H Description of Formations in Groningen field (in Dutch)

The following short descriptions of Dutch formations relevant for the Groningen field were provided by DINO / TNO Geological Survey of the Netherlands.

Mariene afzettingen

Formatie van Maassluis.

Lithologie	Zand, matig fijn tot matig grof, kalkrijk, schelphoudend, afgewisseld met zandige klei. Plaatselijk zijn de afzettingen licht glauconiethoudend en kan grind voorkomen. Overwegend grijs van kleur.
Afzettingsmilieu	Ondiep marien en kust
Dikte	80 – 120 m (max. >250 m)
Ouderdom	Ouderdom: Vroeg-Pleistoceen.

Implicaties en toepassingen	030-2564850
Uitgebreide informatie	https://www.dinoloket.nl/nomenclator-ondiep

Eem Formatie

Lithologie	Zand, fijn tot matig grof en klei, kalk- en schelphoudend.
Afzettingsmilieu	Ondiep marien tot kustvlakte
Dikte	5 – 15 m (max. 45 m, bekken van Amsterdam)
Ouderdom	Eemien

Implicaties en toepassingen	030-2564850
Uitgebreide informatie	https://www.dinoloket.nl/nomenclator-ondiep

Formatie van Naaldwijk

Lithologie	Zand, zeer fijn tot matig grof, schelphoudend, en kalkhoudende sterk zandige tot zwak siltige kleien met schelpen. In geulopvullingen komt schelprijk matig grof tot zeer grof zand voor.
Afzettingsmilieu	Kustvlakte, kustzone, getijdengeulen, wadden, strand en duinen.
Dikte	10 – 30 m (max. 90 m, ter plekke van geulen en kustduinen)
Ouderdom	Holoceen

Implicaties en toepassingen	030-2564850
Uitgebreide informatie	https://www.dinoloket.nl/nomenclator-ondiep

Fluviatiele afzettingen

Formatie van Peize

Lithologie	Zand, matig grof tot uiterst grof, kwartsrijk en lichtgrijs tot wit van kleur. Plaatselijk grindhoudend, bovenin komen lokaal stenen voor. In het onderste deel van de eenheid kunnen donkergrijze tot bruine kleilagen ingeschakeld zijn. De afzettingen zijn meestal kalkarm of kalkloos.
Afzettingsmilieu	Fluviatiel (Eridanos systeem uit Balticum en Noord-Duitsland)
Dikte	50 – 100 m (max. > 200 m)
Ouderdom	Plioceen tot Vroeg-Pleistoceen

Implicaties en toepassingen	030-2564850
Uitgebreide informatie	https://www.dinoloket.nl/nomenclator-ondiep

Formatie van Appelscha

Lithologie	Zand, matig grof tot uiterst grof grindhoudend, kalkloos, overwegend grijswit van kleur.
Afzettingsmilieu	Fluviatiel (brongebied Midden-Duitsland / Bohemen).
Dikte	15 – 100 m (max. 150 m)
Ouderdom	Midden-Pleistoceen

Implicaties en toepassingen	030-2564850
Uitgebreide informatie	https://www.dinoloket.nl/nomenclator-ondiep

Formatie van Urk

Lithologie	Zand, matig fijn tot uiterst grof, zwak tot sterk grindhoudend. De kleur varieert van grijs tot bruin. Het sediment is meestal kalk- en glimmerhoudend; plaatselijk komen kleilagen voor.
Afzettingsmilieu	Fluviatiel (Rijn en Maas)
Dikte	25 – 30 m (max. 60 m)
Ouderdom	Midden-Pleistoceen

Implicaties en toepassingen	030-2564850
Uitgebreide informatie	https://www.dinoloket.nl/nomenclator-ondiep

Glaciale afzettingen

Formatie van Peelo

Lithologie	Zand, uiterst fijn tot uiterst grof, kalkarm, soms zwak tot sterk grindhoudend. De kleur varieert van geel- of lichtgrijs tot zwart. Zandige tot zwak siltige, donkergrijze tot zwarte, harde klei ('potklei'). Deze is veelal kalkrijk en glimmerhoudend en lichtgrijs tot zwart van kleur.
Afzettingsmilieu	Subglaciale dalen en smeltwatermeren
Dikte	<5 tot >500 m (grootste diktes in dalsystemen)
Ouderdom	Elsterien

Implicaties en toepassingen	030-2564850
Uitgebreide informatie	https://www.dinoloket.nl/nomenclator-ondiep

Formatie van Drenthe

Lithologie	Sterk variabel: (1) 'Keileem': Compacte mengsels van zand, klei / leem en soms stenen, keien of blokken. (2) Uiterst grof zand met grind en stenen. (3) Zandige tot zwak siltige klei.
Afzettingsmilieu	De onderscheiden lithologieën zijn gerelateerd aan landijsbedekking: (1) Keileem: gevormd als grondmorene (2) Grove afzettingen: o.h.a. gevormd door smeltwaterstromen (3) Klei: gevormd in smeltwatermeren
Dikte	5 – 20 m (max. 35 m, in smeltwatermeren)
Ouderdom	Saalien

Implicaties en toepassingen	030-2564850
Uitgebreide informatie	https://www.dinoloket.nl/nomenclator-ondiep

Eolische en lokaal-terrestrische afzettingen

Formatie van Drachten

Lithologie	Zand, matig fijn tot matig grof, lichtgrijs tot geelgrijs, zonder silt of zwak siltig, kalkloos, met dunne leemlaagjes en plantenresten.
Afzettingsmilieu	Eolisch, stromend water en meertjes.
Dikte	2 – 15 m
Ouderdom	Midden-Pleistoceen tot Vroeg-Saalien.

Implicaties en toepassingen	030-2564850
Uitgebreide informatie	https://www.dinoloket.nl/nomenclator-ondiep

Formatie van Boxtel

Lithologie	(1) Zand, zeer fijn tot matig grof, zwak tot sterk siltig, kalkloos tot sterk kalkhoudend, lokaal zwak tot sterk grindhoudend. De kleur varieert van lichtgrijs tot geelbruin. (2) Bruine tot geelbruine leem (löss). (3) Zwak tot sterk zandige, kalkloze tot sterk kalkhoudende leem en dunne veen- of gyttjalagen.
Afzettingsmilieu	Eolisch (zand en löss) en beekdalen (leem en veen)
Dikte	2 – 10 m (max. 35 m)
Ouderdom	Midden-Pleistoceen tot Holoceen (NB: Holocene afzettingen zijn als 'Holoceen' gekarteerd)

Implicaties en toepassingen	030-2564850
Uitgebreide informatie	https://www.dinoloket.nl/nomenclator-ondiep

Formatie van Nieuwkoop

Lithologie	Veen, zwak tot sterk kleiig, mineraalarm, kalkloos, bruin tot zwart, zwak tot sterk zandig, en gyttja, kalkloos tot kalkrijk, geel tot groenachtig bruin.
Afzettingsmilieu	Kustvlakte en op waterscheidingen
Dikte	Tot ca 10 m
Ouderdom	Holoceen

Implicaties en toepassingen	030-2564850
Uitgebreide informatie	https://www.dinoloket.nl/nomenclator-ondiep

Gestuwde Formaties

Stuwing door landijs heeft ertoe geleid dat aanzienlijke volumes sediment zijn verplaatst en vervormd tot zgn. stuwwallen. Doordat normale opeenvolgingen en bepaalde karakteristieken van formaties in dit proces kunnen zijn verstoord, is het niet mogelijk om de oorspronkelijke eenheid uit de sedimentkarakteristieken af te leiden. Gestuwde formaties zijn daarom ongedifferentieerd in DGM opgenomen.

Implicaties en toepassingen	030-2564850
Uitgebreide informatie	https://www.dinoloket.nl/nomenclator-ondiep

I Histograms of V_s for Groningen SCPTs

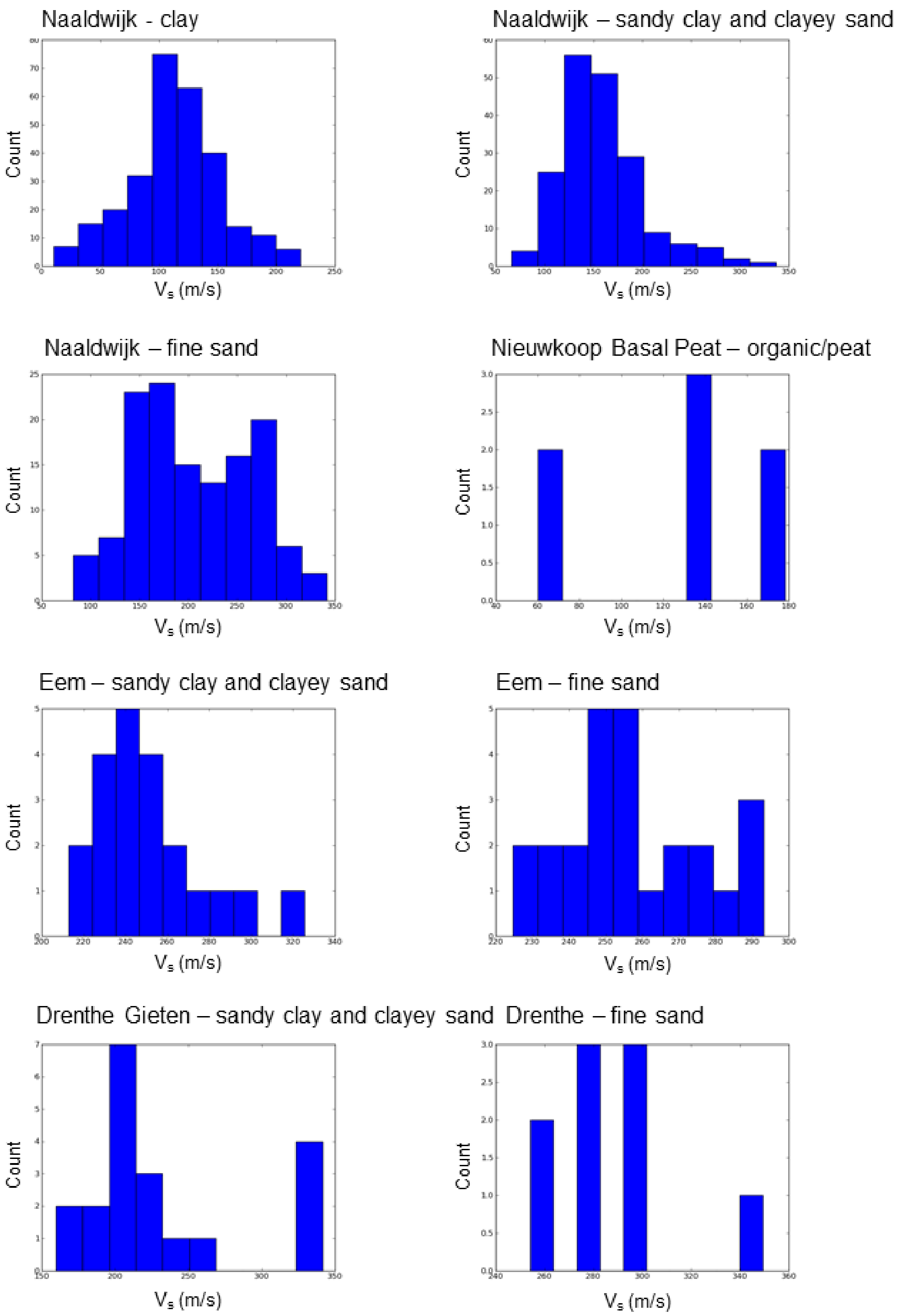


Figure I.1 Histograms of V_s values from SCPTs from the Groningen database for combinations of lithostratigraphy and lithological classes represented in the SCPTs.

