Sistema Nazionale per la Protezione dell'Ambiente

European Commission

ARPAT
Agenzia regionale per la protezione ambientale della Toscana

REGIONE TOSCANA

TAIEX-EIR-P2P
Study visit on Noise Maps and Action Plans

16 – 17 June 2022 - Florence

Noise mapping of Regional Roads and Life NEREiDE Project on Road Action Plan

Dr. Mauro Cerchiai
ARPAT - SAF-AVL

TAIEX
MOVING FORWARD TOGETHER WITH EU EXPERTISE

25 YEARS

Index

- **EU 2002/49/CE directive relating to the assessment and management of environmental noise and action plans** (brief summary)
- **Tuscany regional roads assessment** (2022 run)
- **The LIFE NEREiDE Project**
- **NEREiDE main results**

DIRECTIVE 2002/49/EC (I)

- **Article 5**. **Noise indicators**. “Member States shall apply the noise indicators Lden and Lnight as referred to in Annex I for the preparation and revision of strategic noise mapping in accordance with Article 7”
- **Article 6. Assessment methods.** “The values of Lden and Lnight shall be determined by means of the assessment methods defined in Annex II.”
- **Article 7**. **Strategic noise mapping.** “Member States shall ensure (every five years) strategic noise maps showing the situation in the preceding calendar year have been made”
- The strategic noise maps shall satisfy the minimum requirements laid down in Annex IV.
- The strategic noise maps shall be reviewed, and revised if necessary, at least every five years after the date of their preparation.

DIRECTIVE 2002/49/EC (II) – Art. 8. Action Plans

- '**action plans**' shall mean plans *designed to manage noise issues and effects, including noise reduction if necessary;*
- Member States shall ensure every five years the competent authorities have drawn up **action plans** designed to manage, within their territories, noise issues and effects, including noise reduction if necessary for:
  - (a) places near the major roads, major railways and major airports;
  - (b) agglomerations.
- Such plans shall also aim to protect quiet areas against an increase in noise.

DIRECTIVE 2002/49/EC (II) – Art. 8. Action Plans

- The measures within the plans are at the discretion of the competent authorities; They should:
  - notably address priorities which may be identified by the exceeding of any relevant limit value or by other criteria chosen by the Member States
  - apply in particular to the most important areas as established by strategic noise mapping
- The action plans shall meet the minimum requirements of Annex V
- The action plans shall be reviewed, and revised if necessary, when a major development occurs affecting the existing noise situation, and at least every five years after the date of the approval of those plans.

DIRECTIVE 2002/49/EC (III) – Art. 8. Action Plans

- Member States shall ensure that the public is consulted about proposals for action plans, given early and effective opportunities
  - to participate in the preparation and review of the action plans;
  - that the results of that participation are taken into account;
  - that the public is informed on the decisions taken.
- Reasonable time-frames shall be provided allowing sufficient time for each stage of public participation

DIRECTIVE 2002/49/EC (IV) – ANNEX II

ASSESSMENT METHODS FOR THE NOISE INDICATORS

- Must be used for all mappings done for both strategic noise mapping and action plans
- It deals with noise propagation and road/aircraft/railway/tram/industrial noise sources description
- From Commission Directive (EU) 2015/996 of 19 May 2015 the assessment methods are those form the CNOSSOS/EU model
- They were amended by Commission Delegated Directive (eu) 2021/1226 of 21 December 2020 for the purposes of adapting to scientific and technical progress
- The model is fully described in these directives.

DIRECTIVE 2002/49/EC (IV)

Action Plans minimum requirements

ANNEX V

MINIMUM REQUIREMENTS FOR ACTION PLANS

referred to in Article 8

1. An action plan must at least include the following elements:
   - a description of the agglomeration, the major roads, the major railways or major airports and other noise sources taken into account,
   - the authority responsible,
   - the legal context,
   - any limit values in place in accordance with Article 5,
   - a summary of the results of the noise mapping,
   - an evaluation of the estimated number of people exposed to noise, identification of problems and situations that need to be improved,
   - a record of the public consultations organised in accordance with Article 8(7),
   - any noise-reduction measures already in force and any projects in preparation,
   - actions which the competent authorities intend to take in the next five years, including any measures to preserve quiet areas,
   - long-term strategy,
   - financial information (if available): budgets, cost-effectiveness assessment, cost-benefit assessment,
   - provisions envisaged for evaluating the implementation and the results of the action plan.
2. The actions which the competent authorities intend to take in the fields within their competence may for example include:
   - traffic planning,
   - land-use planning,
   - technical measures at noise sources,
   - selection of quieter sources,
   - reduction of sound transmission,
   - regulatory or economic measures or incentives.
3. Each action plan should contain estimates in terms of the reduction of the number of people affected (annoyed, sleep disturbed, or other).
4. The Commission may develop guidelines providing further guidance on the action plans in accordance with Article 13(2).

Strategic Noise Mapping for the 2022 run

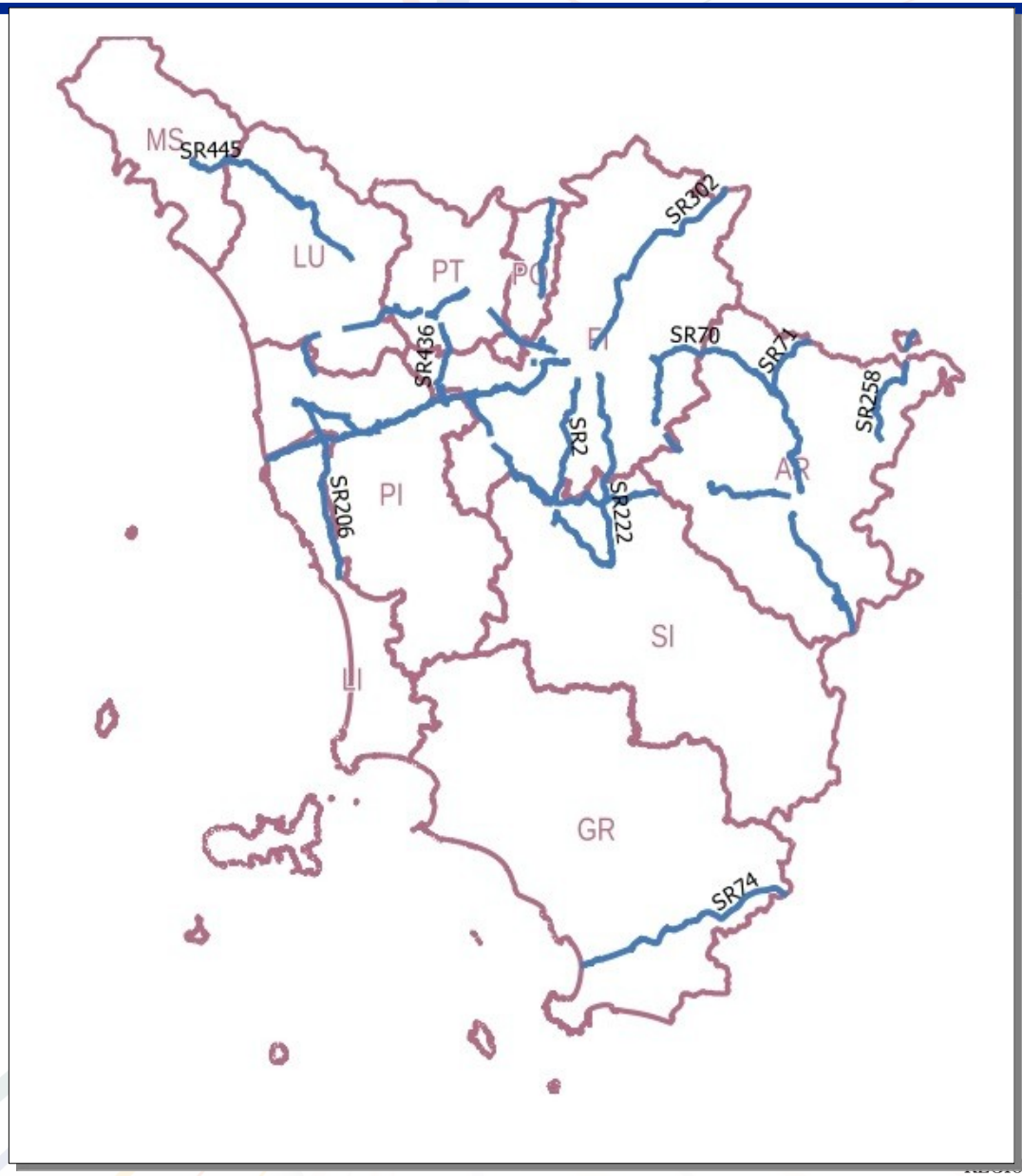
- For this run the main difference with the previous sets is the mandatory use of the **CNOSSOS/EU** computational method and the determination of the exposure to noise
- CNOSSOS/EU provides rules to determine
  - the area exposed to noise;
  - the dwellings and people living in dwellings esposed to noise (from a modified German VBEB determination method)
- A default set of input parameters for all sources definition was given by the method

2022 Strategic Noise Mapping for Tuscany Region Roads

Tuscany Region manages about 844 km of regional roads, and between them the **S.G.C. FIPILI,** that connects Florence with Pisa and Leghorn.

This is one of the most busy roads of Tuscany, just after the A1 motorway (Milan-Rome-Naples)

For 2022 **strategic noise mapping** Tuscany Region identified **28 road sections** that had more than 3 Million vehicle passages a year (i.e. identified as “major roads”).



Regional major roads (202

The following table summarise main information about RT major roads

In the table for each section:

- Regional road name;
- The extension of the section
- Vehicle passages a year

For each of these sections ARPAT did a noise mapping according the EU directive in order to collect the informations required by EU

ID	Asse stradale principale	Tratto	Veicoli/anno
1	SGC Firenze Pisa Livorno	Dal Km 0,000 al Km 75,883	12.610.750
2	SGC Firenze Pisa Livorno	Dal Km 58,200 al Km 80,033	10.067.430
3	SR2 – Strada Regionale Cassia	Dal Km 287,222 al Km 292,598	4.732.955
4	SR66 – Strada Regionale Pistoiese	Dal Km 9,300 al Km 27,800	5.261.522
6	SR69 – Strada Regionale di Valdarno	Dal Km 8,000 al Km 15,700	3.361.285
8	SR69 – Strada Regionale di Valdarno	Dal Km 58,528 al Km 62,510	2.854.300
9	SR69 – Variante di Valdarno	Dal Km 5,980 al Km 10,200	5.357.105
12	SR71 - Strada Regionale Umbro Casentinese Romagnola	Dal Km 111,115 al Km 144,352	4.348.491
13	SR71 - Strada Regionale Umbro Casentinese Romagnola	Dal Km 150,616 al Km 184,417	3.626.751
14	SR206 – Strada Regionale Pisana Livornese	Dal Km 0,520 al Km 5,330	3.064.540
15	SR206 – Strada Regionale Pisana Livornese	Dal Km 29,680 al Km 42,200	4.680.027
16	SR206 – Strada Regionale Pisana Livornese	Dal Km 43,900 al Km 44,985	4.680.027
17	SR222 – Chiantigiana	Dal Km 1,840 al Km 5,744	9.915.590
18	SR302 – Strada Regionale Brisighellese Ravennate	Dal Km 4,850 al Km 14,571	3.343.765
19	SR325 - Strada Regionale della Val di Setta e Val di Bisenzio	Dal Km 62,000 al Km 74,090	6.751.642
20	SR325 - Strada Regionale della Val di Setta e Val di Bisenzio	Dal Km 86,420 al Km 87,672	9.089.960
21	SR429 – Strada Regionale bis di Val d'Elsa	Dal Km 0,000 al Km 11,785	4.598.319
22	SR429 – Strada Regionale variante di Val d'Elsa	Dal Km 0,000 al Km 13,500	3.612.040
23	SR 435 - Strada Regionale Lucchese	Dal Km 2,160 al Km 25,350	6.987.359
24	SR 435 - Strada Regionale Lucchese	Dal Km 27,650 al Km 37,834	6.517.943
25	SR 436 - Strada Regionale Francesca	Dal Km 2,100 al km 4,100	8.689.920
26	SR 436 - Strada Regionale Francesca	Dal Km 6,830 al Km 28,260	4.262.105
27	SR 445 - Strada Regionale della Garfagnana	Dal Km 10,300 al Km 35,000	4.262.105
28	SR70 – Strada Regionale della Consuma	Dal Km 0,000 al km 6,000	3.500.000

