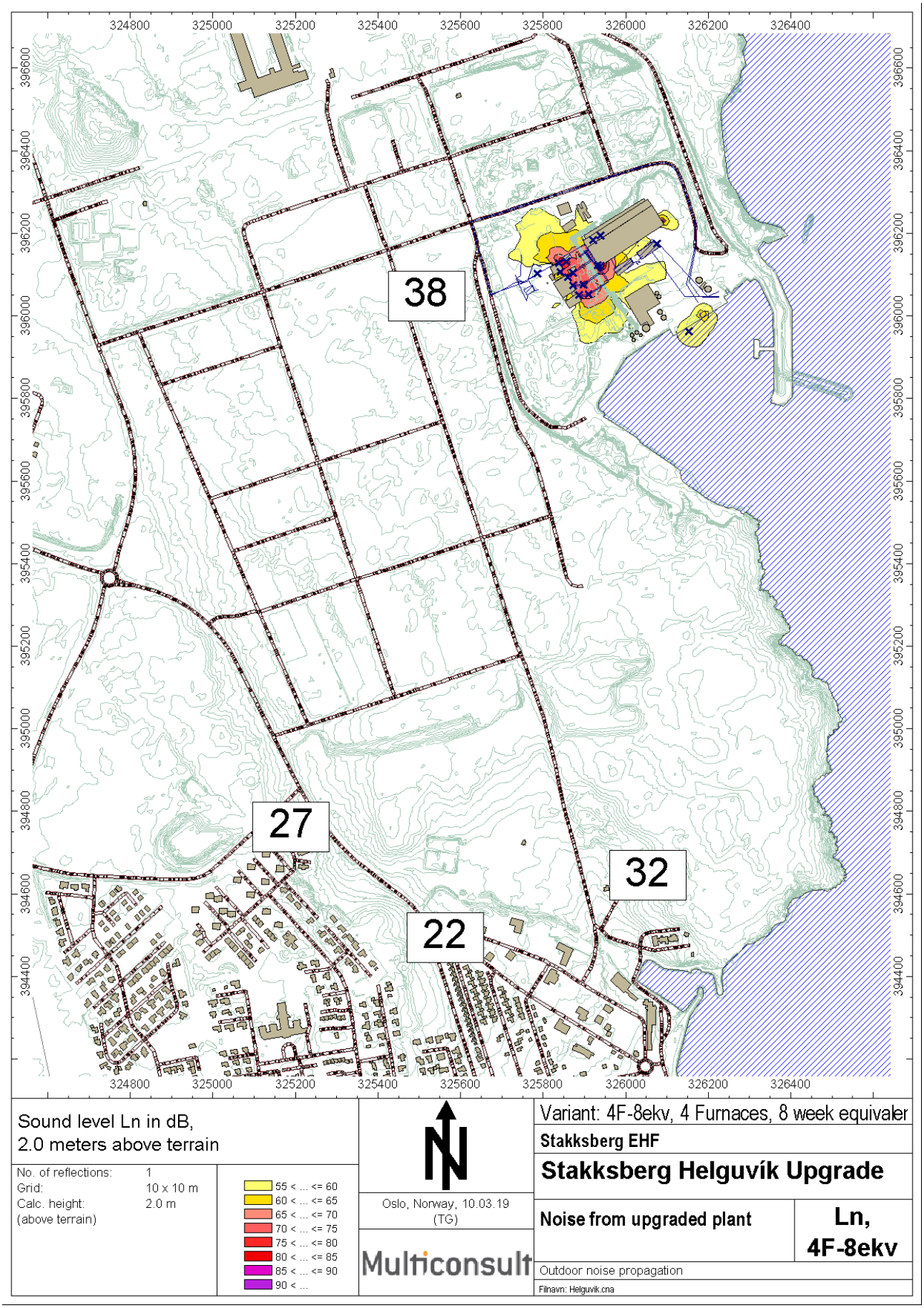
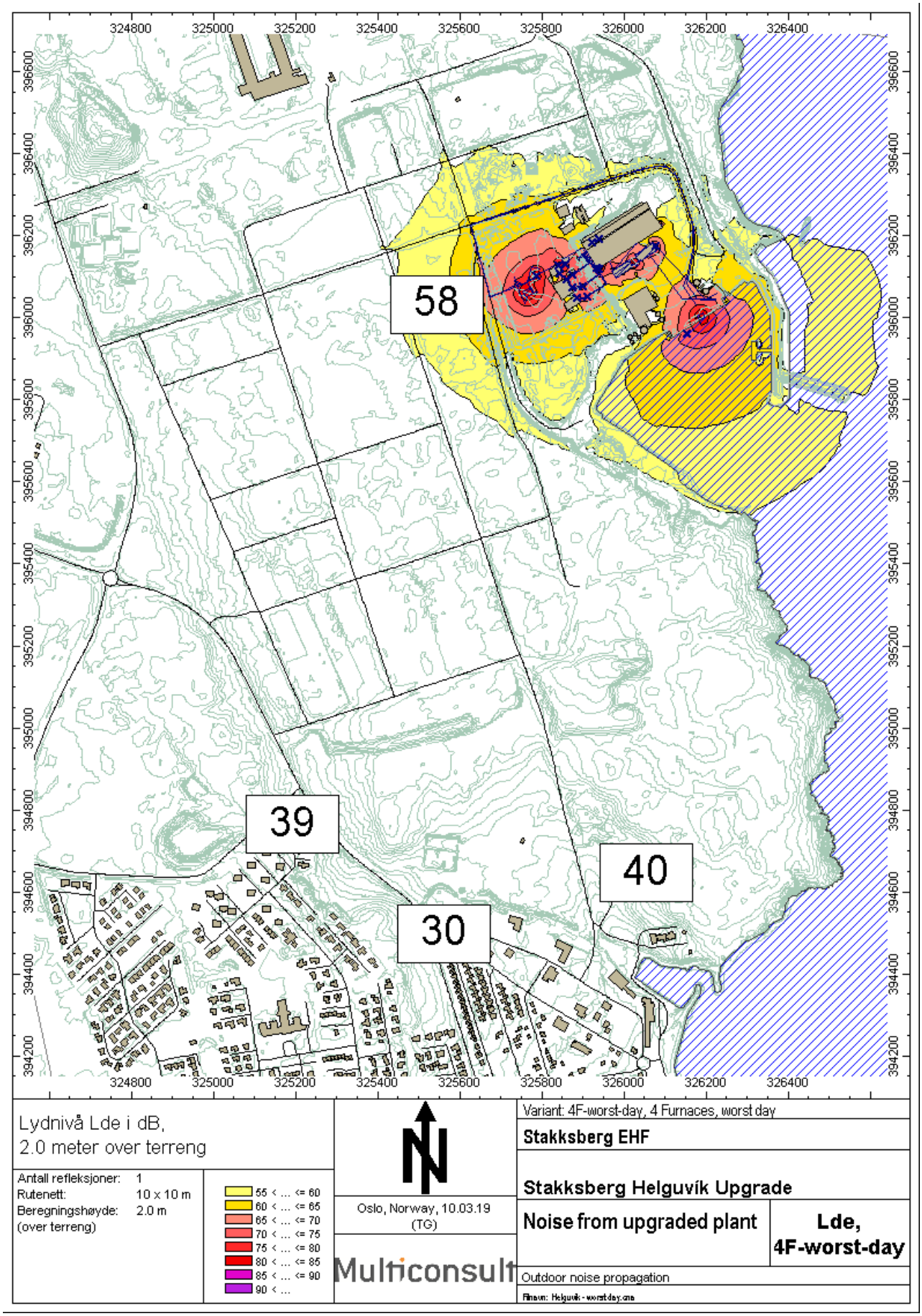
395800
395700
395600
Sound level Lde in dB,
2.0 meters above terrain
No. of reflections: 1
Grid: 10 x 10 m
Calc. height: 2.0 m
(above terrain)
55 < ... <= 60
60 < ... <= 65
65 < ... <= 70
70 < ... <= 75
75 < ... <= 80
80 < ... <= 85
85 < ... <= 90
90 < ...
Oslo, Norway, 10.03.19
(TG)
Multiconsult
Variant: 4F-8ekv, 4 Furnaces, 8 week equivaler
Client: Stakksberg EHF
Stakksberg Helguvík Upgrade
Noise from upgraded plant
Lde,
4F-8ekv
Outdoor noise propagation
Filnavn: Helguvik.cna