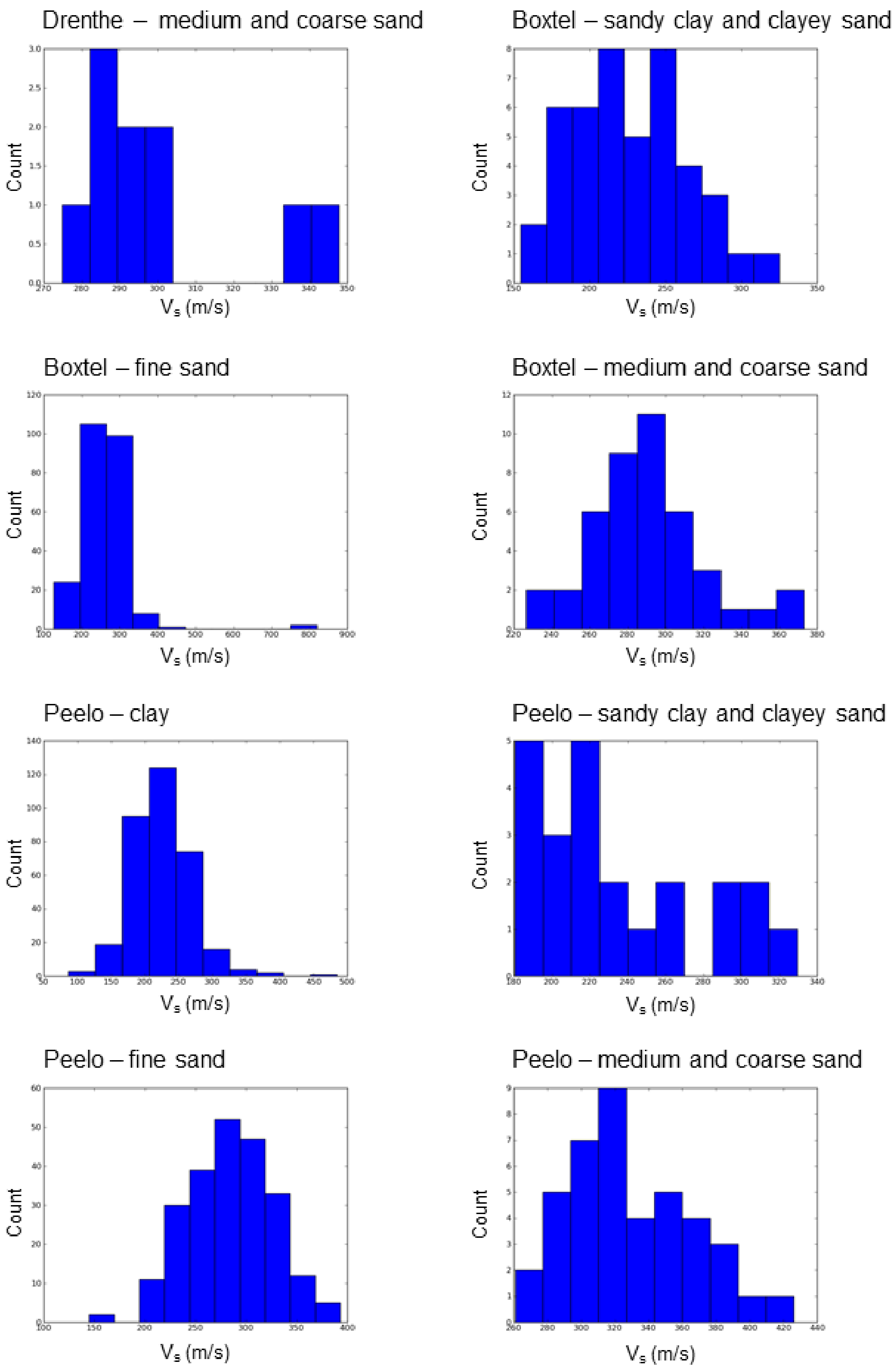


Figure I.1 continued. Histograms of V_s values from SCPTs from the Groningen database for combinations of lithostratigraphy and lithological classes represented in the SCPTs.

J Look up table of V_s for V_{s30}

Table J.1 Groningen-specific shear-wave velocities used to construct the V_{s30} map.

Litho-strati-graphical unit GeoTOP	Most likely lithological class in GeoTOP	Average V_s (m/s)	Standard deviation of V_s (m/s)	Source *)	Remark
AAOP	Anthropogenic	150	30	3	
AP	Organic deposits (peat)	350	70	3	
AP	Clay	350	70	3	
AP	Clayey sand and sandy clay	350	70	3	
AP	Fine sand	350	70	3	
AP	Medium sand, coarse sand, gravel and shells	400	80	3	
BX	Organic deposits (peat)	150	30	3	
BX	Clay	150	30	3	
BX	Clayey sand and sandy clay	226.15	37.63	1	
BX	Fine sand	262.21	66.5	1	
BX	Medium sand, coarse sand, gravel and shells	289.95	31.06	1	
BXKO	Organic deposits (peat)	150	30	3	From BX
BXKO	Clay	150	30	3	From BX
BXKO	Clayey sand and sandy clay	226.15	37.63	3	From BX
BXKO	Fine sand	262.21	66.5	3	From BX
BXKO	Medium sand, coarse sand, gravel and shells	289.95	31.06	3	From BX
BXSI1	Organic deposits (peat)	50	10	3	From NIHO
BXSI1	Clay	85	17	3	From NIHO
BXSI1	Clayey sand and sandy clay	110	22	3	From NIHO
BXSI1	Fine sand	138	27.6	3	From NIHO
BXSI1	Medium sand, coarse sand, gravel and shells	138	27.6	3	From NIHO
BXSI2	Organic deposits (peat)	150	30	3	From BX
BXSI2	Clay	150	30	3	From BX
BXSI2	Clayey sand and sandy clay	226.15	37.63	3	From BX
BXSI2	Fine sand	262.21	66.5	3	From BX
BXSI2	Medium sand, coarse sand, gravel and shells	289.95	31.06	3	From BX
BXWI	Organic deposits (peat)	150	30	3	From BX
BXWI	Clay	150	30	3	From BX
BXWI	Clayey sand and sandy clay	226.15	37.63	3	From BX
BXWI	Fine sand	262.21	66.5	3	From BX
BXWI	Medium sand, coarse sand, gravel and shells	289.95	31.06	3	From BX

Table J.1, continued. *Groningen-specific shear-wave velocities used to construct the V_{s30} map.*

Litho-strati-graphical unit GeoTOP	Most likely lithological class in GeoTOP	Average V_s (m/s)	Standard deviation of V_s (m/s)	Source *)	Remark
DN	Organic deposits (peat)	150	30	3	
DN	Clay	150	30	3	
DN	Clayey sand and sandy clay	226	39	3	
DN	Fine sand	355	71	2	
DN	Medium sand, coarse sand, gravel and shells	450	90	3	
DR	Organic deposits (peat)	200	40	3	
DR	Clay	200	40	3	
DR	Clayey sand and sandy clay	233.01	55.53	3	From DRGI
DR	Fine sand	286.14	26.49	1	
DR	Medium sand, coarse sand, gravel and shells	300.07	22.07	1	
DRGI	Organic deposits (peat)	200	40	3	
DRGI	Clay	200	40	3	
DRGI	Clayey sand and sandy clay	233.01	55.53	1	
DRGI	Fine sand	286.14	26.49	3	From DR
DRGI	Medium sand, coarse sand, gravel and shells	300.07	22.07	3	From DR
EE	Organic deposits (peat)	160	32	3	
EE	Clay	224.46	28.36	1	
EE	Clayey sand and sandy clay	251.68	26.28	1	
EE	Fine sand	256.77	19.06	1	
EE	Medium sand, coarse sand, gravel and shells	257	51	3	
missing	Organic deposits (peat)	190	40	3	Average of all V_s from SCPTs
missing	Clay	190	40	3	Average of all V_s from SCPTs
missing	Clayey sand and sandy clay	190	40	3	Average of all V_s from SCPTs
missing	Fine sand	190	40	3	Average of all V_s from SCPTs
missing	Medium sand, coarse sand, gravel and shells	190	40	3	Average of all V_s from SCPTs
NA	Organic deposits (peat)	85	17	2	
NA	Clay	113.7	38.57	1	
NA	Clayey sand and sandy clay	157.82	42.94	1	
NA	Fine sand	206.39	58.42	1	
NA	Medium sand, coarse sand, gravel and shells	250	50	3	
NASC	Organic deposits (peat)	85	17	3	From NA
NASC	Clay	113.7	38.57	3	From NA
NASC	Clayey sand and sandy clay	157.82	42.94	3	From NA

Table J.1, continued. Groningen-specific shear-wave velocities used to construct the V_{s30} map.

Litho-strati-graphical unit GeoTOP	Most likely lithological class in GeoTOP	Average V_s (m/s)	Standard deviation of V_s (m/s)	Source *)	Remark
NASC	Fine sand	206.39	58.42	3	From NA
NASC	Medium sand, coarse sand, gravel and shells	250	50	3	From NA
NAWA	Organic deposits (peat)	85	17	3	From NA
NAWA	Clay	113.7	38.57	3	From NA
NAWA	Clayey sand and sandy clay	157.82	42.94	3	From NA
NAWA	Fine sand	206.39	58.42	3	From NA
NAWA	Medium sand, coarse sand, gravel and shells	250	50	3	From NA
NAWO	Organic deposits (peat)	85	17	3	From NA
NAWO	Clay	113.7	38.57	3	From NA
NAWO	Clayey sand and sandy clay	157.82	42.94	3	From NA
NAWO	Fine sand	206.39	58.42	3	From NA
NAWO	Medium sand, coarse sand, gravel and shells	250	50	3	From NA
NAZA	Organic deposits (peat)	85	17	3	From NA
NAZA	Clay	113.7	38.57	3	From NA
NAZA	Clayey sand and sandy clay	157.82	42.94	3	From NA
NAZA	Fine sand	206.39	58.42	3	From NA
NAZA	Medium sand, coarse sand, gravel and shells	250	50	3	From NA
NIBA	Organic deposits (peat)	100	20	3	Value from SCPT analysis too high
NIBA	Clay	125	25	3	
NIBA	Clayey sand and sandy clay	150	30	3	
NIBA	Fine sand	150	30	3	
NIBA	Medium sand, coarse sand, gravel and shells	150	30	3	
NIGR	Organic deposits (peat)	50	10	3	From NIHO
NIGR	Clay	85	17	3	From NIHO
NIGR	Clayey sand and sandy clay	110	22	3	From NIHO
NIGR	Fine sand	138	28	3	From NIHO
NIGR	Medium sand, coarse sand, gravel and shells	138	28	3	From NIHO
NIHO	Organic deposits (peat)	50	10	3	
NIHO	Clay	85	17	3	
NIHO	Clayey sand and sandy clay	110	22	3	
NIHO	Fine sand	138	28	3	
NIHO	Medium sand, coarse sand, gravel and shells	138	28	3	
NINB	Organic deposits (peat)	50	10	3	From NIHO
NINB	Clay	85	17	3	From NIHO

Table J.1, continued. *Groningen-specific shear-wave velocities used to construct the V_{s30} map.*

Litho-strati-graphical unit GeoTOP	**Most likely lithological class in GeoTOP**	**Average V_s (m/s)**	**Standard deviation of V_s (m/s)**	**Source *)**	**Remark**
NINB	Clayey sand and sandy clay	110	22	3	From NIHO
NINB	Fine sand	138	27.6	3	From NIHO
NINB	Medium sand, coarse sand, gravel and shells	138	27.6	3	From NIHO
PE	Organic deposits (peat)	200	40	3	
PE	Clay	224.76	44.57	1	
PE	Clayey sand and sandy clay	233.97	43.67	1	
PE	Fine sand	285.57	43.1	1	
PE	Medium sand, coarse sand, gravel and shells	330.42	37.96	1	
UR	Organic deposits (peat)	150	30	3	
UR	Clay	190	38	2	
UR	Clayey sand and sandy clay	220	44	3	
UR	Fine sand	250	50	2	
UR	Medium sand, coarse sand, gravel and shells	290	58	3	
URTY	Organic deposits (peat)	150	30	3	From UR
URTY	Clay	190	38	2	From UR
URTY	Clayey sand and sandy clay	220	44	3	From UR
URTY	Fine sand	250	50	2	From UR
URTY	Medium sand, coarse sand, gravel and shells	290	58	3	From UR

*) Sources:

1= SCPT analysis Groningen

2 = TNO look up table Wassing et al., 2003

3 = expert estimate

K Check scenarios and GeoTOP for municipality Loppersum pilot

Section 5.2 described the check between scenarios made during schematisation and GeoTOP beta version for an example geological area (2010). The check has been performed for several other geological areas in municipality Loppersum and adjacent areas. The general observations from the other geological areas are summarised in this appendix. They are sorted into general remarks and remarks typical for specific geological areas.

General remarks

Extra clay or sandy clay intervals

Some extra clay or sandy clay intervals are recognized in the voxel stacks that are not described in the scenario's (e.g. geological area 602, 1004). They can for instance originate from a nearby well in another area in data scarce regions. To accommodate for this effect, a minimum size for a geological area was defined.

Clay/peat layers with irregular geometry

When a clay/peat layer is not deposited on a semi-horizontal surface (i.e. the same voxel-level), this layer appears smeared over a depth range in the voxel stack summary. This might suggest a less uniform area. In the scenarios, this is solved with by defining a minimum and maximum height of the layer. When the height differences are too large and mappable, a new geological area is defined.

Data density

Comparing voxel stack summaries and scenarios, it is observed that the 'best representation' also depends on data density. When there are very few or no wells present at a certain depth interval (frequently below NAP-20 m), the scenarios indicate 50-50% probability of scenario A vs. B. Although both can be true, this evaluation often finds the GeoTOP voxel stacks to be a better representation (e.g. area 1010). GeoTOP shows more variation which can for instance originate from a nearby well in another area. When there are wells and CPTs available, the scenarios are more indicative than GeoTOP. In this situation, GeoTOP often has a relatively large noise component. When there are many deep wells, layers (e.g. pot clay intervals) are often represented in more detail in the GeoTOP model than in the general schematization scenarios (e.g. area 3002).