Noise mapping of the Tuscany Region major roads

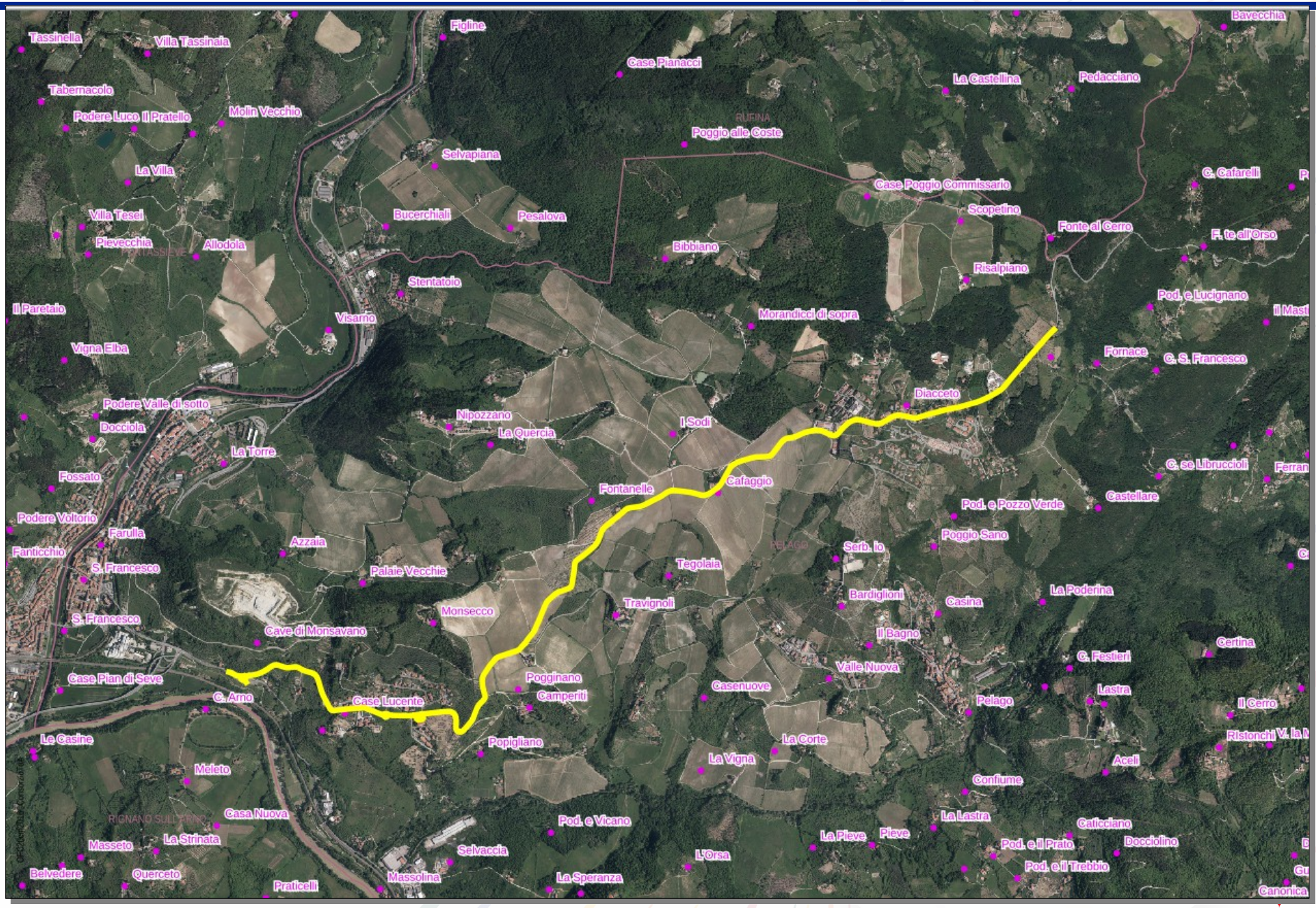
- In the following slides some of the results are reported with some example maps. In total:

Level interval	inhabitants		dwellings		Area [km²]	
	Lden	Ln	Lden	Ln	Lden	Ln
50 - 54	20325	8817	4224	2113	43.26	42.88
55 - 59	13362	5390	2989	1314	46.65	22.02
60 - 64	7868	3593	2038	929	39.84	13.7
65 - 69	6837	2687	1726	677	26.34	8.03
70 - 74	6609	1792	1725	496	25.54	6.58
> 75	3049	1491	927	477	14.99	3.94

Strategic Noise Mapping – examples - SR 70 north

- This stretch is located in the municipality of Pelago (FI)
- It’s about 6.0 km long
- It’s mean traffic in the year 2020 was about 3.2 M vehicle passages/year

Strategic Noise Mapping – examples - SR 70 north



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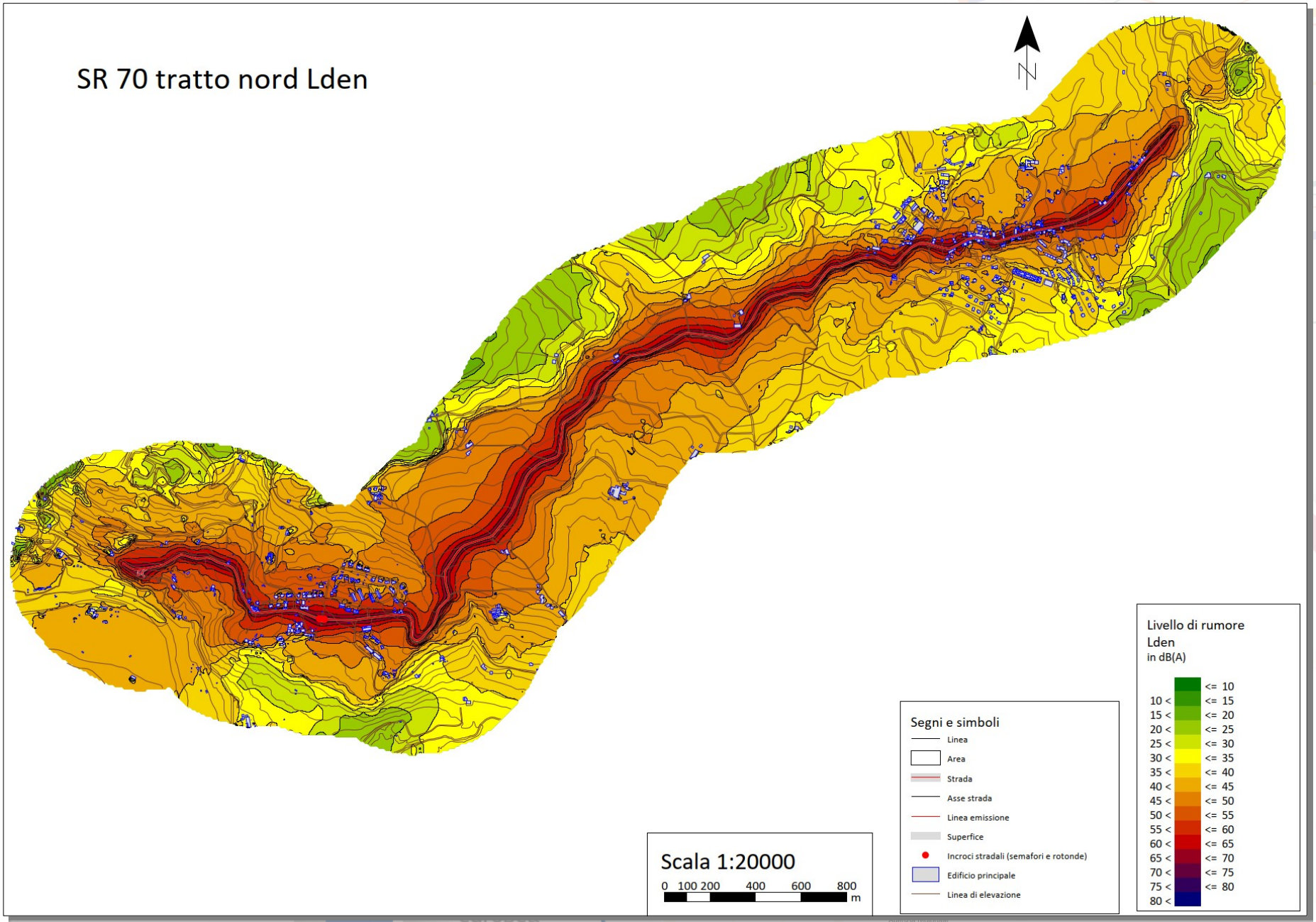
Strategic Noise Mapping – examples - SR 70 – LDEN Values