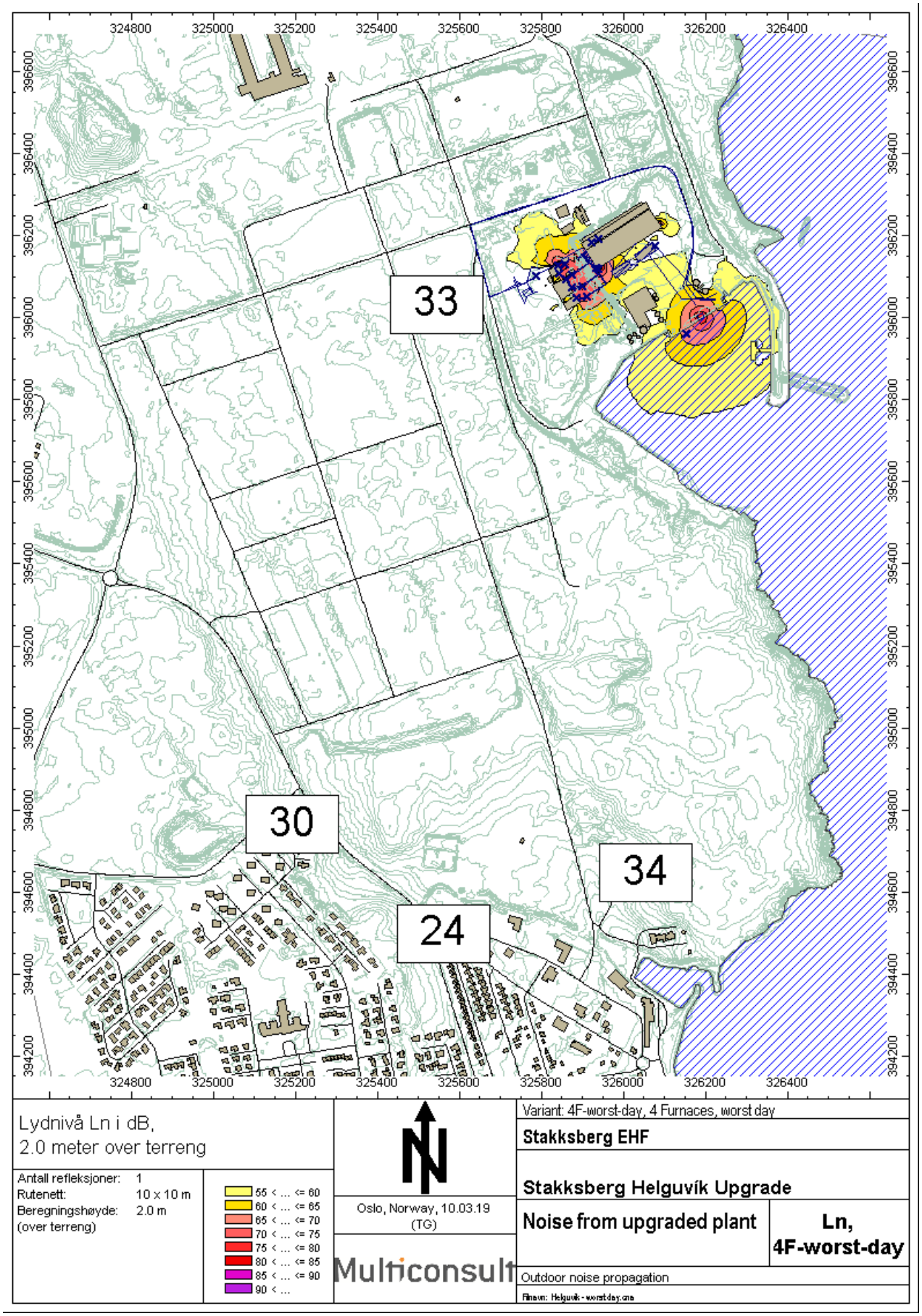
6.2 Four furnaces – 8 weeks equivalent. Noise level at night (23-07), L_n