Scenario limitations

The codes used in the scenarios during schematization do not cover all types of geology that are encountered. Some typical geological intervals are sometimes difficult to recognize in GeoTOP. Pgsf (fine glacial outbreak sands) are suggested to be fine sand, but in several regions it mainly consists of (medium) coarse sand. Potclay labelled as Pgcc is generally described as compact glacio-lacustrine clays, but in wells is often described as sandy clay, resulting from the mixing of fine sand/clay laminated sediments, and subsequently modelled in GeoTOP as sandy clay. To further complicate this, in (deep) wells potclay could be described as fine sand with clay lumps. In GeoTOP, this is classified as lithological class 3 (clayey sand/sandy clay) and it may not be recognized as potclay anymore. Moreover, the lower part of the potclay can in some areas be sandier than the top. This also does not fit in the available potclay code.

Remarks for specific geological units

It must be taken into account that the observations given below do not occur in each geological area and scenario. Often, the scenarios correspond well with the GeoTOP voxel stacks. However, these observations are listed here, because they were found to occur relatively more often than other differences. Therefore, they might explain outliers further on in this project.

Peelo Formation

The Peelo Formation is the most complicated layer: in regions with lower well density (which is in a large part of the area of interest), overestimates of clay are observed. When the GeoTOP model has no geological information (wells) or guidance, it gives a random infill to the voxels. In the Peelo Formation, this random infill contains at least 15% of clay (Figure K.1). This is the case, even when all deep wells further away from the voxel location give no indication of clay. For instance, in geological area 1003 there is 15-60% (on average 35%) of lithological class 2 and 3 with no wells indicating this. When we check the profiles in iMod (Figure K.1), we note that this clay content is a random infill of GeoTOP in the lower part of the Peelo Formation. The amount of wells penetrating to this depth level is small. Overall, the level of 15% clay may be true, but for this project this random noise should be taken into account.

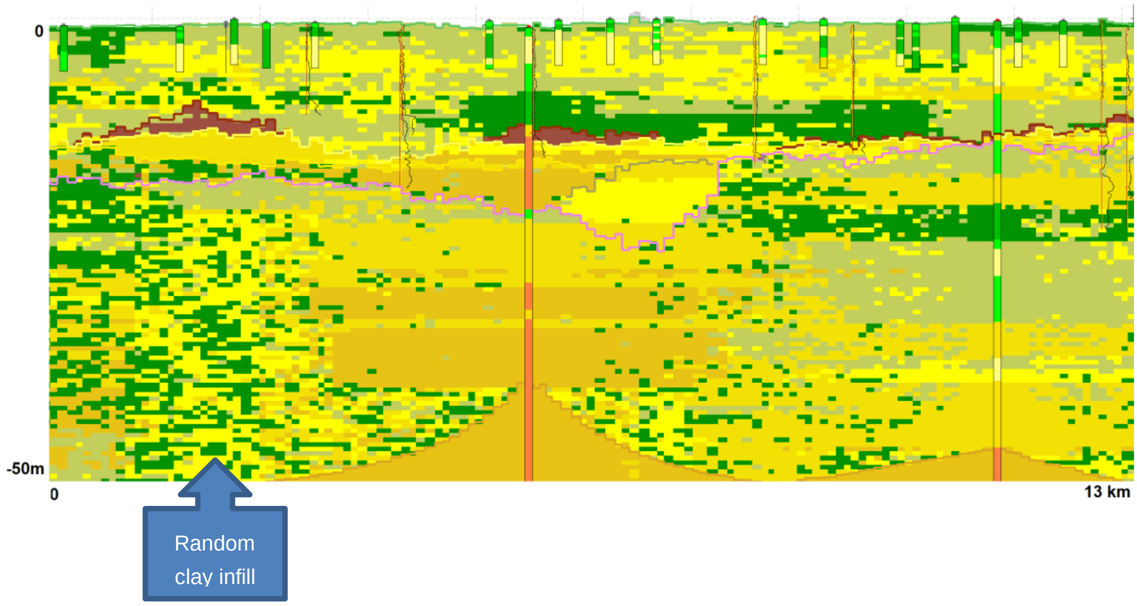


Figure K.1 Representative cross section of GeoTOP for random clay infill. Viewed in iMod, including wells. The left part of this profile is an example of random clay infill in the Peelo Formation, creating standard 15% of clay beneath NAP-30 m.

Also in the Peelo Formation, we observe underestimations of (medium) coarse sand. An example is shown in Figure K.2. In wells, the (medium) coarse sand can be up to ~40%, while the GeoTOP stacks give only 10% (e.g. geological area 303).

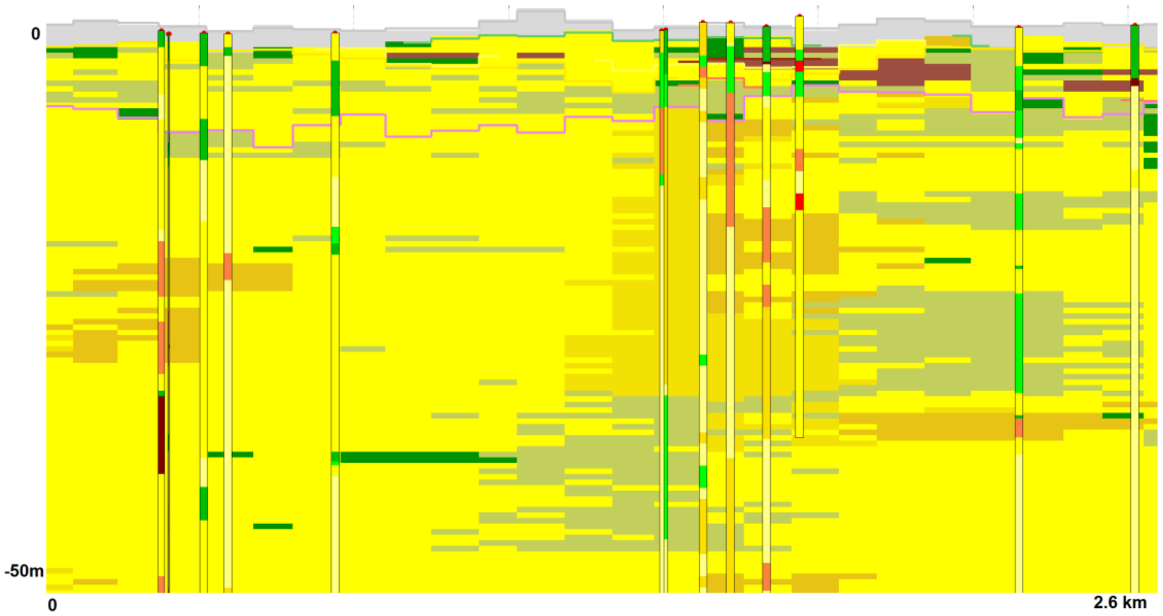


Figure K.2 Representative cross section of GeoTOP for underestimation of coarse sand. Viewed in iMod, including wells. Several intervals of coarse sand present in the wells, these only have a small effect on the voxel stacks.

Basal Peat

The probability of the basal peat layer is often overestimated during schematization (e.g. area 1010 and Figure 5.2 in the main report); GeoTOP seems to be more accurate. Only the thickness is sometimes overestimated in GeoTOP. In the stacks, the peat layers can become up to 2.5m thick, while in the wells peat thickness is usually limited to several decimetres (e.g. area 1101).

Nieuwkoop Formation

Nieuwkoop Formation, Nij Beets Member and Griendtsveen Member: the thickness of peat in the top is often overestimated in GeoTOP (example in Figure K.3). Wells show ~30% peat infill in the top 3 meters, whereas GeoTOP contains up to 60% peat (e.g. area 101).

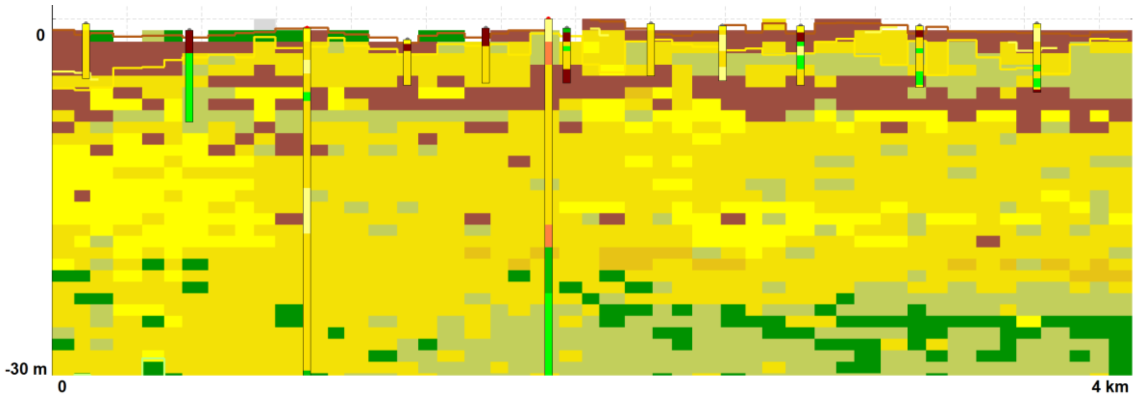


Figure K.3 Representative cross section of GeoTOP for overrepresentation of peat. Viewed in iMod, including wells, showing the Boxtel Formation, Southeast of the city of Groningen. In the top, the sandy wells are not well represented in the voxel stacks and the peat occurrence below the wells is based on a single well.

Boxtel Formation

Boxtel Formation: Sometimes GeoTOP overestimates the occurrence of peat. One well with a thin peat layer can have a large influence (e.g. area 3002, 2804). In Figure K.3, the lower peat occurrence (at NAP-6 m) is based on a very small amount of wells relatively far away from this profile.

L Check scenarios and GeoTOP for Groningen field

One of the assumptions in the schematisation is that the more or less homogeneous scenarios in the geological area correspond to more or less homogeneous voxel stacks in the GeoTOP voxels of that geological area. To verify this assumption, the scenario plots were compared to the plots of GeoTOP voxel stack summaries for a random selection of 10% of the geological areas. The voxel stack summary shows the percentage of different lithologies per 0.5 m depth interval, averaged for all voxel stacks within the geological area. The same procedure has been followed as for the Loppersum pilot (section 5.2).

The geological areas that were subjected to the check were: 306; 316; 609; 801; 1004; 1011; 1014; 1402; 1703; 1706; 1719; 1802; 2002; 2005; 2006; 2020; 2024; 2106; 2207; 2809; 3003; 3004; 3305; 3412; 3413. The location of the selected geological areas is shown in Figure L.1.Of these areas, several consist of areas containing a part of onshore and offshore area of the Wadden Sea. The decision to split geological areas containing both land and sea was made after the construction of the version 1 GSG-model map. The geological areas containing both land and sea might therefore contain scenarios that are not representative of both the land and sea. This applies to geological areas 801, 2006 and 2020. The scenarios describe the polygons still containing both land and sea, whereas the voxel stack summaries were made after the split. Therefore, the voxel stack summaries contain only land voxels and no sea voxels.

Table L.1 summarises the results of the comparison. Because of the general problems with the representation of the Peelo Formation in GeoTOP, this Formation is not considered in the similarity qualification.

In general, (i.e. 75% of the inspected geological areas) the GeoTOP voxel stack summaries examined in this quality check correspond quite well with the constructed scenarios in the schematisation. They were assigned quality labels of similarity of ‘good’ to ‘moderate’.

Figure L.2 shows an example for a geological area with good similarity between scenarios and voxel stack summary (geological area 3003).In this example, all individual geological layers of the scenarios (Figure L.2, left) can be clearly distinguished as lined-up, horizontal layers in the lithology summary (Figure L.2, right). Figure L.3 is an example of a moderate similarity and described in the section on Basal peat and on Peelo.

For 25% of the geological areas the differences between the schematization scenarios and the GeoTOP voxel stack summaries is larger, resulting in a qualification ‘moderate/poor’ to ‘poor’. This is mainly caused by the high heterogeneity of the subsurface and GeoTOP model issues, as was already mentioned in Appendix K. An example is given in Figure L.4 and described in the section on Wadden Sea geological areas.