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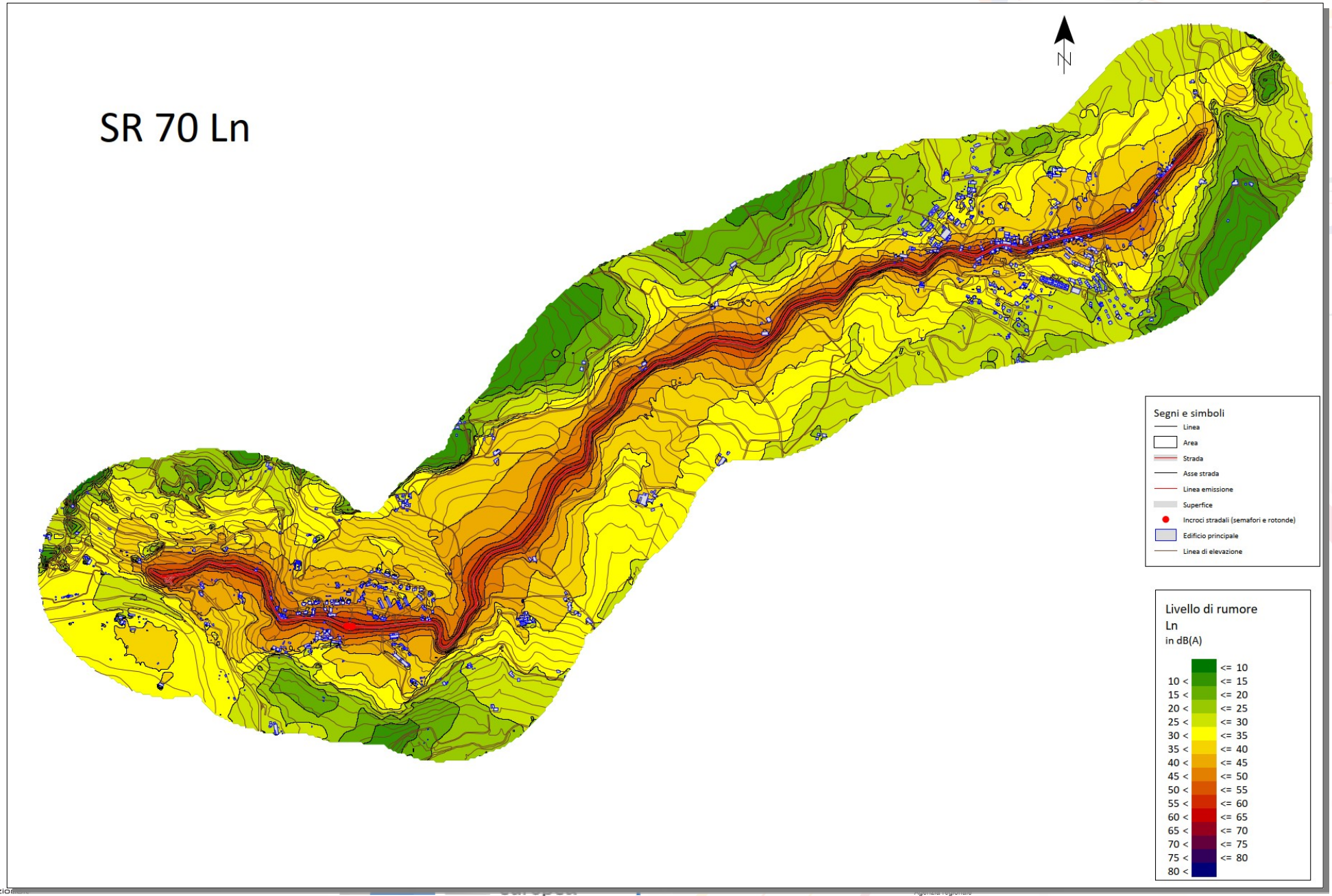
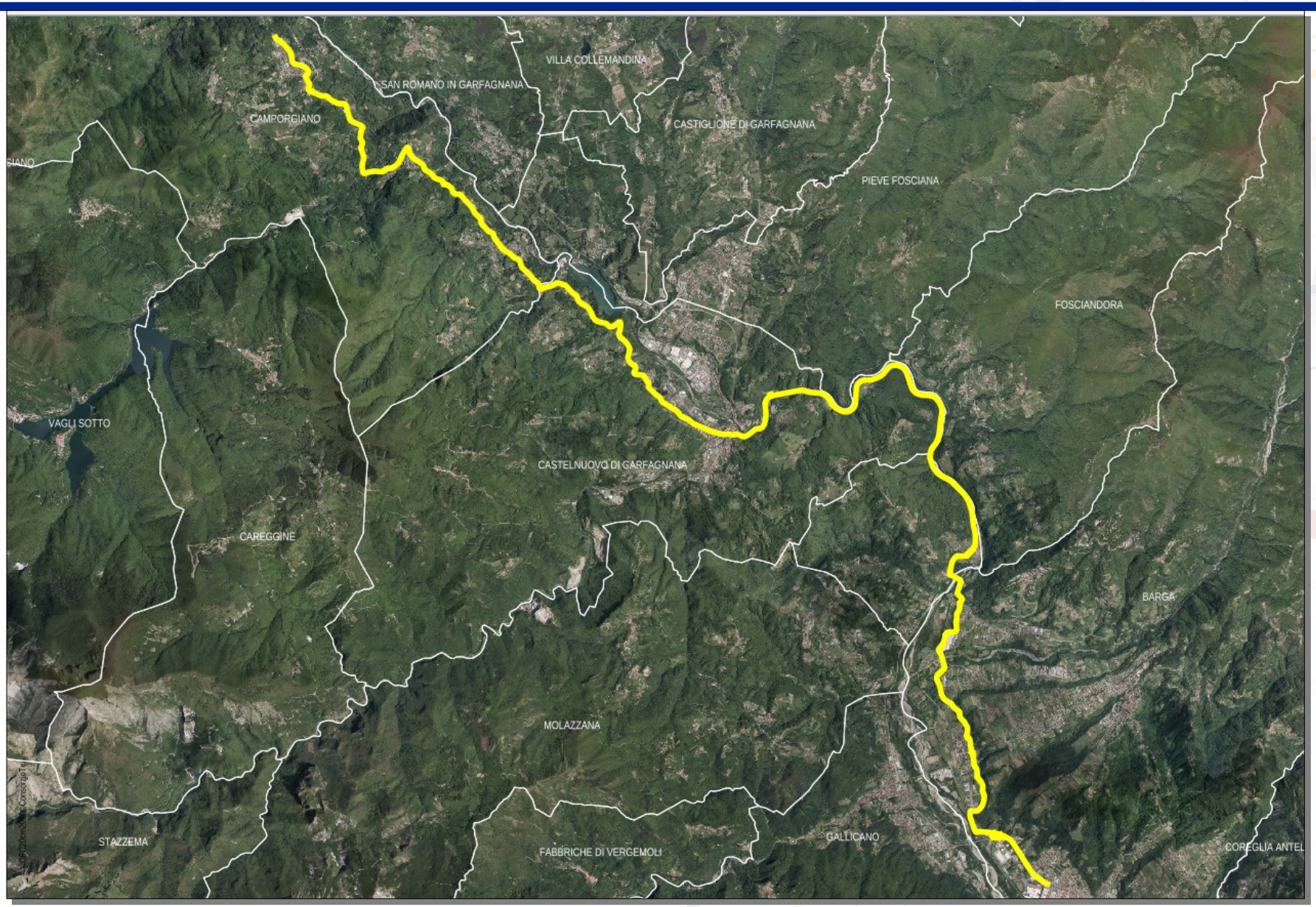
Strategic Noise Mapping – examples - SR 70 – LN Values



Strategic Noise Mapping – examples - SR 445

- This stretch is located in the provinces of Florence, Pisa and Leghorn
- It’s about 24.7 km long
- It’s mean traffic in the year 2020 was about 4.3 M vehicle passages/year

Strategic Noise Mapping – examples - SR 445



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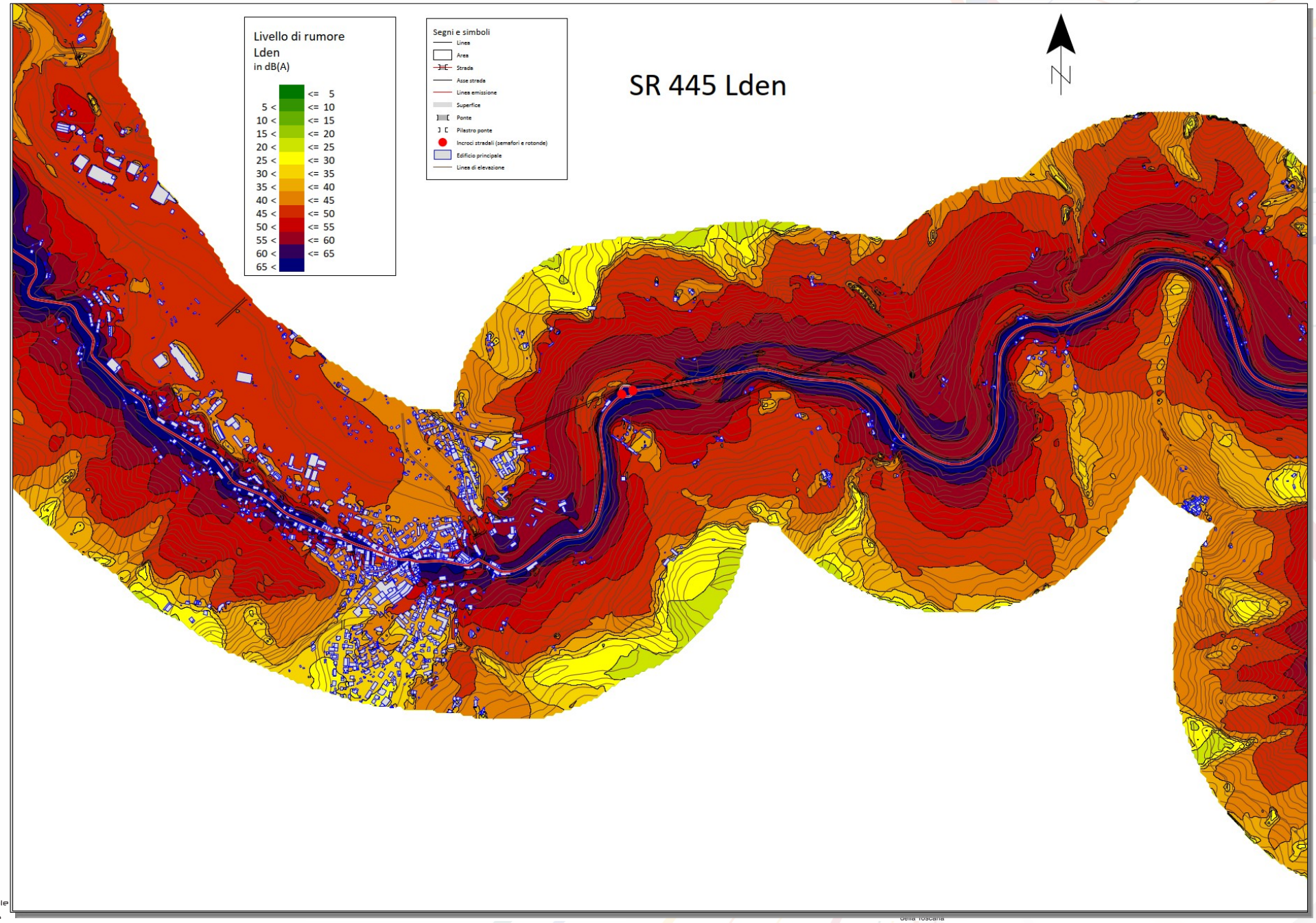
Strategic Noise Mapping – examples - SR 445 – LDEN Values



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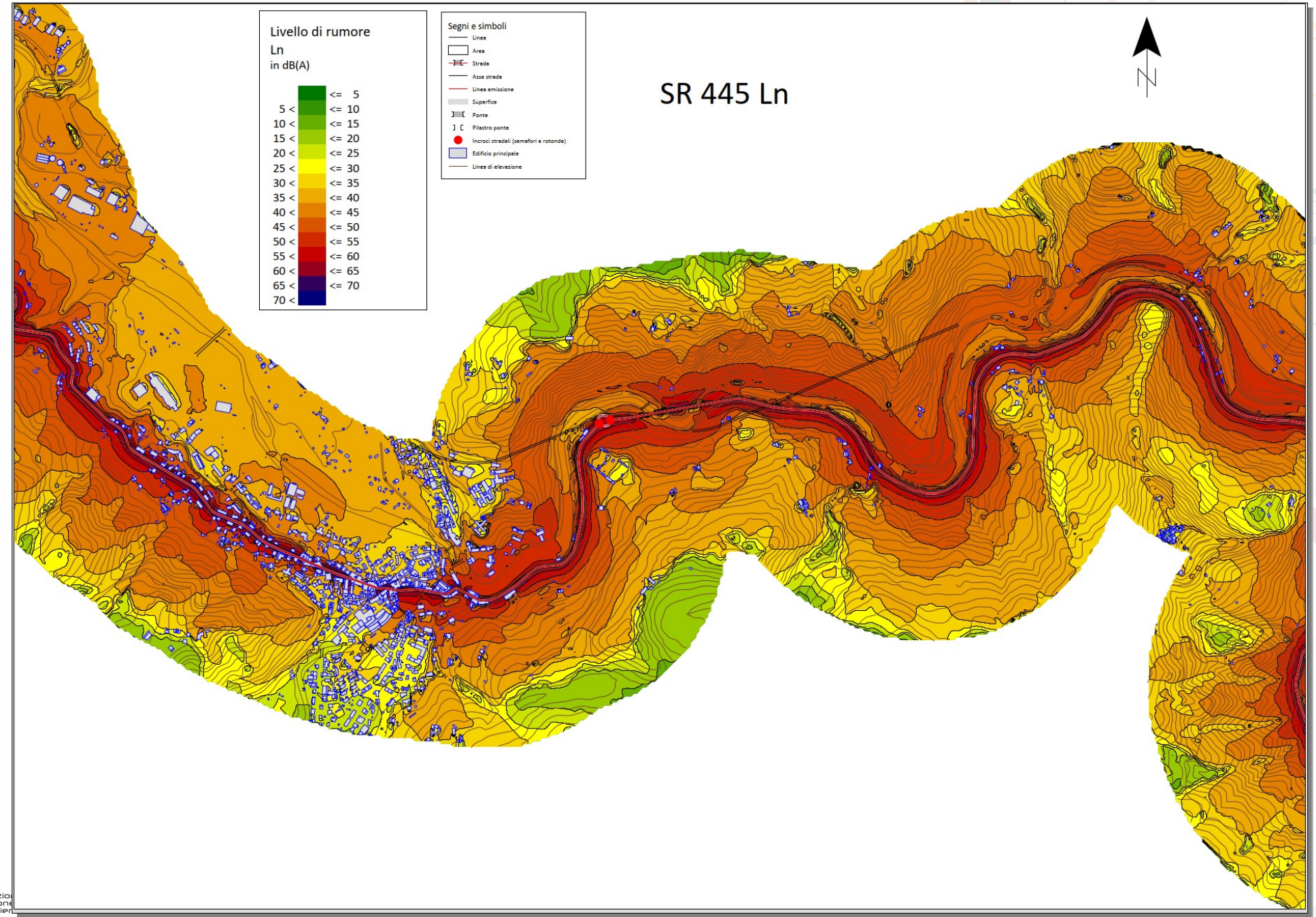
Strategic Noise Mapping – examples - SR 445 – LN Values



Strategic Noise Mapping – examples – SGC FIPILI

- This stretch is located in the provinces of Florence, Pisa and Leghorn
- It's about 98 km long
- It's mean traffic in the year 2020 was more than 12 M vehicle passages/year
- In the following picture the stretch near the centre of Pisa is shown