6.3 Four furnaces – worst-day noise at day and evening (07-23). 16 hour noise level, L_{de}



6.4 Four furnaces – worst-day. Noise level at night (23-07), L_n



7 Discussion of results

For comparison with the requirements, reference is made to chapter 3.

Subchapter 5.1 through 5.4 show the calculations results for an upgraded one-furnace option. Subchapter 6.1 through 6.4 show the calculation results for a possible four furnaces option. The results show both day-/evening equivalent levels, and night-time equivalent levels for different configurations.

None of the results exceeds the noise allowance or the governmental regulation under the given assumptions in chapter4, and no noise reducing measures are required.

At the most exposed residential area receiver points, the levels are as indicated in the table below.

Table 4 Summary of results at the closest and most exposed receiver points. All numbers in dB(A).

Case	**L_{DE} [dB(A)]**	**L_N [dB(A)]**
One furnace 8-week average	22-32	20-30
Four furnaces 8-week average	26-35	22-32
One furnace, worst day case	30-40	24-33
Four furnace, worst day case	30-40	24-34
Requirement:	**55**	**40**

The calculations reveal that the dominating noise sources are handling of quartz (dumping from truck and offloading from ship), quartz falling from the conveyor band down the hoppers at the top of the day bins, and noise from ducts connected to the furnace house draft. Even though not required with respect to neighborhood noise compliance, but rather as a suggested optimization, improvements on the hoppers could reduce the plant noise. In this case, the hopper's wall structure can be lined with durable, hard rubber on the inside. In addition, spraying the outside of the chute with damping compound such as DG-500 or Noxudol can reduce vibration and radiated sound.. This could lower the total radiated noise from the plant significantly.

The requirement relating to indoor maximum noise level, $L_{AF,max}$, is under no relevant circumstance in danger of being exceeded. By assuming a standard house façade sound reduction of 30 dB, the noise level outside the façade would need to be 75 dB(A) $L_{p,AF,max}$ (45+30 dB). Given the distances to the closest dwellings, the sound pressure level at the plant would need to be around 140 dB at the harbor. This is highly unlikely.

8 References

[1] The Danish Academy of Technical Sciences (DTU), «Environmental noise from industrial plants - General prediction method», Report no. 32, 1982.
[2] «Meeting between Multiconsult and SHU representatives Kristleifur Andrésson and 'Steini' at SHU / Stakksbraut 9, Reykjanesbær», 28-nov-2018.

9 Appendix

Table 5 List of noise sources and sound power, as well as operating time and assumed number of incidents per hour (if applicable). The data is listed according to the calculated variants in chapters 5 and 6.