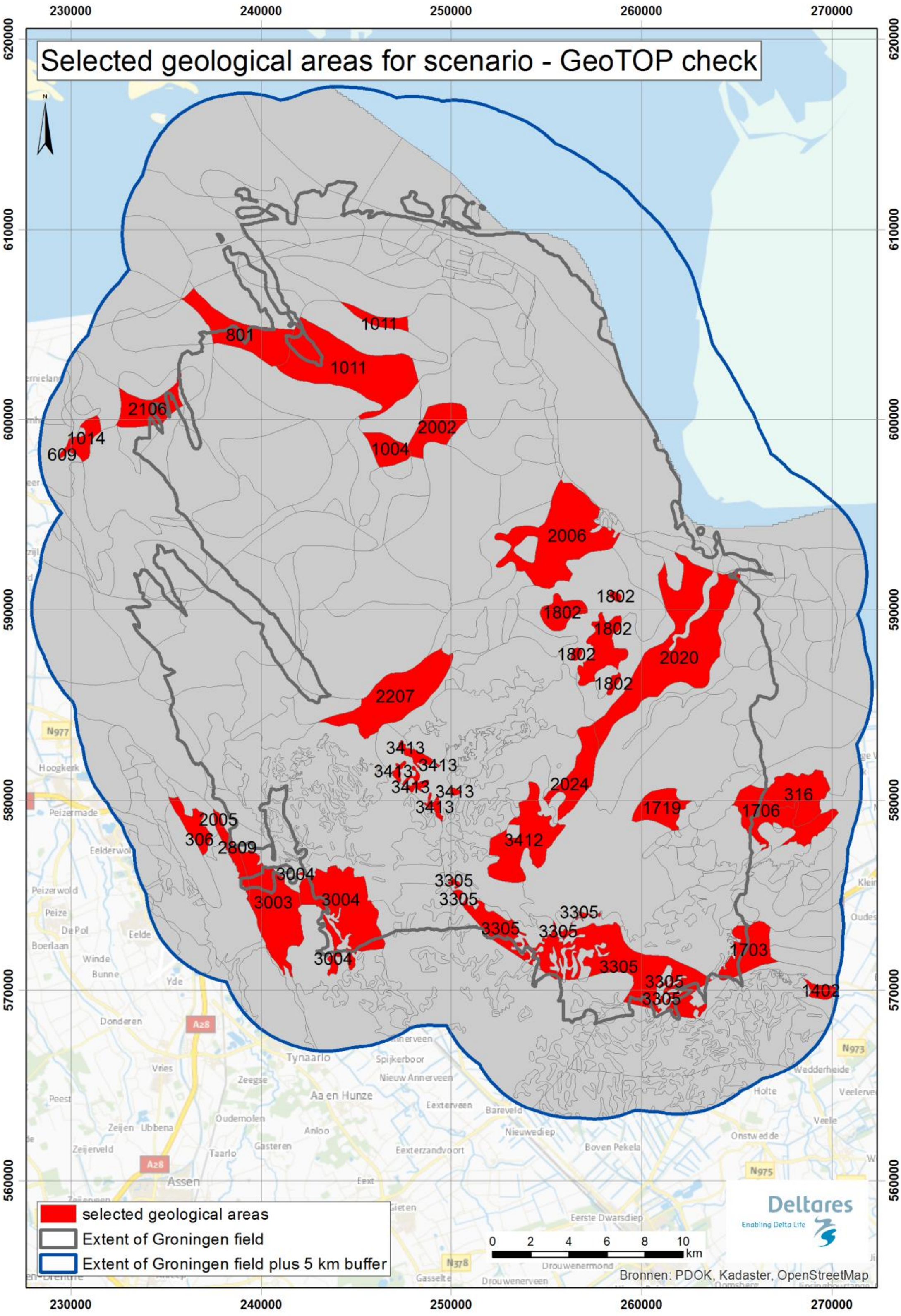


Figure L.1 Location of selected geological areas for the check of scenarios and GeoTOP voxel stack summaries for the version 1 of the GSG-model.

Table L.1 Comparison between scenarios in schematisation and voxel stack summaries (VSS) from GeoTOP for randomly selected geological areas.

Geol. area	Similarity between scenarios and voxel stack summary (VSS)	Number of scenarios	Holocene/ Pleistocene	Heterogeneous or homogeneous geological area	Not described intervals present	Nieuwkoop Basal Peat representation in scenarios	Nieuwkoop Holland peat or Nij Beets representation in scenarios	Polygon containing both Wadden Sea and land polygon	Remarks
306	good	4	PL	homogeneous	no	not present	not present	no	Top of PE in VSS shows more PGCC (85%vs50%) than in scenario. Base of PE Pgcc is over-represented in scenarios.
316	good	6	PL	homogeneous	no	not present	not present	no	PE resemblance is poor
609	good	2	HL+PL	heterogeneous	no	not present	not present	no	-
801	poor	2	HL+PL	heterogeneous	yes	not present	not present	yes	HL is poorly represented in scenarios; misuse of Tfsc code. PE resemblance is poor. Area is too heterogeneous.
1004	moderate	2	HL+PL	heterogeneous	no	over-represented	not present	no	Pgcc probability of 40% in VSS is missed in scenarios
1011	moderate	8	HL+PL	heterogeneous	yes	over-represented	not present	no	HL is poorly represented in scenarios; misuse of Tfsc code. Pgsc interval is not visible in VSS.
1014	good	4	HL+PL	homogeneous	no	over-represented	not present	no	PE resemblance is poor
1402	moderate	2	HL+PL	heterogeneous	yes	under-represented	not present	no	Pgsf is too shallow in scenarios. Pasf is not visible in VSS.
1703	moderate/ poor	1	HL+PL	heterogeneous	no	over-represented	not present	no	HL is poorly represented in scenarios. PE resemblance is very poor. No difference between Pasf and Pvsm visible in VSS.
1706	good	4	HL+PL	homogeneous	no	over-represented	not present	no	PE resemblance is poor
1719	good	4	HL+PL	homogeneous	no	over-represented	not present	no	PE resemblance is poor
1802	moderate	2	HL+PL	heterogeneous	no	over-represented	not present	no	Pgcs is largely over-represented in scenarios (100%vs40%). PE resemblance is very poor.
2002	moderate	2	HL+PL	heterogeneous	no	over-represented	over-represented	no	Lower Tfcc contains ca. 50% sand. PE resemblance is poor.

Table L.1, continued. Comparison between scenarios in schematisation and voxel stack summaries (VSS) from GeoTOP for randomly selected geological areas.

Geol. area	Similarity between scenarios and voxel stack summary (VSS)	Number of scenarios	Holocene/ Pleistocene	Heterogeneous or homogeneous geological area	Not described intervals present	Nieuwkoop Basal Peat representation in scenarios	Nieuwkoop Holland peat or Nij Beets representation in scenarios	Polygon containing both Wadden Sea and land polygon	Remarks
2005	moderate	8	HL+PL	heterogeneous	no	over-represented	well represented	no	Depth values in scenarios are not correct. PE resemblance is poor.
2006	poor	4	HL+PL	heterogeneous	no	over-represented	over-represented	yes	Pgsc is not visible in VSS. Area is too heterogeneous.
2020	poor	4	HL+PL	heterogeneous	no	over-represented	over-represented	yes	Shpp and Sbpp appears merged in VSS. Area is too heterogeneous.
2024	moderate	8	HL+PL	homogeneous	no	over-represented	over-represented	no	Shpp and Sbpp appears merged in VSS
2106	moderate	2	HL+PL	heterogeneous	no	over-represented	over-represented	no	PE resemblance is poor.
2207	moderate/ poor	2	HL+PL	heterogeneous	yes	under-represented	under-represented	no	Shpp and Sbpp appears merged in VSS. Pvsm contains a lot of peat. PE resemblance is very poor.
2809	good	2	HL+PL	homogeneous	no	not present	well represented	no	PE resemblance is poor
3003	good	8	HL+PL	heterogeneous	no	not present	well represented	no	-
3004	good	8	HL+PL	homogeneous	no	not present	well represented	no	-
3305	good	8	HL+PL	homogeneous	no	not present	well represented	no	PE resemblance is poor
3412	good	8	PL	homogeneous	no	not present	not present	no	-
3413	good	4	PL	homogeneous	no	not present	not present	no	PE resemblance is poor

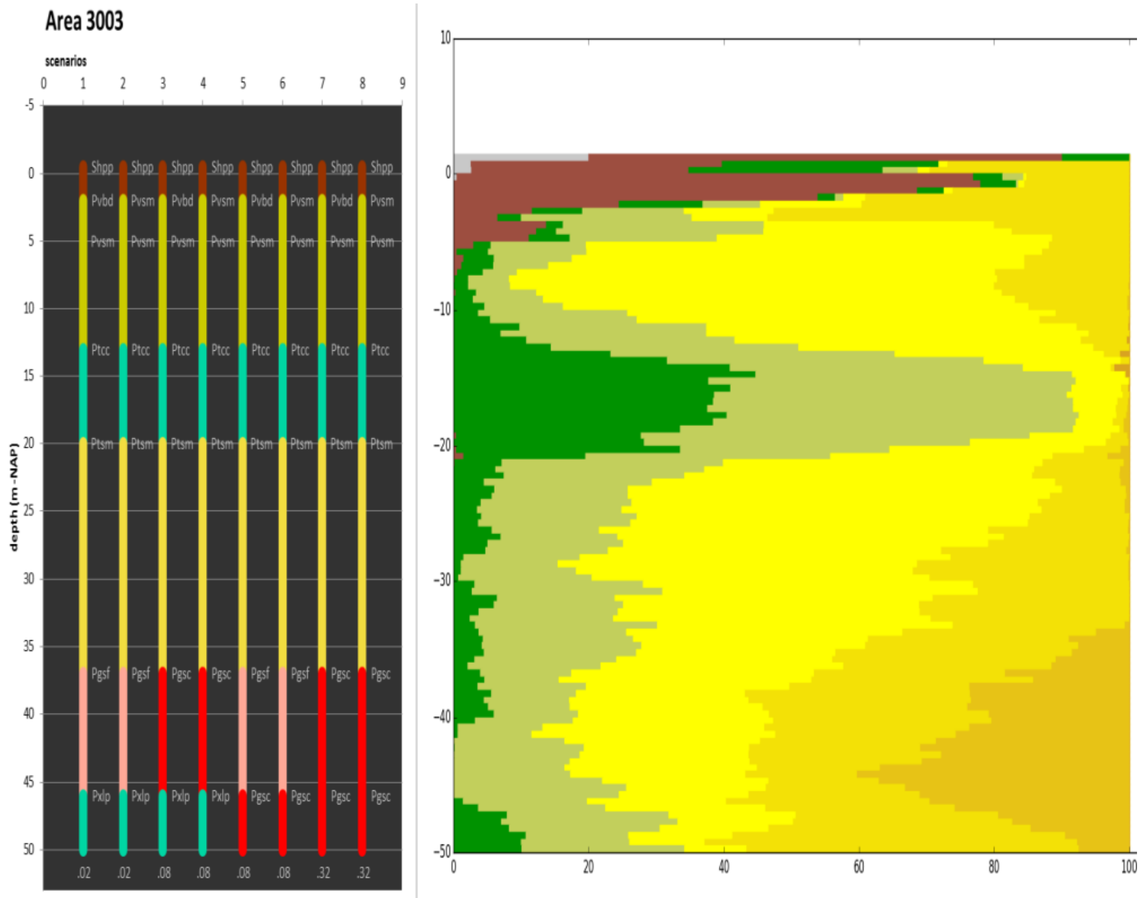


Figure L.2 Example of good similarity between scenarios (left panel) and GeoTOP voxel stack summary (right panel). Results for geological area 3003.

Basal peat

The probability of basal peat in the lateral extent is repeatedly overestimated in the schematization. This is illustrated by the results of geological area 1004 in Figure L.3. In the scenario plot (Figure L.3, left panel), the probabilities for basal peat (Sbpp) are estimated at 70%. However, the GeoTOP voxel stack summary (Figure L.3, right panel) shows an occurrence of basal peat of approx. 15%. This implies an overestimation in Basal peat occurrence in the scenarios.

The thickness of the Basal peat, on the contrary, is more realistically represented in the scenario plots. In Figure L.3, left panel, the estimated thickness of the Basal peat is 0.7 m, which is a realistic value for the thickness of Basal peat in the northern-Netherlands (section 2.1). The GeoTOP voxel stack summary, however, shows a (combined) thickness of approx. 7 m (Figure L.3, right panel). In the GeoTOP voxel stack summary, the Basal peat thickness is largely overestimated. This is probably due to the distortion of non-horizontal layers in voxel stacks, as mentioned in Appendix K for Loppersum. When a layer is not deposited on a (semi-) horizontal surface (i.e. on the same voxel-level), smearing of the layer over a large depth range can be observed in the voxel stack summary, suggesting a less uniform area.