Strategic Noise Mapping – examples – SGC FIPILI

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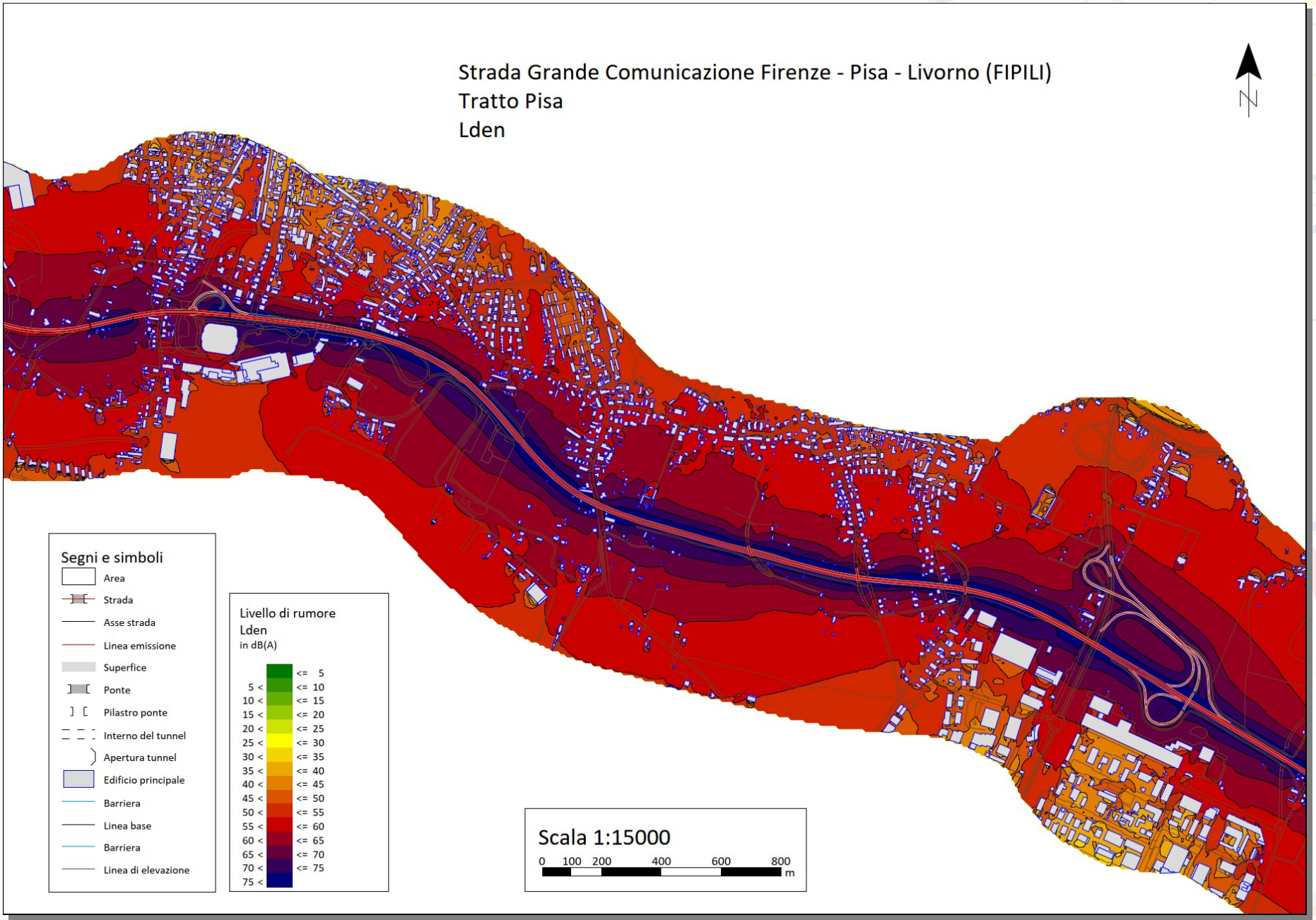
Strategic Noise Mapping – examples – FIPILI - Pisa – LDEN Values



The Project LIFE NEREiDE

nereide

www.nereideproject.eu

PROJECT NEREiDE LIFE15 ENV/IT/000268

“**N**oise **E**fficiently **RE**duced by recycle**D** pav**E**ments”

Partnership:

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Dipartimento di Ingegneria Civile e Industriale

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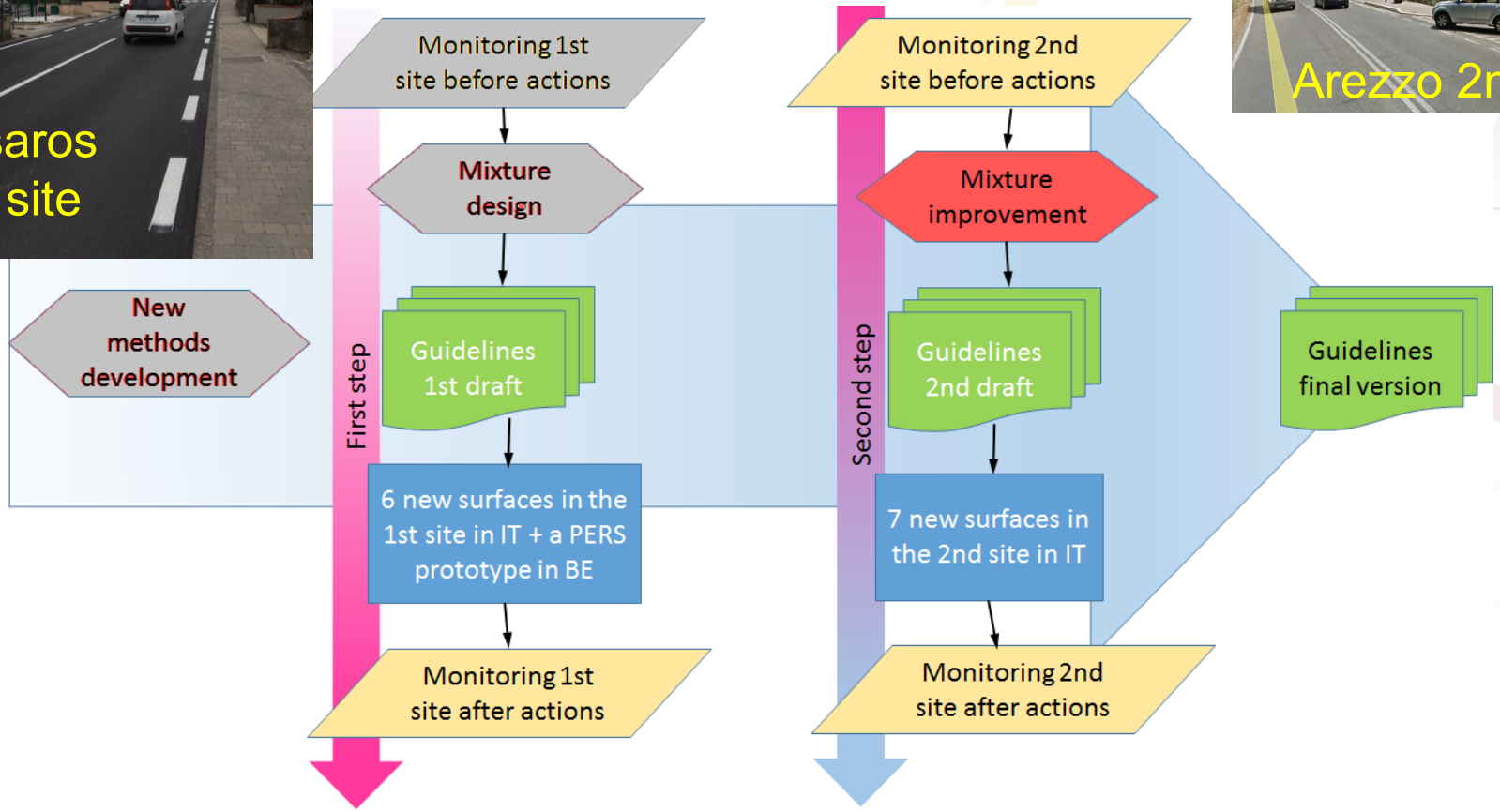
Main Objectives of the Project

- **Use of new porous asphalt pavements and low noise surfaces composed by recycled asphalt pavements and crumb rubber from scrap tires.**
- Thus, achieving specific benefits:
  - to reduce the disposal of waste materials;
  - to achieve a significant reduction of noise in urban areas and health improvement;
  - to improve safety in urban areas;
  - to improve air pollution due to asphalt laying.

LIFE NEREiDe – Main Actions

- The project was composed by:
  - a first site with 6 different stretches about 400 m long each, including rubber from end-of-life tyres;
  - a second site with 6 different stretches about 400 m long each, including rubber from end-of-life tyres and recycled asphalts.
- The effectiveness of the new pavements were evaluated by measurements of surface characteristics, acoustical and psychoacoustical properties and by surveys submitted to the exposed population, based on a before-after evaluation
- *Guidelines on monitoring activities were developed in order to upgrade and to improve the methods to assess the effectiveness in urban areas.*

LIFE NEREiDE main actions



Acoustical parameters analysed

- For each stretch, the values of the noise descriptor are acquired using methods according to technical standards, in particular road pavements are characterized by:
  - **L_{CPX} [dB(A)]** index related to the velocity of 50 km/h for each direction, according to Close ProXimity Method (CPX), ISO 11819-2;
  - **L_{Aeq} [dB(A)]** noise equivalent levels for daytime and night-time periods, according to Italian laws' limits and European noise indicators L_{DEN}, according to 2002/49/CE Directive;
  - **L_{C-A} [dB]** indicator, that is the difference between C-weighted and A-weighted noise levels indicator. The value is averaged over each measurement day for both daytime and night-time reference periods;
  - **DALY** values, according to methodological procedures described in the WHO publication "Burden of disease from environmental noise – quantification of healthy life years lost in Europe";
  - **SPBI and L_1 [dB(A)]** indexes, according to the statistical pass-by method (SPB) ISO 11819-1, as described in Action B12.1 (see "Deliverable B12.1 - Urban Pass-By validation report").
- All noise indicators, with the exception of the CPX, were measured at the roadside and their values were normalised to 7.5 m distance from the centre of each lane.

Project RESULTS (NOISE REDUCTION ANALYSIS)

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Surfaces used in the first site

Stretch	Name/ Type	Site (km)	Laying Date	Aggregate diameter	Bitumen%	Rubber%	Voids%
1	Open ref.	18+000 – 18+437	20/12/2017	10 mm	4.6	---	25.2
2	Open dry	17+615 – 18+000	29/05/2018*	8 mm	5.6	1.0	19.1
3	Gap dry	17+240 – 17+615	13/12/2017	8 mm	8.0	3.0	10.5
4	Gap ref.	16+467 – 17+240	06/12/2017	10 mm	5.2	---	7.0
5	Gap wet	12+897 – 12+514	18/01/2018	8 mm	8.1	1.6	5.9
6	Open wet	12+514 – 12+078	17/01/2018	8 mm	5.7	1.1	17.6

* a first laying of 19/12/2017 was replaced due to bad laying

Stretch	Name/Type	Description
1	Open Ref.	Open-graded wearing course control mixture.
2	Open Dry	SBR/NR modified mixture prepared as per dry process for open-graded wearing course by using warm-mix technology.
3	Gap Dry	SBR/NR modified mixture prepared as per dry process for gap-graded wearing course by using warm-mix technology.
4	Gap Ref.	Gap-graded wearing course control mixture.
5	Gap Wet	SBR/NR modified mixture prepared as per wet process for gap-graded wearing course by using warm-mix technology.
6	Open Wet	SBR/NR modified mixture prepared as per wet process for open-graded wearing course by using warm-mix technology;

First site measurement locations

Location of the six stretches: two at Pian del Quercione (left) and four at Bozzano Quiesa (right). Every coloured segment represent a different pavement type (see table 1)

The SR 439 is a regional road with a single lane per direction and mostly without footpaths. Lanes are 3.5 m width. The speed limit is set to 50 km/h, standard for urban settlements.