Noise source / activity	Total sound power, LWA [dB]	Source type in calculation	Incidents per hour when in operation	Operation time (minutes), 8 week average One furnace			Operation time (minutes), 8 week average Four furnaces			Operation time (minutes), worst day One furnace			Operation time (minutes), worst day Four furnaces		
				Day	Evening	Night	Day	Evening	Night	Day	Evening	Night	Day	Evening	Night
Ship, engine idle	103	Point		62	21	10	246	82	41	720	240	120	720	240	120
ID Fan	97	Point		720	240	480	720	240	480	720	240	480	720	240	480
Reverse Fan	100	Point		720	240	480	720	240	480	720	240	480	720	240	480
Pouring and casting exhaust fan	108	Point		720	240	480	720	240	480	720	240	480	720	240	480
HP Compressor	83	Point		720	240	480	720	240	480	720	240	480	720	240	480
LP Compressor	83	Point		720	240	480	720	240	480	720	240	480	720	240	480
Furnace building air intake. Top of roof.	88	Point		720	240	480	720	240	480	720	240	480	720	240	480
Filter crushing house	105	Point		257	0	0	386	129	0	600	0	0	720	240	0
Quartz dumped into feeder	116	Point		2	0	0	8	0	0	65	21	0	260	84	0
Coal and wood chip dumped into feeder	106	Point		3	0	0	12	0	0	163	0	0	660	0	
Trucks with quartz, wood chips, charcoal bags and low ash coal to upper area	105	Moving point	8	70	21	0	720	240	0	720	240	0	720	240	0
Conveyor band w/raw material to day bins	87	Line		720	0	0	720	240	0	720	0	0	720	240	0
Conveyor band w/raw material from day bins to furnace house	87	Line		720	240	480	720	240	480	720	240	480	720	240	480
Wheel loader w/coal and wood chips, upper area	106	Moving point	34	24	8	0	94	32	0	720	240	0	720	240	0
Wheel loader w/quartz, upper area	106	Moving point	34	18	6	0	72	24	0	720	240	0	720	240	0
Wheel loader w/ quartz from storage to crusher house	106	Moving point	0.5	257	0	0	386	129	0	600	0	0	720	240	0
Container mover w/micro silica from bag house to harbor	116	Moving point	0,3	0,2	0	0	0,8	0	0	0,2	0	0	0,8	0	0

Noise source / activity	Total sound power, LWA [dB]	Source type in calculation	Incidents per hour when in operation	Operation time (minutes), 8 week average One furnace			Operation time (minutes), 8 week average Four furnaces			Operation time (minutes), worst day One furnace			Operation time (minutes), worst day Four furnaces		
				Day	Evening	Night	Day	Evening	Night	Day	Evening	Night	Day	Evening	Night
Container mover w/silicon from crusher house to harbor	116	Moving point	0,3	5	0	0	12	0	0	5	0	0	12	0	0
Wheel loader (fork) w/silicon from furnace house to cooling storage	106	Moving point	0,4/0,8	720	240	480	720	240	480	720	240	480	720	240	480
Silica dust bags from crusher house to container	106	Moving point	0,3	0,2	0	0	0,8	0	0	0,2	0	0	0,8	0	0
Unloading quartz from ship at harbor	116	Area		23	8	2	98	33	2	720	240	120	720	240	120
Unloading coal and wood chips from ship at harbor	106	Area		33	10	2	126	44	4	0	0	0	0	0	0
Outside top of day bin house. Raw material falling from conveyor-band to hoppers / bins. Radiated sound power includes steel wall sound reduction	95	Area / vertical area		720	0	0	720	240	0	720	0	0	720	240	0
Duct break out noise	102	Area		720	240	480	720	240	480	720	240	480	720	240	480
Dumping quartz from truck to ground	133	Area	8	0,7	0	0	2,8	0	0	16	5	0	16	5	0
Outside crusher house, with two crushers and screens. Radiated sound power includes Paroc wall sound reduction.	85	Area		257	0	0	386	129	0	600	0	0	720	0	0
Outside cooling storage house during chiseling. Radiated sound power includes canvas sound reduction.	116	Area / vertical area		26	0	0	103	0	0	30	0	0	120	0	0
Air intake, north side of furnace house	88	Vertical area		720	240	480	720	240	480	720	240	480	720	240	480
At gate openings, crusher house. Radiated sound power includes canvas sound reduction.	102	Vertical area		257	0	0	386	129	0	600	0	0	720	0	0
At gate openings, furnace building	92	Vertical area		720	240	480	720	240	480	720	240	480	720	240	480
At conveyor band opening on day bin building upper level	116	Vertical area		720	0	0	720	240	0	720	0	0	720	240	0