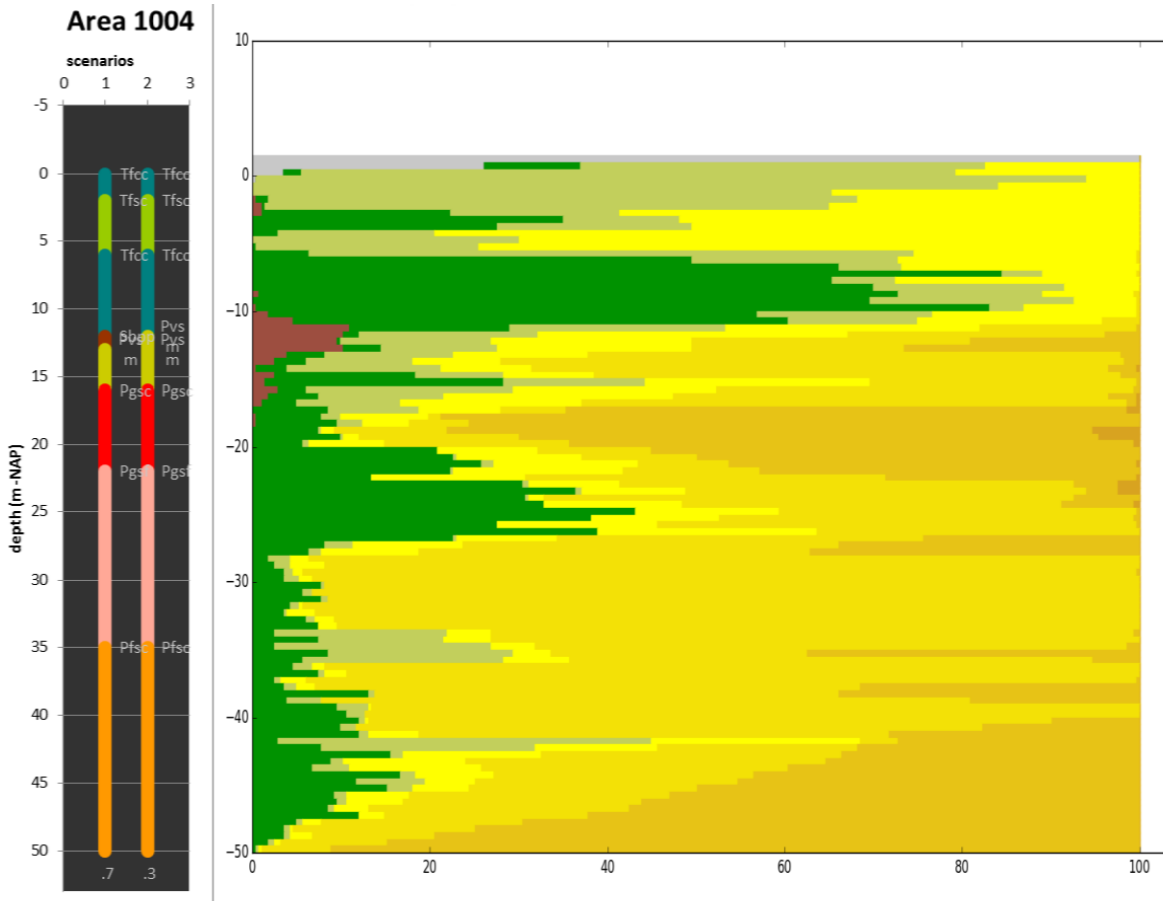


Figure L.3 Example of moderate similarity between scenarios (left panel) and GeoTOP voxel stack summary (right panel). Results for geological area 1004.

Peelo

The Peelo Formation appears to be the most challenging geological unit in the shallow subsurface in terms of representation. This is illustrated with the same example in Figure L.3. The scenario plot (Figure L.3, left) shows 100% Peelo fine sands (Pgsf) between NAP-22 m and NAP-35 m, whereas the voxel stack summary (Figure L.3, right) shows an interval of 40% clay between approx. NAP-20 and NAP-28 m. This corresponds to Peelo Potclay (Pgcc). In the scenarios, however, only Peelo fine sands (Pgsf) are included.

The differences in representations for the Peelo Formation is mainly caused by the absence of relevant geological information (borehole information). This results in poor estimates of Peelo in the scenarios and a largely randomly infill of lithology in the GeoTOP voxels.

As noted in Appendix K, overestimates of clay are observed in areas with low borehole density. This is caused by the random filling of the GeoTOP lithological model with at least 15% of clay for the Peelo Formation.

Wadden Sea geological areas

Special attention needs to be paid to the Wadden Sea polygons, since especially the scenarios in these geological areas appear to poorly represent the main profile types.

During schematisation, no special attention was paid to polygons containing both offshore and onshore parts (i.e. land and Wadden Sea). During the quality control, we decided to split the polygons containing both land and Wadden Sea into two parts: one polygon containing the onshore domain (keeping the original polygon number), the other polygon containing the offshore part (appointed a new polygon number). Because of this separation, the scenarios for these geological areas (e.g. area 801) neither represent the onshore nor the offshore regions correctly, resulting in the qualification-label ‘poor’.

Figure L.4 clearly illustrates this problem. In this example, the top 17 m are labelled ‘Tfsc – mudflat channels: clay and sand, alternating’ in the scenarios (Figure L.4, left). This facies-code comprises the encountered lithologies, but does not reflect the separately identifiable geological layers. The top 7.5 meters (NAP to NAP-7.5 m) in Figure L.4 (right panel) clearly consist of (clayey) sand, while the deeper part (NAP-7.5 m to NAP-17 m) contains more (sandy) clay.

The large differences between the scenario plots and the GeoTOP voxel stack summaries largely hampers the assessment of the internal-consistency of these geological areas.

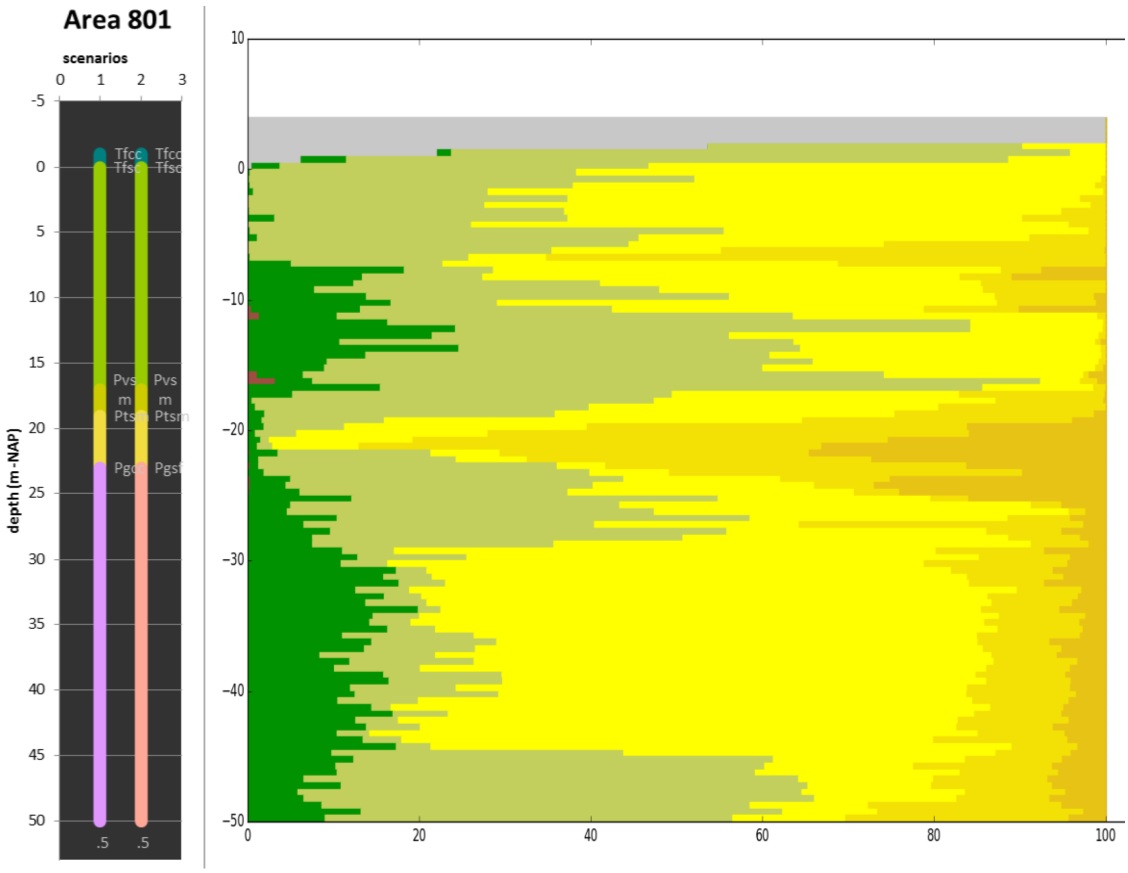


Figure L.4 Example of poor similarity between scenarios (left panel) and GeoTOP voxel stack summary (right panel). Results for geological area 801. Note that the left panel shows the scenarios for both land and sea part of geological area 801 (before split Wadden Sea polygons), whereas the right panel shows the voxel stack summary of the onshore part of geological area 801 only (after split of Wadden Sea polygons).

Conclusions

- 75% of the checked GeoTOP voxel stacks summaries correspond well with the scenario plots of schematisation.
- Special attention needs to be paid to the Wadden Sea polygons, since especially the scenarios in these geological areas appear to poorly represent the main profile types in the geological area.

Recommendations

The poor representation of the Peelo Formation in both the scenario plots and GeoTOP voxel stack summaries might influence the later results for Vs30 or site response calculations. The voxel infill of Peelo layers can potentially be largely improved by the use of CPTs (Appendix M).

Because of the large differences between the scenario plots and the GeoTOP voxel stack summaries of the Wadden Sea border-polygons, the quality control of these geological areas is difficult. It is recommended to evaluate the site response results for those geological areas and to assess whether the extents of these geological areas need to be adjusted in a future version of the GSG-model.

M Impact of adding CPT data

During the course of schematization of the surface to NAP-50 m part (September to November 2014) new CPT data became available at several moments. The schematization database was updated accordingly, implying a varying data density during the various stages of schematization (Figure 3.4). We assessed the impact of addition of all extra CPT data for schematization purposes and tested the robustness (and consistency) of the geological areas.

The initially defined and during the schematization process adjusted boundaries of the geological boundaries, are primarily based on borehole data. During the subsurface schematization, CPTs were mainly used for correlation in between boreholes. In general, the CPTs that fall in the middle parts of a geological area do not affect the position of the boundaries of the geological areas.

The CPTs that are located near the boundaries of the geological areas might influence the position of the boundary. Two trajectories of CPTs were used to assess this impact. The first trajectory consists of additional Fugro CPTs crossing the Groningen gas field roughly from west to east (Figure M.1). The location of the boundaries along this trajectory was checked. No adjustments were needed based on the additional CPTs. In between borehole locations, CPTS are valuable for answering specific geological questions, such as the determination of the Holland peat or Basal peat occurrence and refining the Peelo Formation lithology classes. Figure M.2 shows a cross section in iMod view, containing borehole records and CPTs, in combination with the GeoTOP model as background including the boundaries of several stratigraphical units. In this plot, the random infill of the Peelo Formation (as described in appendices K and L) is visible as randomly alternating GeoTOP lithological classes (clay, sand and sandy clay / clayey sand), between approx. NAP-10 m and NAP-50 m. This (random) infill does not represent a natural geological phenomenon. It is caused by the absence of relevant boreholes within the Peelo Formation interval. The CPTs present this cross section, however, show relevant detail of the lithological character of the Peelo Formation. The interpreted CPTs show a typical clay CPT (green arrows) and sand CPT (yellow arrows). This additional information largely enhances the lithological representation of the Peelo Formation.

The second trajectory consists of additional Wiertsema CPTs along the dike between Eemshaven and Delfzijl (Figure M.3). Along this trajectory the location of boundaries of geological areas were checked using the additional CPT data. Figure M.4 shows a cross section in iMod view with the indication of the boundary between geological areas 2001 (without Drenthe-Gieten Formation, marked as DRGI) and 2101 (with Drenthe-Gieten Formation). Based on the additional CPTs, the boundary between these geological areas remains unchanged. This is true for all geological boundaries along this trajectory. Therefore we conclude that adding CPTs to the database generally does not affect the location of the boundaries of geological areas.