Surfaces used in the second site

Stretch	Name/Type	Site (km)	Laying Date	Aggregate diameter	Bitumen %	Rubber %	Voids %
1-DW	Dense wet	130+747 -131+173	18/04/2019	8 mm	7.1	1.2	5.4
2-OW	Open wet	131+271 –131+804	9 - 10/05/2019	8 mm	7.1	1.2	20.5
3-OD	Open dry	131+804 -132+198	10 - 13/05/2019	8 mm	6.7	1.0	18
4-GW	Gap wet	135+983 - 136+595	20/05/2019	10 mm	8.0	1.5	7.9
5-GD	Gap dry	138+207 - 138+690	15 - 22/05/2019	10 mm	8.1	1.0	6.7
6-DD	Dense dry*	140+553 - 141+091	15/04/2019 dir_{AR} 23/05/2019 dir_{CF}	8 mm	6.4	1.0	7.7

* layings are divided by direction on different days.

Stretch	Name/Type	Description
1	Dense wet	SBR/NR wet modified mixture for dense-graded wearing course including recycled asphalt pavement (RAP) and prepared by using warm-mix technology.
2	Open wet	SBR/NR wet modified mixture for open-graded wearing course including recycled asphalt pavement (RAP) and prepared by using warm-mix technology.
3	Open dry	SBR/NR dry modified mixture for open-graded wearing course including recycled asphalt pavement (RAP) and prepared by using warm-mix technology.
4	Gap wet	SBR/NR dry modified mixture for dense-graded wearing course including recycled asphalt pavement RAP) and prepared by using warm-mix technology.
5	Gap dry	SBR/NR dry modified mixture for gap-graded wearing course including recycled asphalt pavement (RAP) and prepared by using warm-mix technology.
6	Dense dry	SBR/NR wet modified mixture for gap-graded wearing course including recycled asphalt pavement (RAP) and prepared by using warm-mix technology.

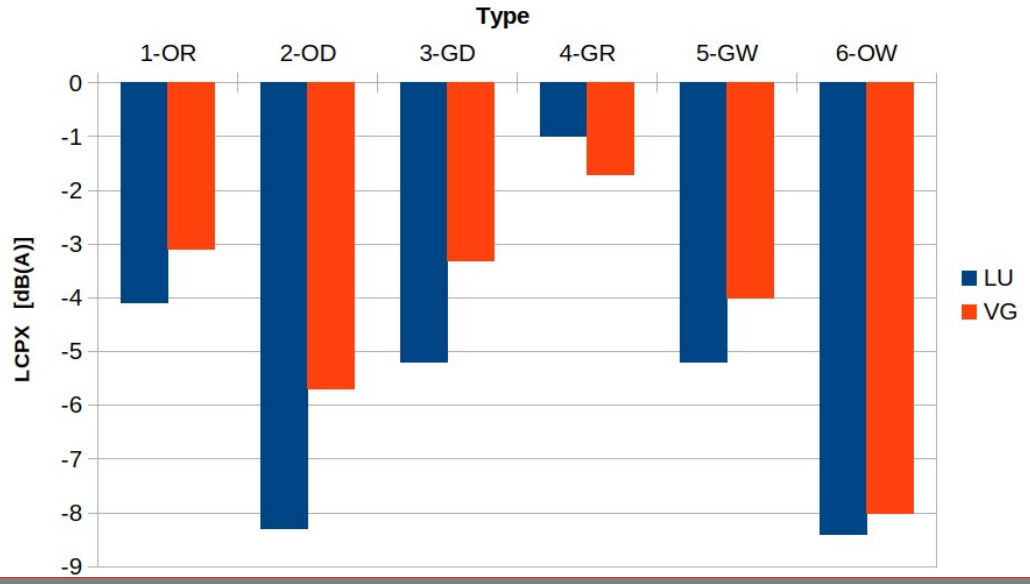
Second site measurement locations

The six continuous monitoring stations (red squares) locations.

The SR 71 is a regional road with a lane per direction and mostly with footpaths. Lanes are 3.5 m width. The speed limit is set to 50 km/h as standard for urban settlements, for stretches crossing urban area, and 70 km/h outside it. The road is almost straight for most of the stretches and real average speed is quite higher.

Site 1 – CPX @ 50 km/h

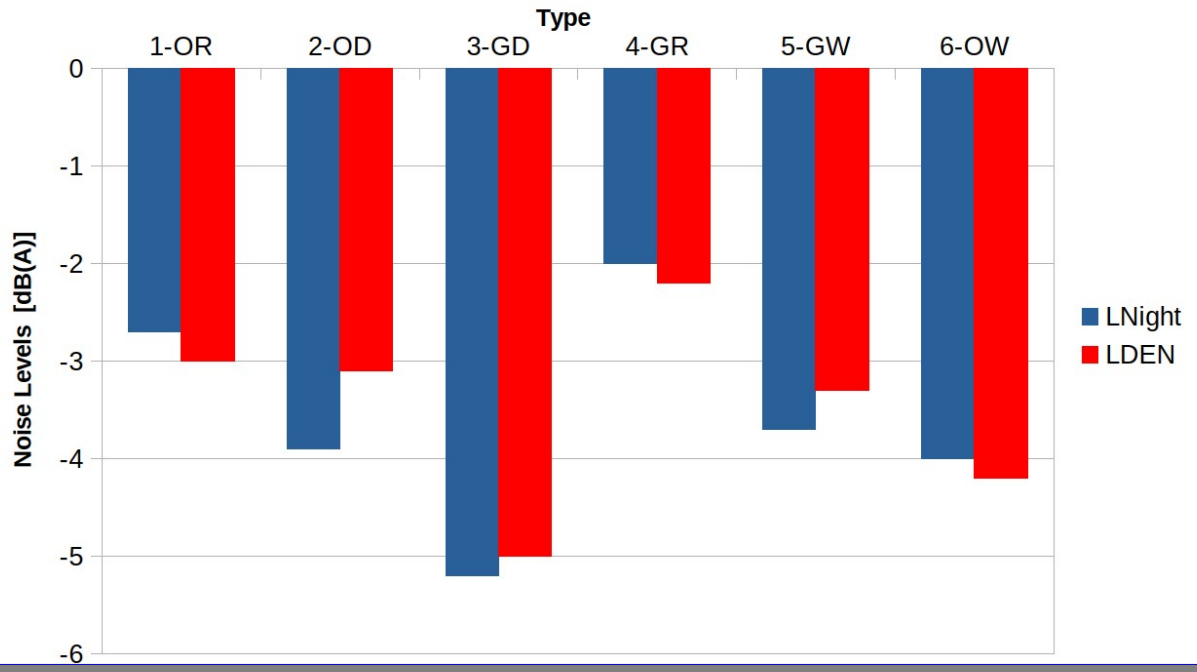
Stretch	Direction: to Viareggio			Direction: To Lucca		
	"Before"	"After"	After - Before	"Before"	"After"	After - Before
1-OR	96.5 ± 2,2	92.4 ± 0.8	-4.1	96.0 ± 3.6	92.9 ± 0.8	-3.1
2-OD	97.0 ± 2,1	88.7 ± 0.8	-8.3	95.1 ± 2.7	89.4 ± 0.7	-5.7
3-GD	96.5 ± 3,0	91.3 ± 0.7	-5.2	95.0 ± 3.1	91.7 ± 0.8	-3.3
4-GR	94.6 ± 1,2	93.6 ± 0.8	-1.0	94.8 ± 1.4	93.1 ± 0.8	-1.7
5-GW	96.5 ± 1,9	91.3 ± 0.8	-5.2	95.0 ± 1.6	91.0 ± 0.8	-4.0
6-OW	95.9 ± 1,6	87.5 ± 0.8	-8.4	95.3 ± 2.3	87.3 ± 0.8	-8.0



Site 1 - L_{Aeq}

L_{Aeq} values for the European indicators. All values are in dB(A). The expanded uncertainty is 0.8 dB(A) with a level of confidence of about 95%.

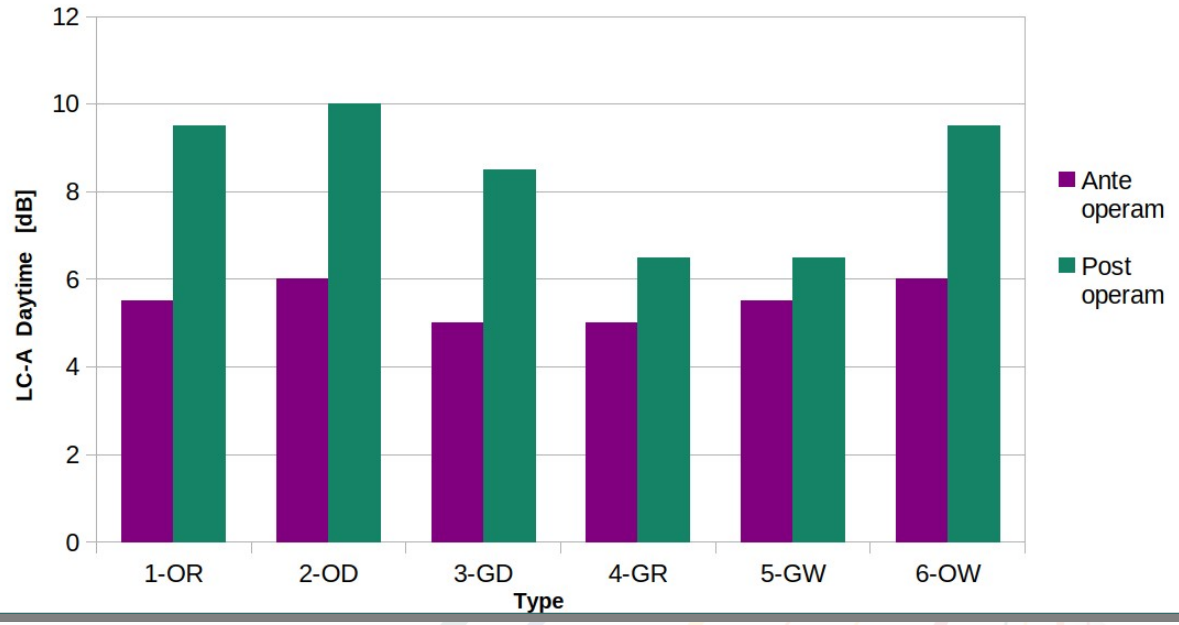
Stretch	L_{Day}			$L_{Evening}$			L_{Night}			L_{DEN}		
	"Before"	"After"	After - Before	"Before"	"After"	After - Before	"Before"	"After"	After - Before	"Before"	"After"	After - Before
1-OR	66.1	62.7	-3.4	64.8	61.8	-3.0	59.4	56.7	-2.7	67.8	64.8	-3.0
2-OD	66.1	63.8	-2.3	64.8	61.4	-3.4	59.4	55.5	-3.9	67.8	64.7	-3.1
3-GD	68.1	63.8	-4.4	67.3	61.7	-5.6	62.6	57.4	-5.2	70.5	65.5	-5.0
4-GR	68.1	65.7	-2.4	67.3	64.8	-2.4	62.6	60.5	-2.0	70.5	68.3	-2.2
5-GW	70.5	67.7	-2.8	69.1	66.0	-3.1	64.8	61.1	-3.7	72.7	69.4	-3.3
6-OW	69.8	65.6	-4.3	68.3	63.3	-5.0	63.8	59.7	-4.0	71.8	67.6	-4.2