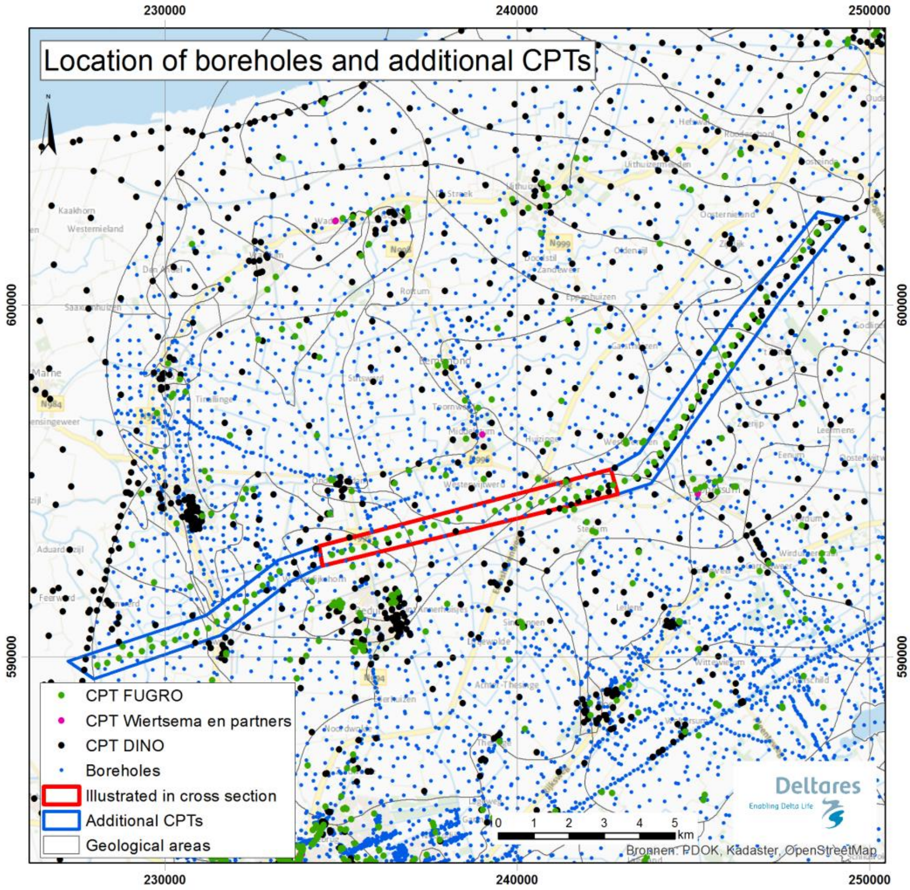


Figure M.1 Location of the trajectory of additional Fugro CPTs in the blue box. The results for the red box are shown in Figure M.2.

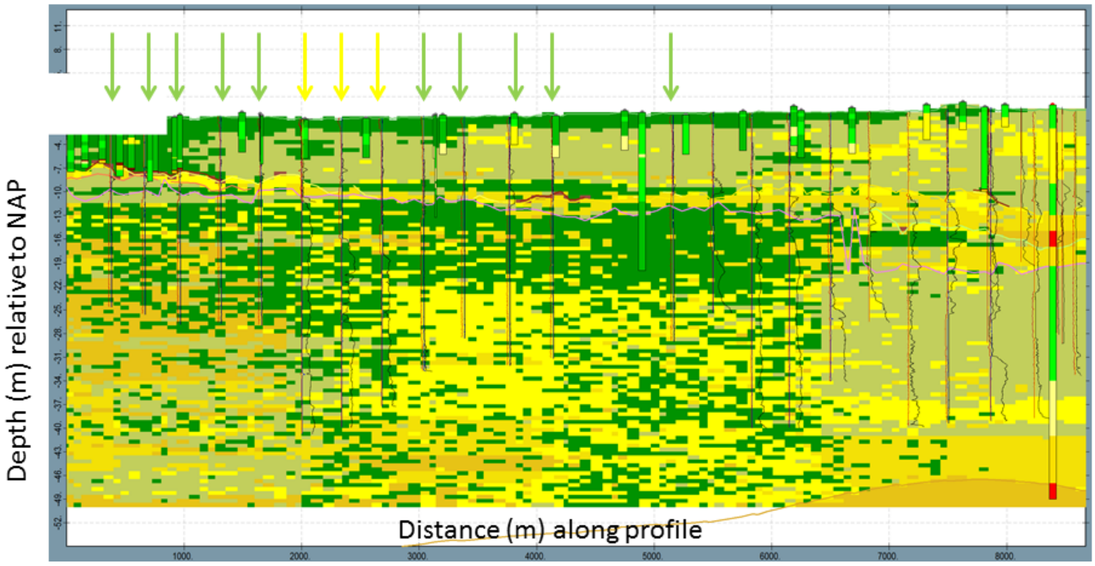


Figure M.2 Cross section with GeoTOP on the background showing additional CPT information for the section shown in Figure M.1. CPTs give additional information on the presence of either clay (green arrows) or sand (yellow arrows) for the Peelo Formation.

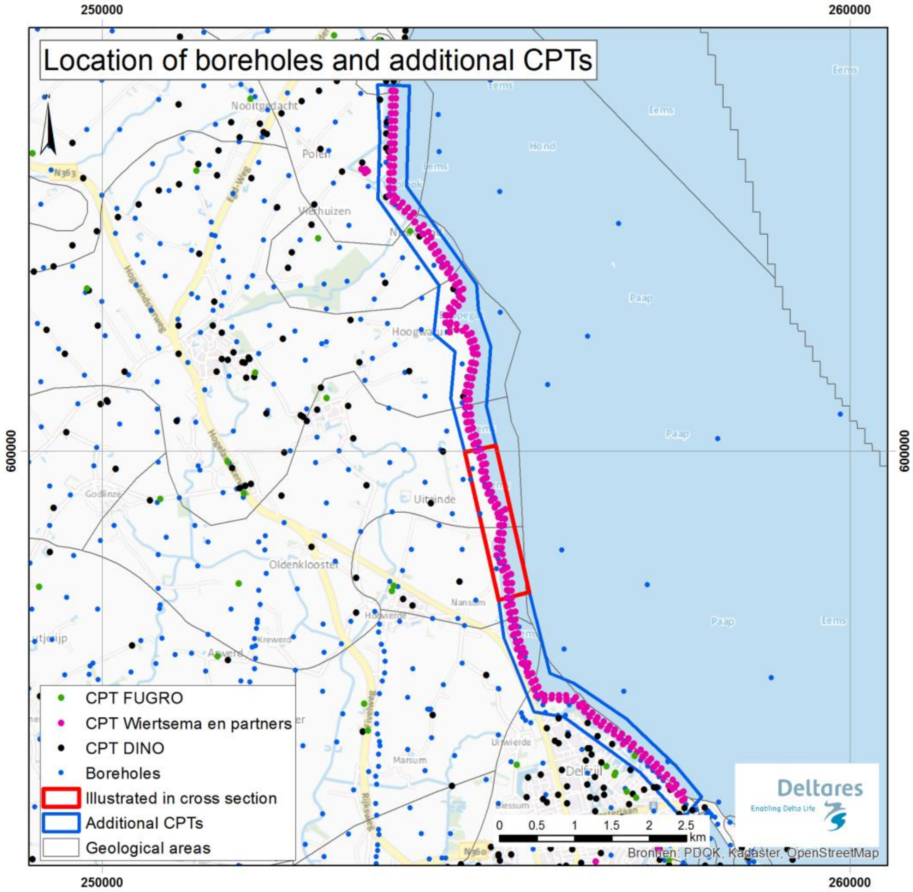


Figure M.3 Location of the trajectory of additional Wiertsema CPTs in the blue box. The results for the red box are shown in Figure M.4

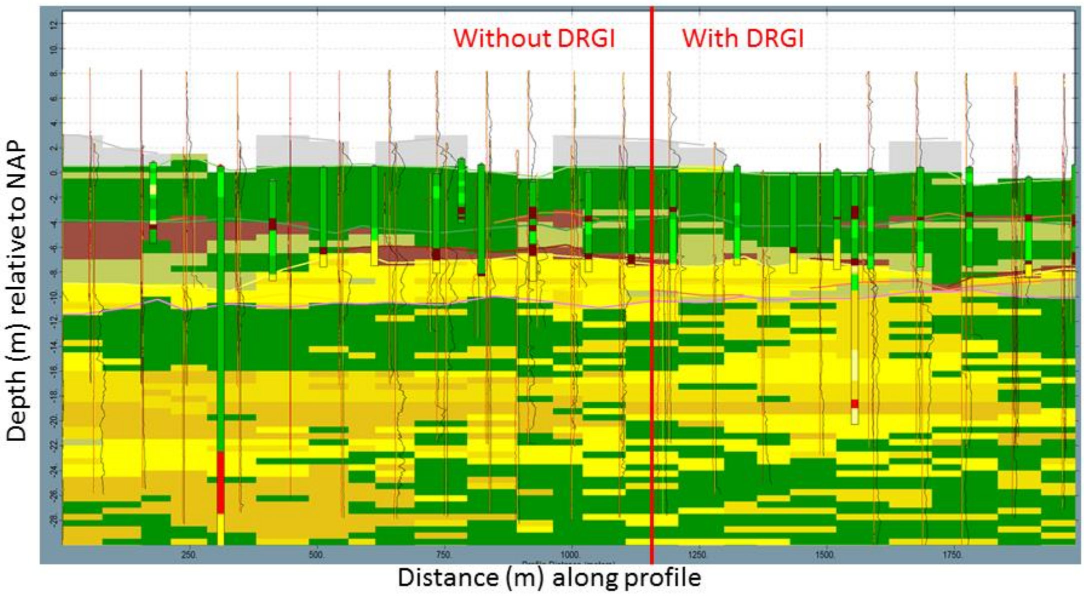


Figure M.4 Cross section with GeoTOP on the background showing additional CPT information for the section shown in Figure M.3. Example showing the robustness of the boundaries of the geological areas. The boundary between geological areas 2001 (without DRGI) and 2101 (with DRGI) is located at the red line. With additional CPTs, the best location for the boundary is still the red line. No adjustments needed to be made to the boundaries of the geological areas.

N Version 1 map of geological areas for surface to NAP-50 m depth range (A3 scale)

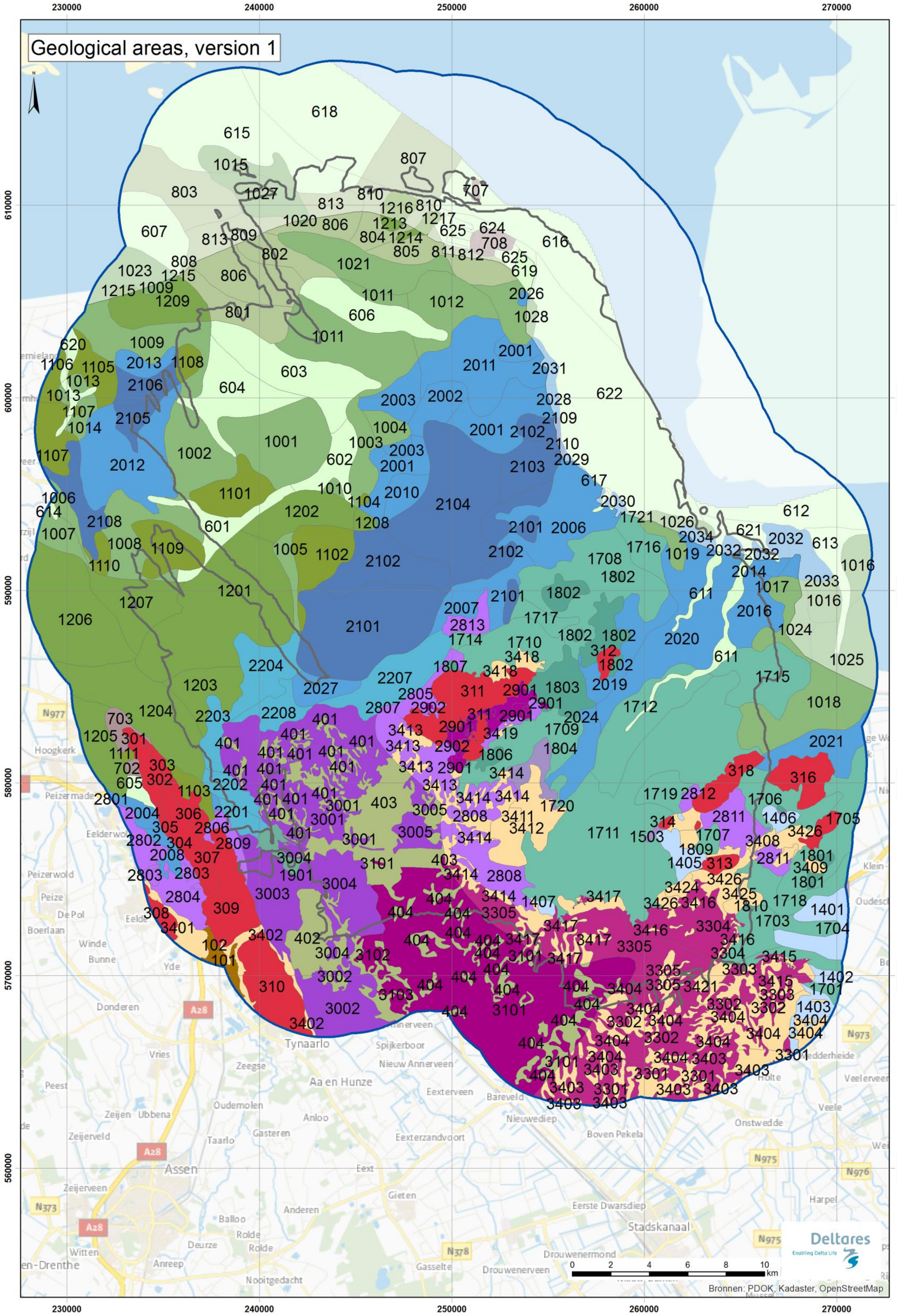


Figure N.1 Version 1 map of geological areas for the surface to NAP-50 m depth range for the Groningen gas field and 5 km buffer. Identical colours indicate similar geological build-up. The map is provided on A3 scale with a legend in Appendix N. For legend, see Figure N.2.

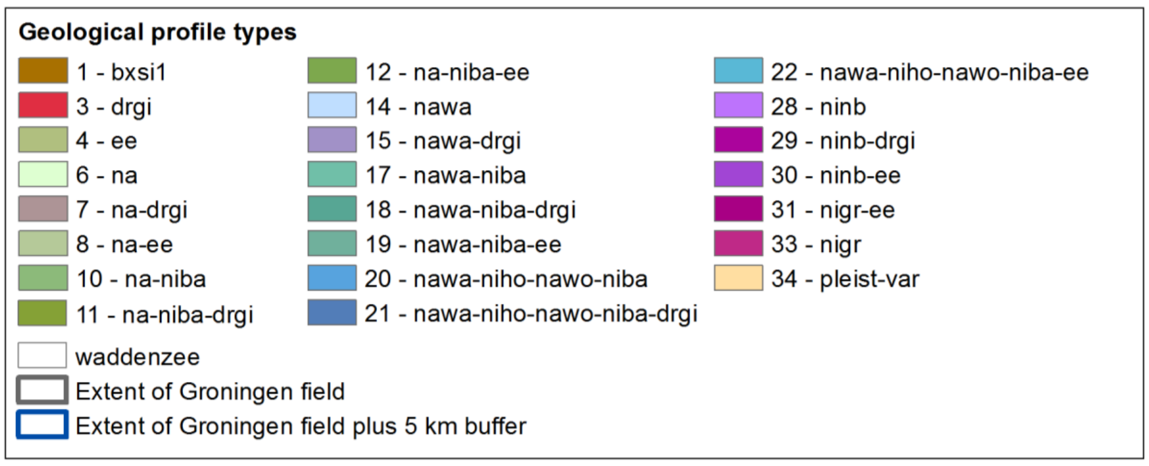
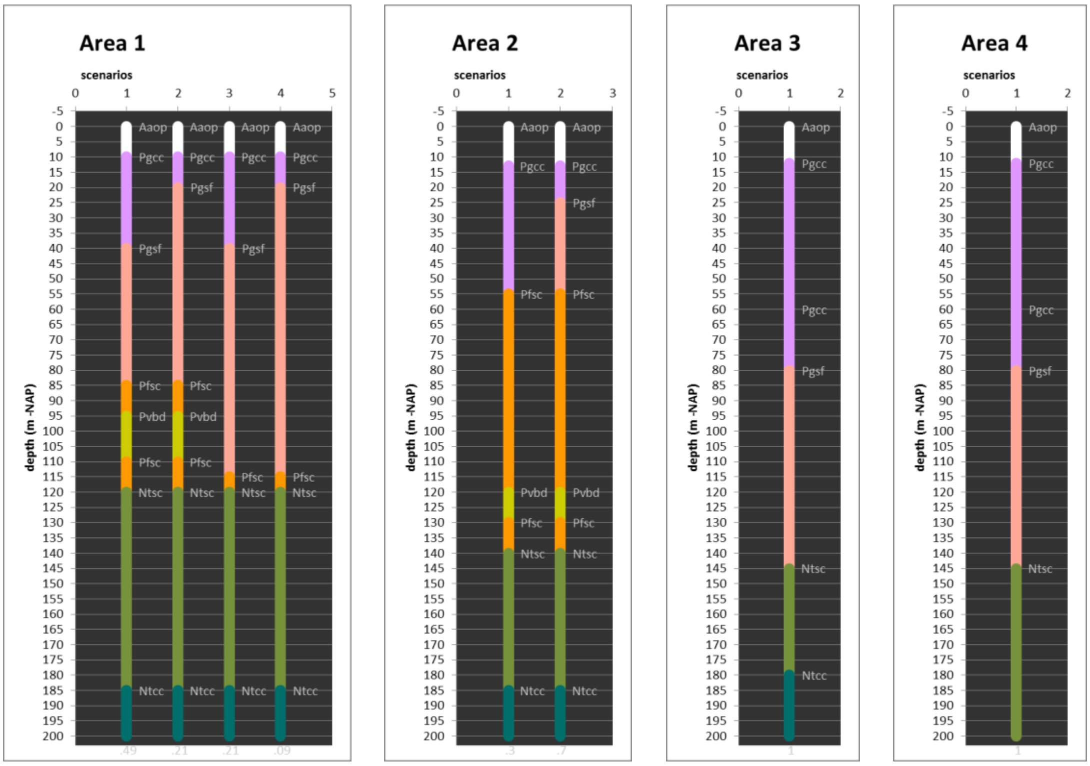
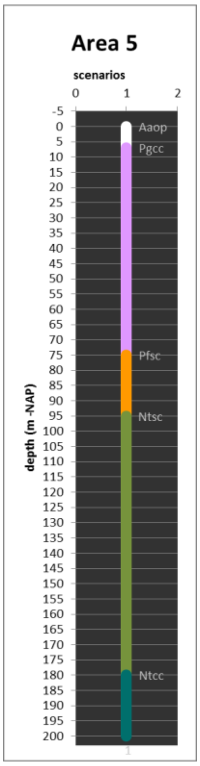


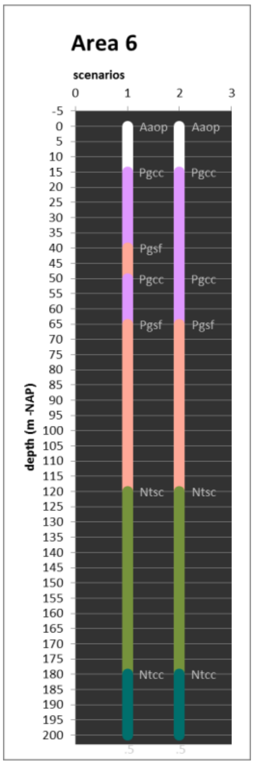
Figure N.2 Legend to the Version 1 map of geological areas for the surface to NAP-50 m depth range for the Groningen gas field and 5 km buffer.

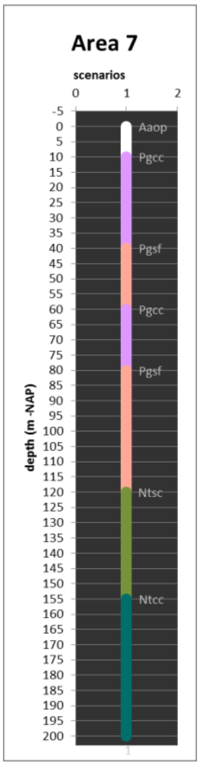
O Scenarios of geological areas for depth range of approx. NAP-50m to NAP-200 m

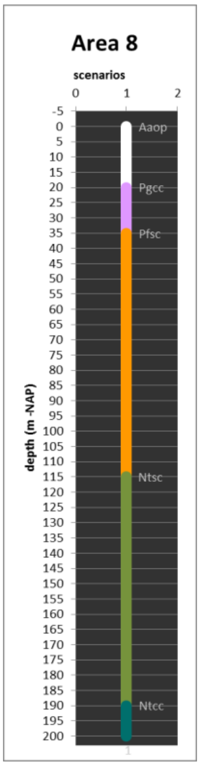
The scenarios belong to the geological areas of Figure 6.8, for the deeper subsurface of approx. NAP-50 m to NAP-200 m.

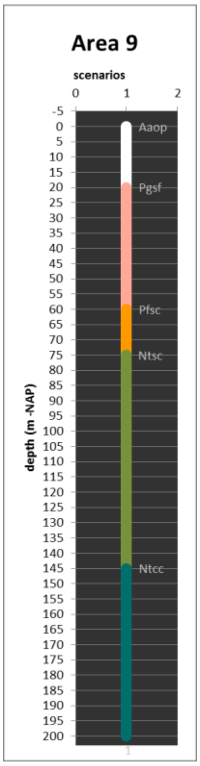


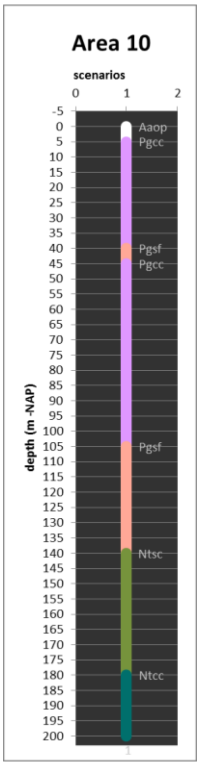

Area 5
scenarios
depth (m -NAP)
Aaop
Pgcc
Pfsc
Ntsc
Ntcc

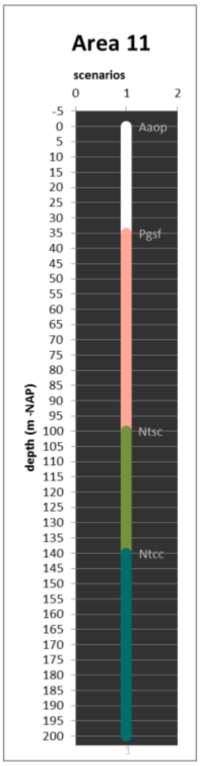

Area 6
scenarios
depth (m -NAP)
Aaop
Pgcc
Pgsf
Pgcc
Pgsf
Ntsc
Ntcc
Aaop
Pgcc
Pgcc
Pgsf
Ntsc
Ntcc

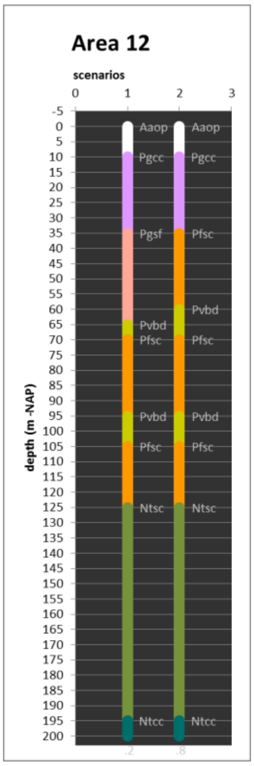

Area 7
scenarios
depth (m -NAP)
Aaop
Pgcc
Pgsf
Pgcc
Pgsf
Ntsc
Ntcc

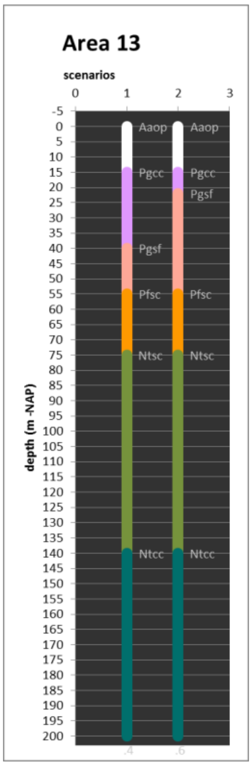

Area 8
scenarios
depth (m -NAP)
Aaop
Pgcc
Pfsc
Ntsc
Ntcc

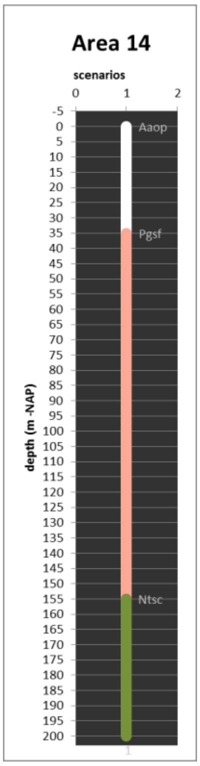

Area 9
scenarios
depth (m -NAP)
Aaop
Pgsf
Pfsc
Ntsc
Ntcc

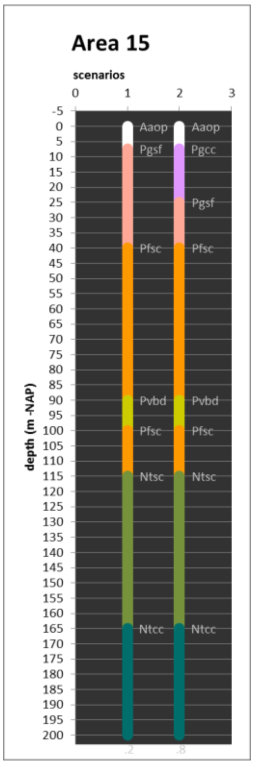

Area 10
scenarios
depth (m -NAP)
Aaop
Pgcc
Pgsf
Pgcc
Pgsf
Ntsc
Ntcc

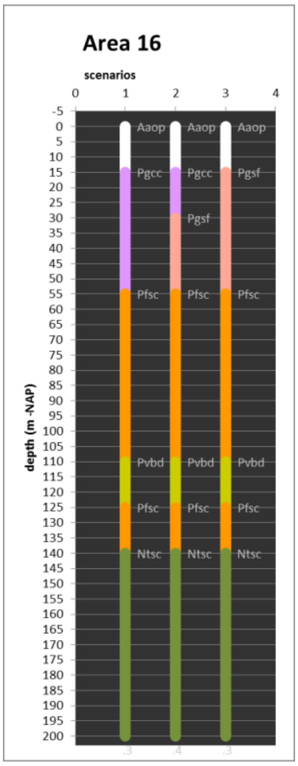

Area 11
scenarios
depth (m -NAP)
Aaop
Pgsf
Ntsc
Ntcc

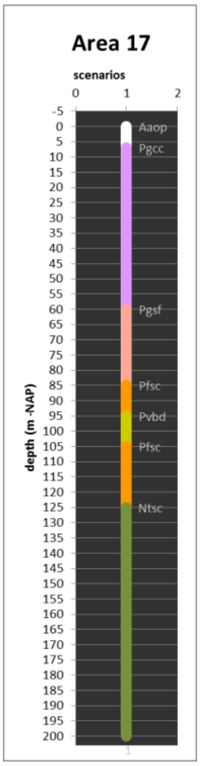

Area 12
scenarios
depth (m -NAP)
Aaop
Pgcc
Pgsf
Pvbd
Pfsc
Pvbd
Pfsc
Ntsc
Ntcc
Aaop
Pgcc
Pfsc
Pvbd
Pfsc
Pvbd
Pfsc
Ntsc
Ntcc