Site 1 - $L_{C\text{-}A}$

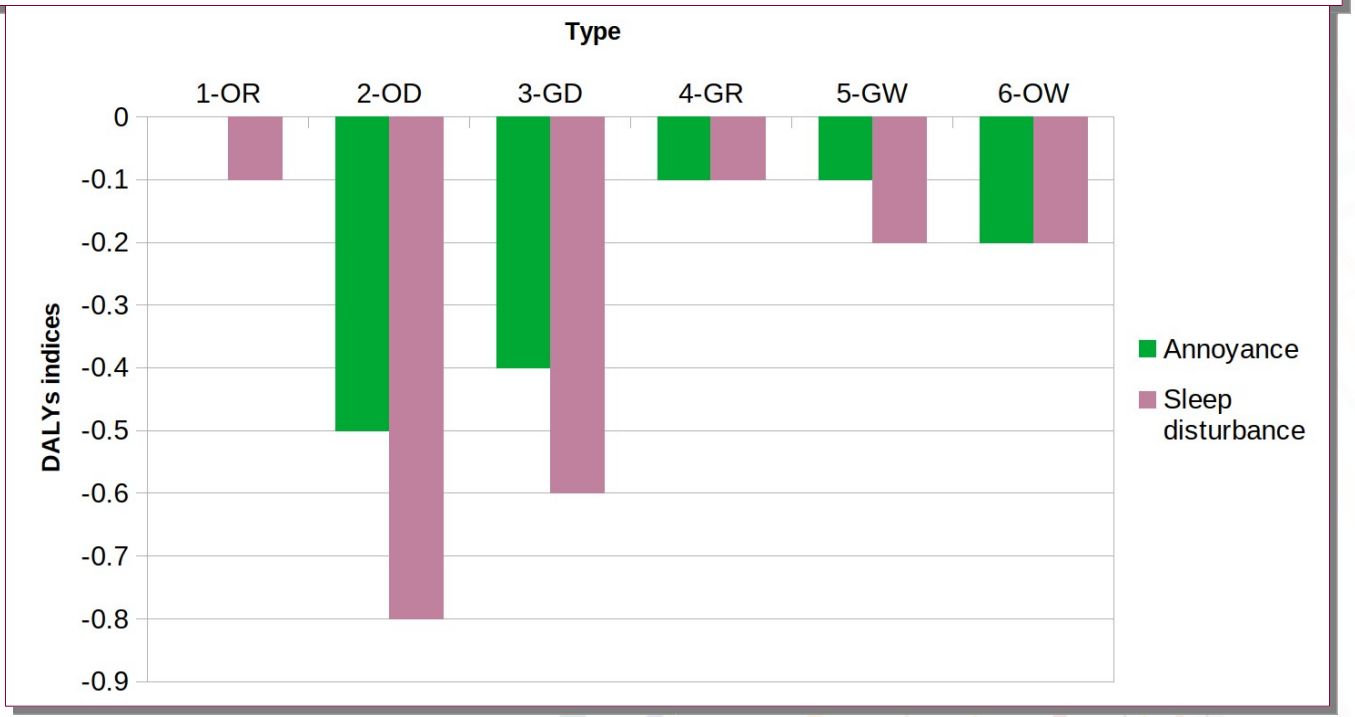
$L_{C\text{-}A}$ noise indicator values averaged for each stretch. Values in dB. Values after ± sign represent value uncertainty with a level of confidence of about 95%.

Stretch	$L_{C\text{-}A}$ daytime (6.00 - 20.00)			$L_{C\text{-}A}$ nighttime (22.00 - 6.00)		
	"Before"	"After"	After - Before	"Before"	"After"	After - Before
1-OR	5.5 ± 0.3	9.5 ± 0.7	4.0	5.0 ± 1.3	9.5 ± 1.7	4.5
2-OD	6.0 ± 0.2	10.0 ± 0.5	4.0	5.0 ± 0.5	9.0 ± 1.0	4.0
3-GD	5.0 ± 0.2	8.5 ± 0.7	3.5	3.5 ± 0.4	7.5 ± 1.2	4.0
4-GR	5.0 ± 0.1	6.5 ± 0.1	1.5	3.0 ± 0.4	4.5 ± 0.3	1.5
5-GW	5.5 ± 0.2	6.5 ± 0.2	1.0	4.5 ± 03	6.0 ± 0.4	1.5
6-OW	6.0 ± 0.3	9.5 ± 0.2	3.5	4.5 ± 0.5	9.0 ± 0.6	4.5



Site 1 - DALY

Stretch	DALY Annoyance			DALY Sleep disturbance			DALY Cognitive impairment		
	"Before"	"After"	After - Before	"Before"	"After"	After - Before	"Before"	"After"	After - Before
1-OR	0.1	0.1	0.0	0.3	0.2	-0.1	0.0	0.0	
2-OD	1.1	0.6	-0.5	1.9	1.1	-0.8	0.0	0.0	
3-GD	1.2	0.8	-0.4	2.1	1.5	-0.6	0.3	0.2	-0.1
4-GR	0.6	0.5	-0.1	1.1	1.0	-0.1	0.0	0.0	
5-GW	0.5	0.4	-0.1	0.9	0.7	-0.2	0.2	0.2	0.0
6-OW	0.6	0.4	-0.2	1.1	0.9	-0.2	0.0	0.0	
TOTAL	**4.1**	**2.8**	---	**7.4**	**5.4**	---	---	---	---



Sistema Nazionale per la Protezione dell'Ambiente

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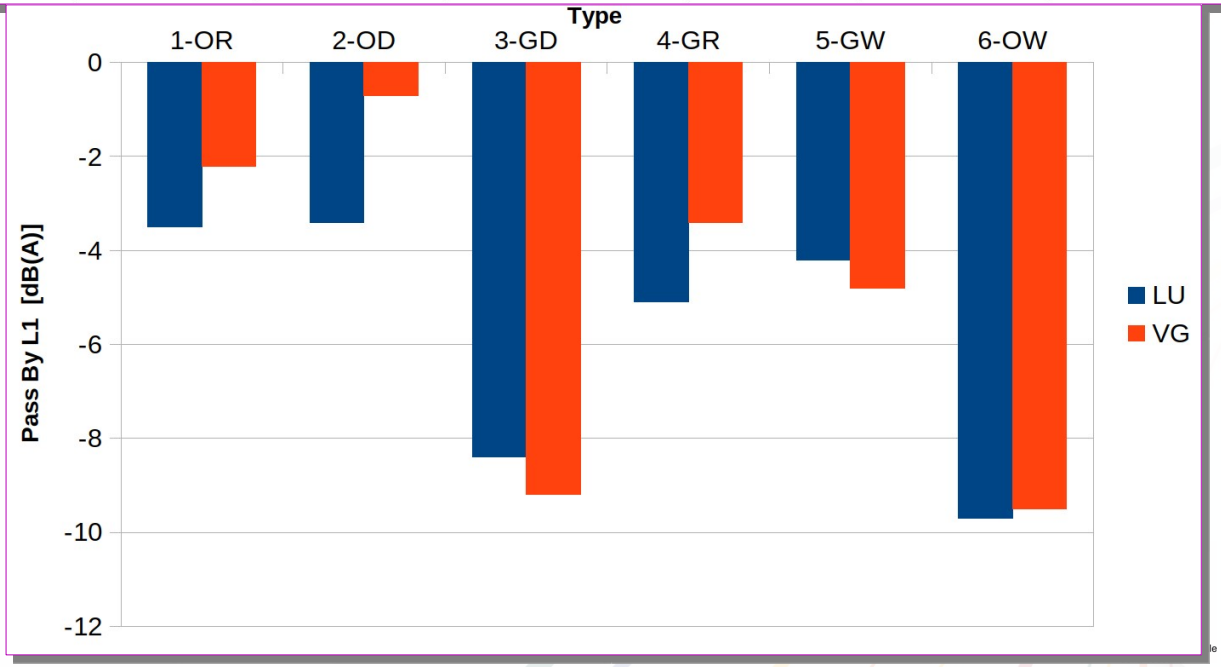
Site 1 – SPB - L_1

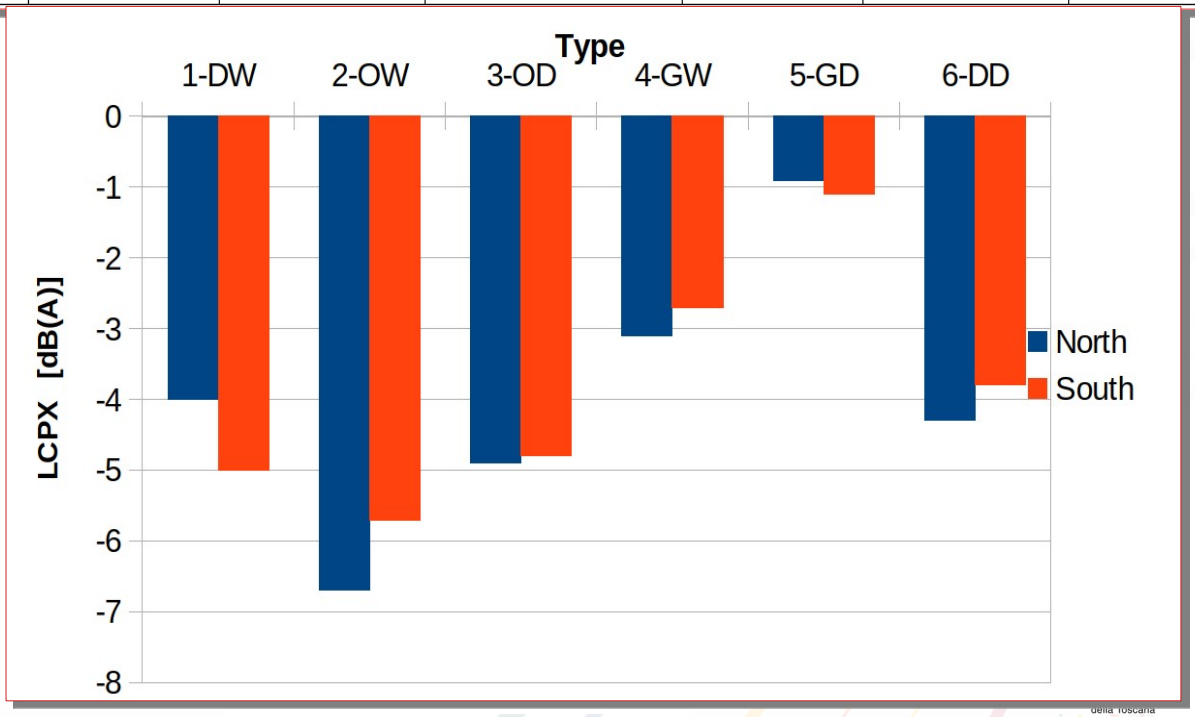
Pass by Values L_1 and related expanded uncertainties with a level of confidence of about 68%. Quantities in dB(A).

Stretch	Direction: to Viareggio			Direction: To Lucca		
	"Before"	"After"	After - Before	"Before"	"After"	After - Before
1-OR	71.1 ± 2.7	68.9 ± 1.9	-2.2	73.7 ± 1.9	70.2 ± 0.4	-3.5
2-OD	71.1 ± 2.7	70.4 ± 1.9	-0.7	73.7 ± 1.9	70.3 ± 0.4	-3.4
3-GD	74.6 ± 0.5	65.4 ± 1.2	-9.2	76.1 ± 1.2	67.7 ± 1.0	-8.4
4-GR	74.6 ± 0.5	71.2 ± 1.2	-3.4	76.1 ± 1.2	71.0 ± 1.3	-5.1
5-GW	74.6 ± 0.6	69.8 ± 1.0	-4.8	74.7 ± 1.0	70.5 ± 1.5	-4.2
6-OW	76.7 ± 0.8	67.2 ± 0.9	-9.5	75.7 ± 0.9	66.0 ± 0.8	-9.7



Site 2 – CPX @ 50 km/h

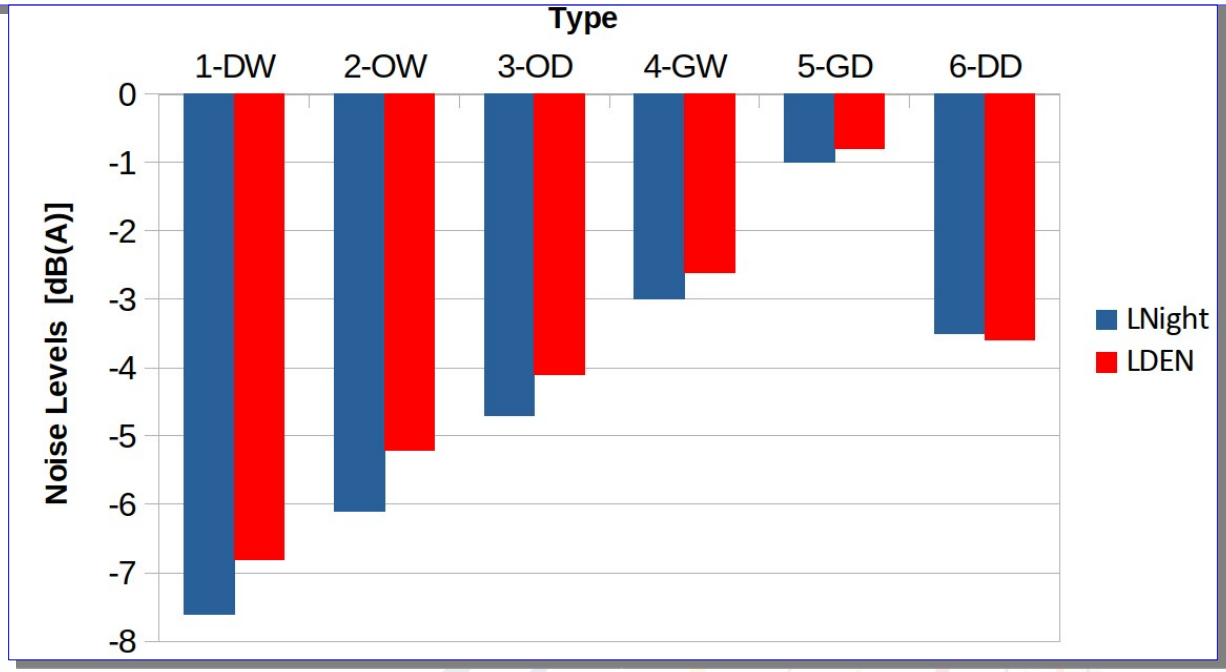
Stretch	Direction: North (to Arezzo)			Direction: South (from Arezzo)		
	"Before"	"After"	After - Before	"Before"	"After"	After - Before
1-DW	94.3 ± 1.9	90.3 ± 0.9	-4.0	95.0 ± 2.7	90.0 ± 0.9	-5.0
2-OW	94.9 ± 1.6	88.2 ± 0.8	-6.7	94.1 ± 1.7	88.4 ± 0.8	-5.7
3-OD	94.6 ± 1.4	89.7 ± 0.8	-4.9	94.5 ± 2.1	89.7 ± 0.8	-4.8
4-GW	94.6 ± 1.5	91.5 ± 0.8	-3.1	94.5 ± 1.3	91.8 ± 0.8	-2.7
5-GD	92.1 ± 3.1	91.2 ± 0.8	-0.9	92.4 ± 1.9	91.3 ± 0.8	-1.1
6-DD	94.5 ± 1.5	90.2 ± 0.8	-4.3	94.1 ± 1.8	90.3 ± 0.8	-3.8



Site 2 - L_{Aeq}

L_{Aeq} values for the European indicators. All values are in dB(A). The expanded uncertainty is 0.8 dB(A) with a level of confidence of about 95%.

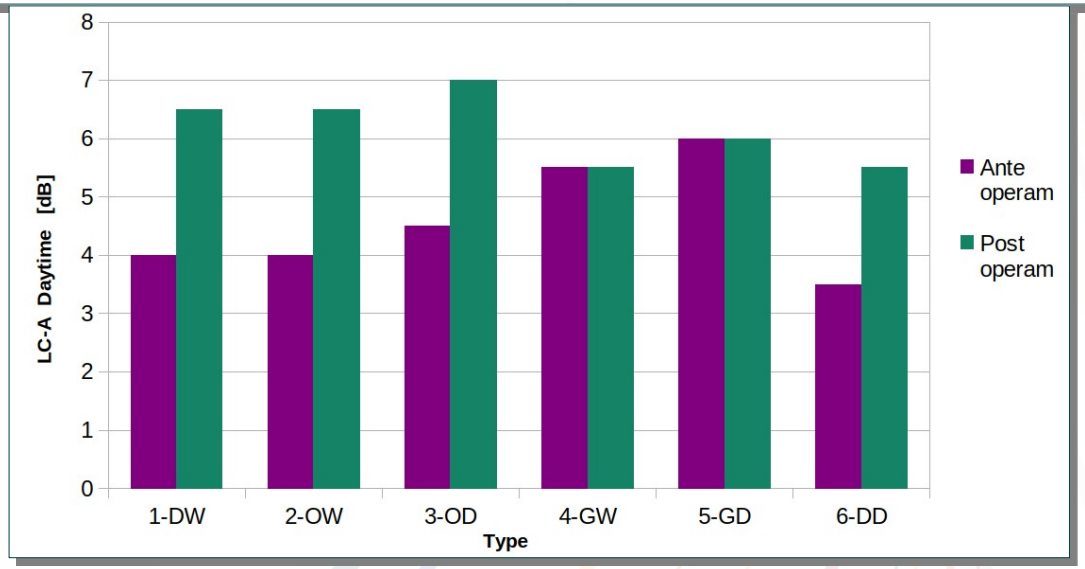
Stretch	L_{Day}			$L_{Evening}$			L_{Night}			L_{DEN}		
	"Before"	"After"	After - Before	"Before"	"After"	After - Before	"Before"	"After"	After - Before	"Before"	"After"	After - Before
1-DW	72.1	66.8	-5.3	71.6	63.9	-7.7	67.4	59.8	-7.6	75.0	68.2	-6.8
2-OW	69.3	65.2	-4.1	67.7	61.9	-5.8	63.2	57.0	-6.1	71.3	66.0	-5.2
3-OD	68.8	65.6	-3.2	67.7	63.4	-4.3	63.1	58.5	-4.7	71.1	67.0	-4.1
4-GW	69.4	67.4	-2.0	68.4	66.2	-2.2	65.3	62.2	-3.0	72.6	69.9	-2.6
5-GD	67.3	67.1	-0.3	66.3	65.4	-0.9	62.9	61.8	-1.0	70.3	69.5	-0.8
6-DD	70.7	67.2	-3.5	69.6	65.4	-4.2	65.3	61.8	-3.5	73.1	69.5	-3.6



Site 2 - L_{C-A}

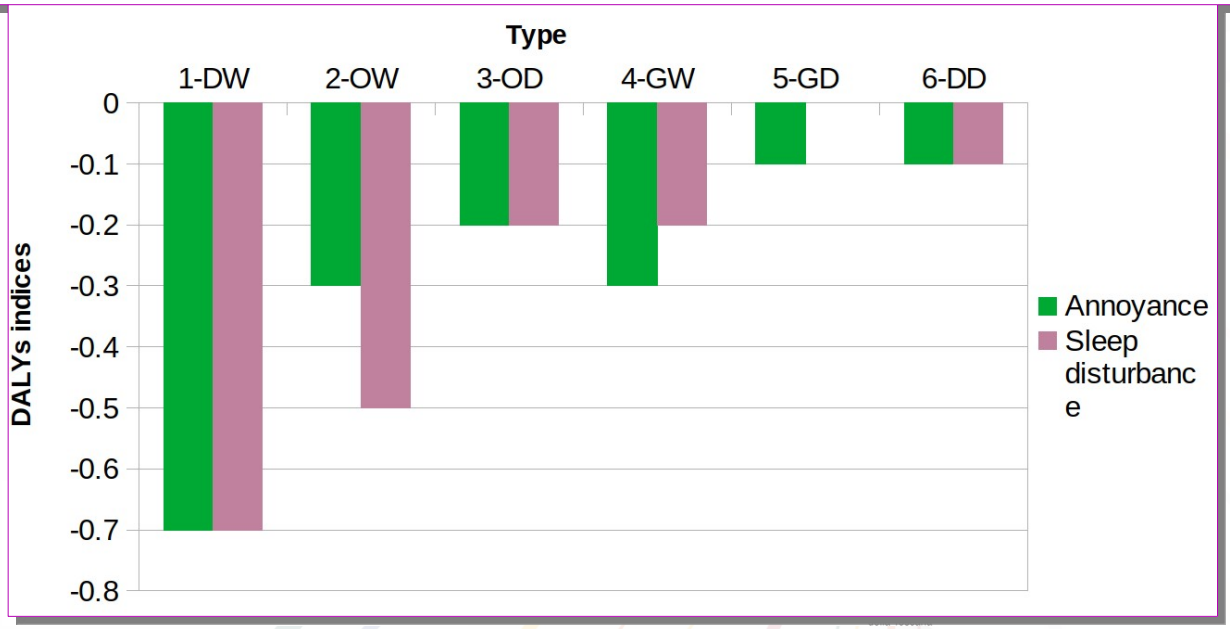
L_{C-A} noise indicator values averaged for each stretch. Values in dB. Values after ± sign represent value uncertainty with a level of confidence of about 95%.

Stretch	L_{C-A} diurnal (6.00 - 20.00)			L_{C-A} nocturnal (22.00 - 6.00)		
	"Before"	"After"	After - Before	"Before"	"After"	After - Before
1-DW	4.0 ± 0.2	6.5 ± 0.3	2.5	3.0 ± 0.3	5.0 ± 0.4	2.0
2-OW	4.0 ± 0.2	6.5 ± 0.4	2.5	4.0 ± 0.5	6.0 ± 0.5	2.0
3-OD	4.5 ± 0.2	7.0 ± 0.2	2.5	3.5 ± 0.3	5.5 ± 0.3	2.0
4-GW	5.5 ± 0.2	5.5 ± 0.2	0.0	4.0 ± 0.4	4.0 ± 0.3	0.0
5-GD	6.0 ± 0.1	6.0 ± 0.1	0.0	4.5 ± 0.4	4.5 ± 0.3	0.0
6-DD	3.5 ± 0.4	5.5 ± 0.2	2.0	2.5 ± 0.2	4.5 ± 0.3	2.0



Site 2 - DALY

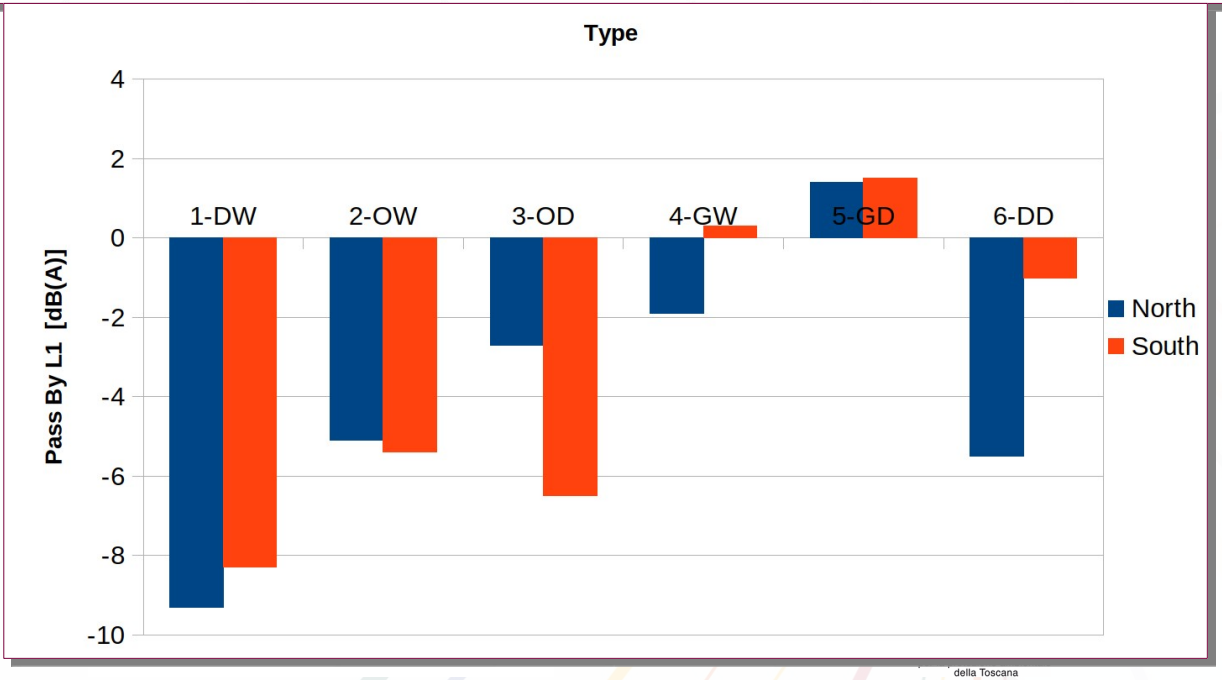
Stretch	DALY Annoyance			DALY Sleep disturbance			DALY Cognitive impairment		
	"Before"	"After"	After - Before	"Before"	"After"	After - Before	"Before"	"After"	After - Before
1-DW	1.1	0.4	-0.7	1.7	1.0	-0.7	0.0	0.0	
2-OW	0.7	0.4	-0.3	1.3	0.8	-0.5	0.0	0.0	
3-OD	0.5	0.3	-0.2	0.9	0.7	-0.2	0.0	0.0	
4-GW	0.7	0.4	-0.3	1.2	1.0	-0.2	0.0	0.0	
5-GD	0.3	0.2	-0.1	0.6	0.6	0.0	0.2	0.2	0.0
6-DD	0.6	0.5	-0.1	1.1	1.0	-0.1	0.1	0.1	0.0
TOTAL	3.9	6.8	---	2.2	5.1	---	---	---	---



Site 2 – SPB - L_1

Pass by Values L_1 and related expanded uncertainties with a level of confidence of about 68%. Quantities in dB(A).

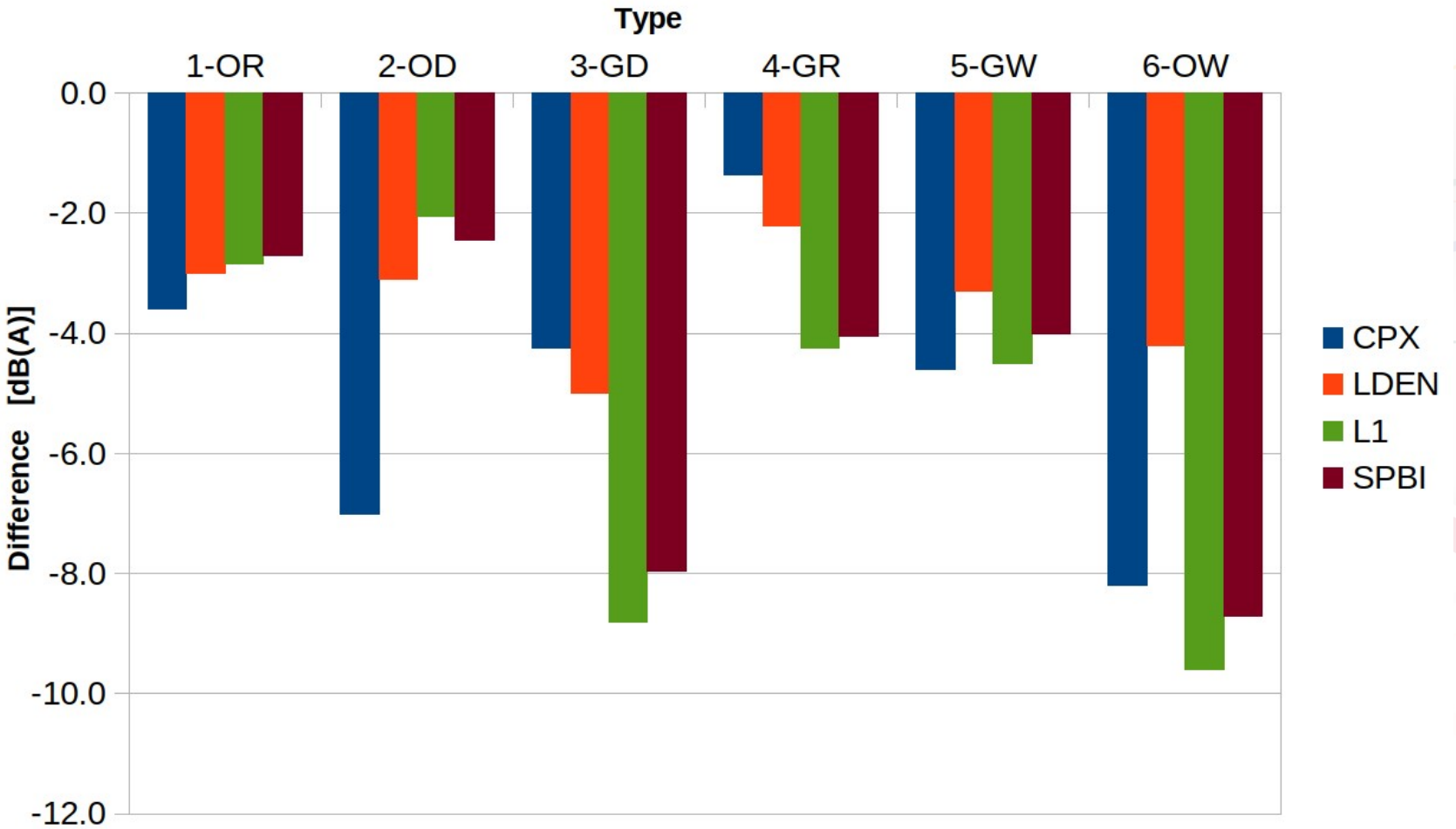
Stretch	Direction: North (to Arezzo)			Direction: South (from Arezzo)		
	"Before"	"After"	After - Before	"Before"	"After"	After - Before
1-DW	78.8 ± 1.8	69.5 ± 2.0	-9.3	77.6 ± 0.3	69.3 ± 1.8	-8.3
2-OW	73.3 ± 0.6	68.2 ± 2.7	-5.1	73.9 ± 2.8	68.5 ± 1.9	-5.4
3-OD	73.1 ± 1.2	70.4 ± 1.2	-2.7	76.4 ± 1.2	69.9 ± 1.0	-6.5
4-GW	73.4 ± 3.3	71.5 ± 1.6	-1.9	73.3 ± 2.5	73.6 ± 1.3	0.3
5-GD	70.8 ± 1.3	72.2 ± 0.5	1.4	71.8 ± 2.4	73.3 ± 1.8	1.5
6-DD	75.1 ± 1.6	69.6 ± 3.1	-5.5	72.4 ± 2.7	71.4 ± 2.9	-1.0



Project results – LNP as a valid solution

- One of the key objectives of the Nereide project is the design and construction of ***low-noise pavements (LNPs)*** as a valid solution to noise pollution.
- A LNP is defined as a pavement which **can reduce to some extent traffic noise emissions in relation to a reference pavement.**
- Actually, **it exists neither a unique quantification of the extent of noise reduction nor a unique definition of the reference pavement**;
- the most widely used definition of LNP has been adopted, i.e. "**the pavement able to provide a reduction of -3 dB(A) with respect to a Dense Asphalt Concrete (DAC)**" being a DAC an asphalt mix with less than 8 % voids;
- based on this, the existing pavements of the implementation site prior to the intervention have been taken as reference DAC.

Site 1 - Summary



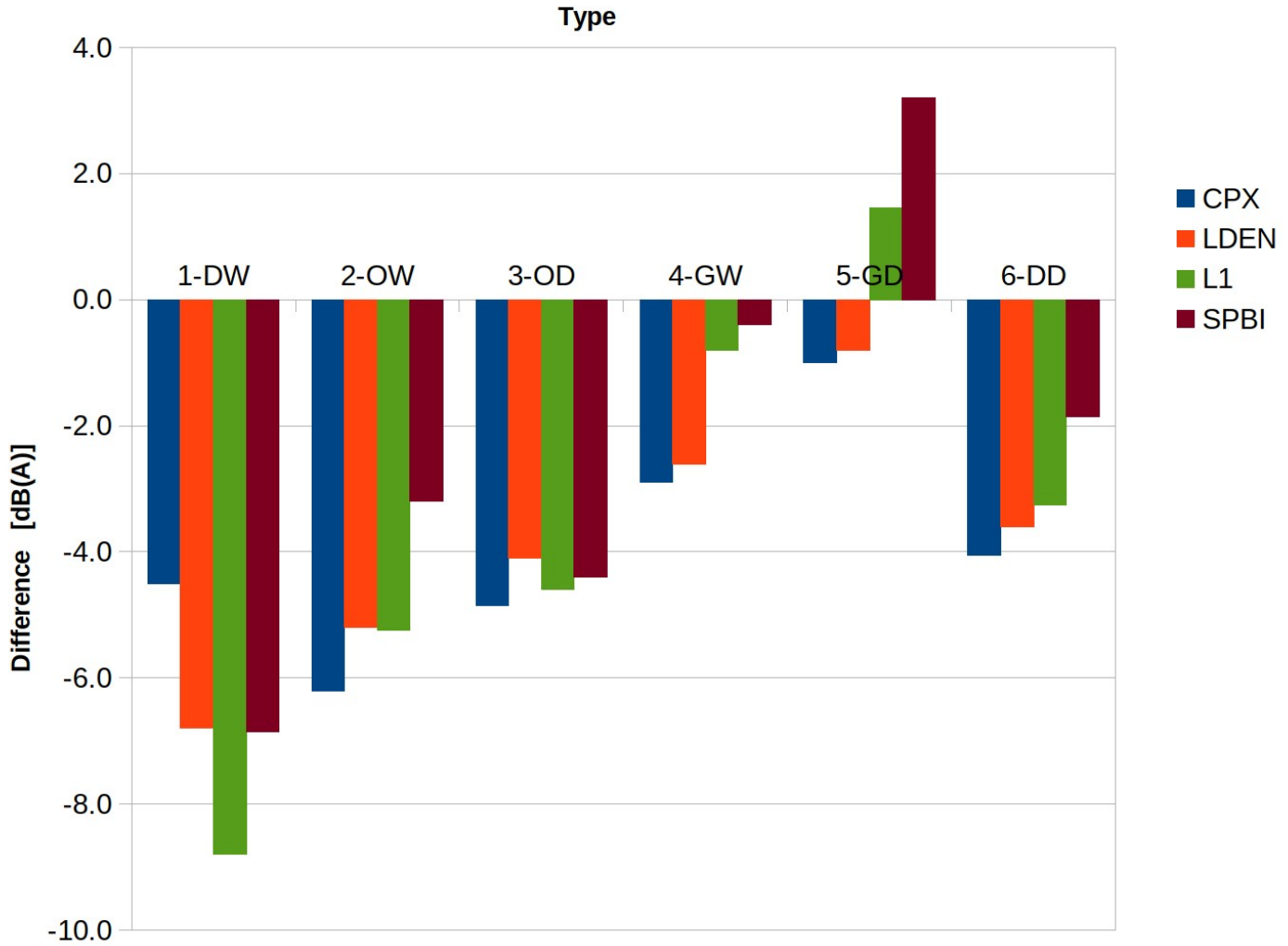
Differences between after and before noise indicators for site 1 stretches.

Project Results for site 1 surfaces

- The **Open wet, Open reference and Gap wet** surfaces show a uniform response for all of them.

- The other three pavements show an alternate behaviour in indicators:
  - for **Open dry** pavement CPX results are better than L_1, L_{DEN} and SPBI results;
  - for **Gap dry and Gap reference** the CPX differences between post and ante operam are worse than the other indicators ones

Site 2 - Summary



Project Results for site 2 surfaces

- Only the **Open dry** wearing course shows a uniform response for all of them.
- The other five pavements show an alternate behaviour in indicators:
  - best performances may be seen for **dense wet** and **open wet** surfaces;
  - while **gap dry** and **gap wet** show worst noise performances.
- From a noise levels assessment point of view the observed **frequency shift towards low frequencies** is a great enhancement.

Project conclusions (I)

- Comparing the results of the acoustic and psychoacoustic performances found on the finished pavements with the granulometric and volumetric characteristics of the corresponding mixtures, **the following general considerations can be done:**

  1) To obtain the acoustic benefits of a surface layer **it is essential to ensure compliance with the granulometric and volumetric requirements of the corresponding mixture**

  2) **on-site control tests need to perform during the laying of the asphalt mixture** by a mobile laboratory equipped with the necessary instrumentation for testing.

  3) If the particle size and volumetric requirements are met, **unexpected noise levels can be attributed to improperly paving.**

Project conclusions (II)

- If RAP (Recycled Asphalt Pavement) is introduced in the mixtures, it must be suitably selected in order **to ensure that the particles have a maximum diameter less than 8 mm** and to avoid that it contains an excess of sand (range 0.5-4 mm).

Project conclusions (IV)

- There have been **evident benefits** from both an acoustic and psychoacoustic point of view. In fact:

  1) For both sites, both **measured psychoacoustical and acoustical parameters show a reduction of value**s and as a consequence a decrease of the corresponding perceived annoyance.

  2) Noise reduction, considering as an example the LDEN values, is from 0.8 dB(A) to 6.5 dB(A) **depending on the type of road pavement**.

  3) The social survey results confirm the above outcome, as **citizens report a general reduction of the perceived noise and annoyanc**e.

  4) Both the objective evaluation and the subjective responses show a reduction of the values related to the PA and %HA.

Sistema Nazionale per la Protezione dell'Ambiente

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ARPAT
Agenzia regionale per la protezione ambientale della Toscana

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