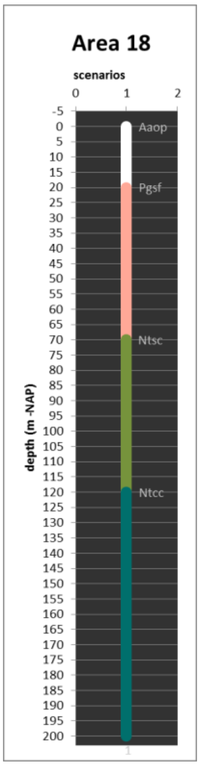

Area 13
scenarios
depth (m -NAP)
Aaop
Pgcc
Pgsf
Pfsc
Ntsc
Ntcc

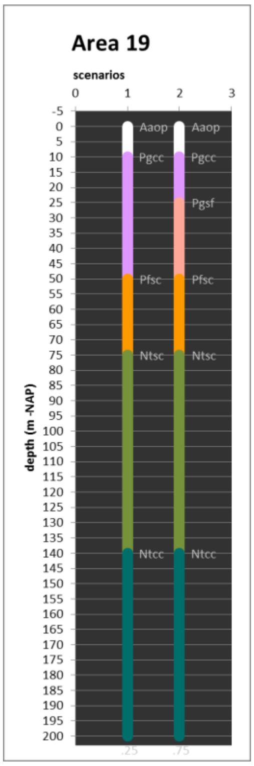

Area 14
scenarios
depth (m -NAP)
Aaop
Pgsf
Ntsc

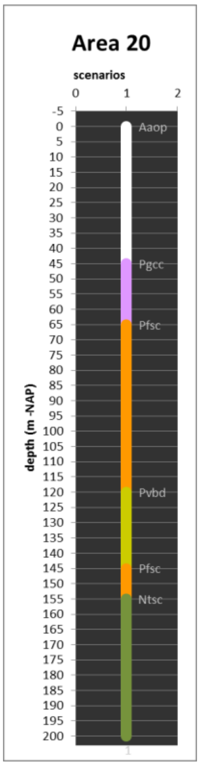

Area 15
scenarios
depth (m -NAP)
Aaop
Pgsf
Pgcc
Pfsc
Pvbd
Ntsc
Ntcc

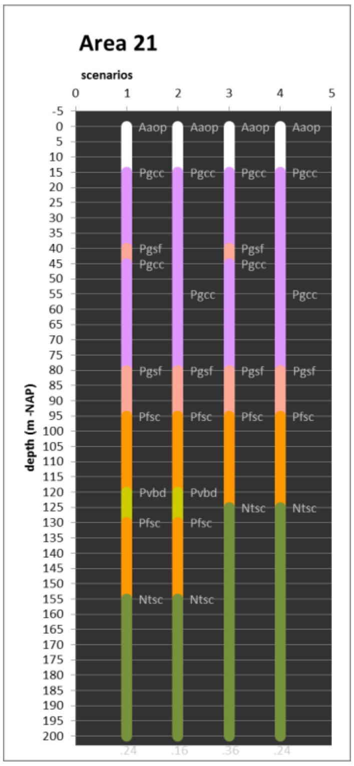

Area 16
scenarios
depth (m -NAP)
Aaop
Pgcc
Pgsf
Pfsc
Pvbd
Ntsc

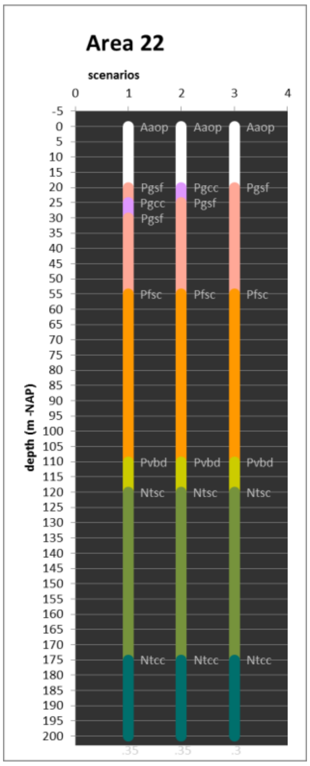

Area 17
scenarios
depth (m -NAP)
Aaop
Pgcc
Pgsf
Pfsc
Pvbd
Ntsc

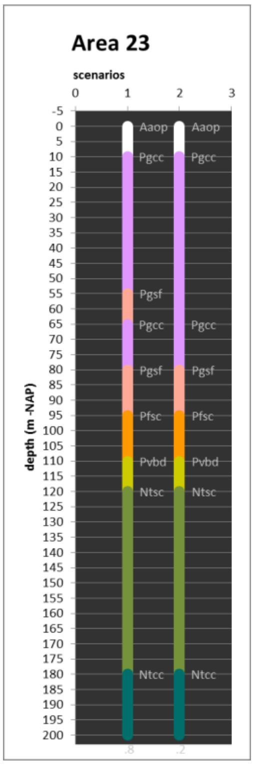

Area 18
scenarios
depth (m -NAP)
Aaop
Pgsf
Ntsc
Ntcc

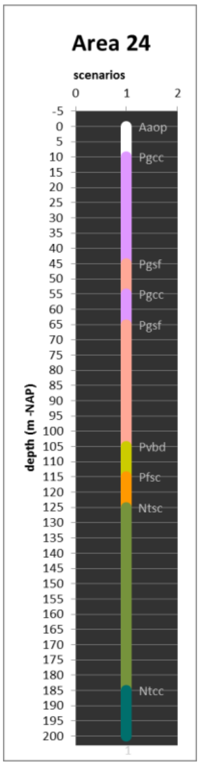

Area 19
scenarios
depth (m -NAP)
Aaop
Pgcc
Pgsf
Pfsc
Ntsc
Ntcc

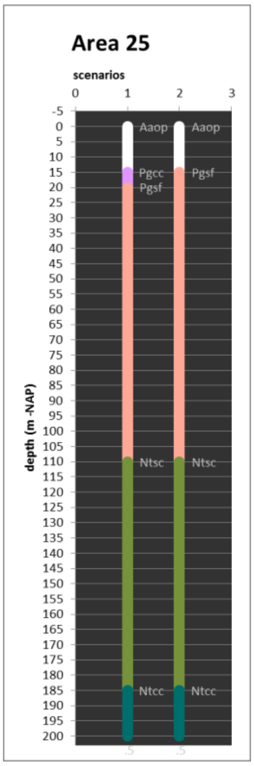

Area 20
scenarios
depth (m -NAP)
Aaop
Pgcc
Pfsc
Pvbd
Ntsc

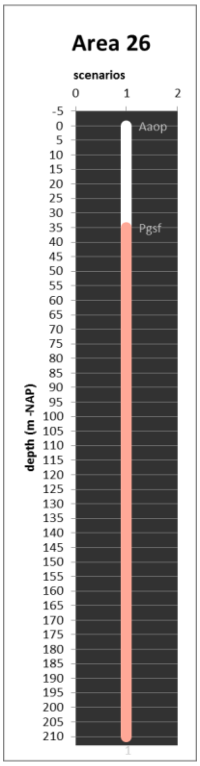

Area 21
scenarios
depth (m -NAP)
Aaop Aaop Aaop Aaop
Pgcc Pgcc Pgcc Pgcc
Pgsf Pgsf
Pgcc Pgcc
Pgcc Pgcc
Pgsf Pgsf Pgsf Pgsf
Pfsc Pfsc Pfsc Pfsc
Pvbd Pvbd
Ntsc Ntsc
Pfsc Pfsc
Ntsc Ntsc
.24 .16 .36 .24

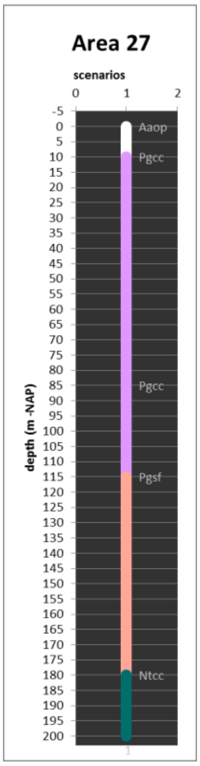

Area 22
scenarios
depth (m -NAP)
Aaop Aaop Aaop
Pgsf Pgcc Pgsf
Pgcc Pgsf
Pgsf
Pfsc Pfsc Pfsc
Pvbd Pvbd Pvbd
Ntsc Ntsc Ntsc
Ntcc Ntcc Ntcc
.35 .35 .3

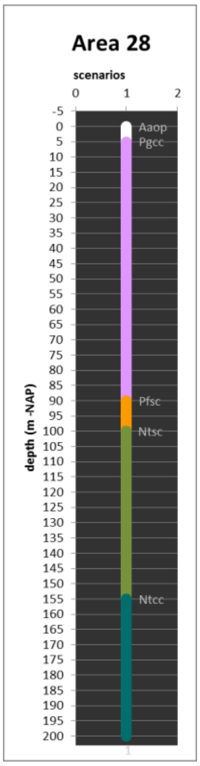

Area 23
scenarios
depth (m -NAP)
Aaop Aaop
Pgcc Pgcc
Pgsf
Pgcc Pgcc
Pgsf Pgsf
Pfsc Pfsc
Pvbd Pvbd
Ntsc Ntsc
Ntcc Ntcc
.8 .2

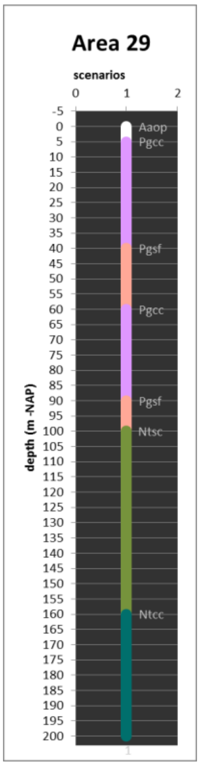

Area 24
scenarios
depth (m -NAP)
Aaop
Pgcc
Pgsf
Pgcc
Pgsf
Pvbd
Pfsc
Ntsc
Ntcc
1

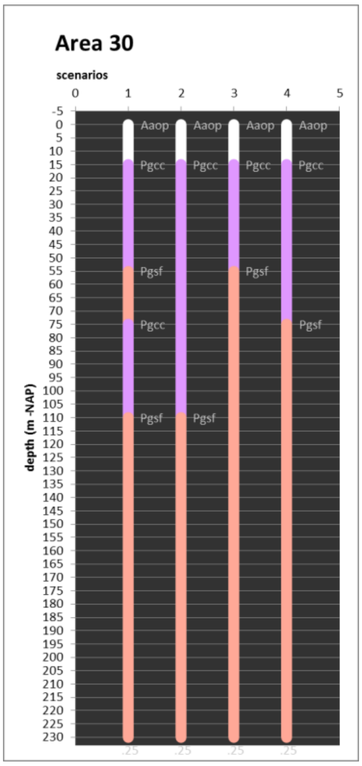

Area 25
scenarios
depth (m -NAP)
Aaop Aaop
Pgcc Pgsf
Pgsf
Ntsc Ntsc
Ntcc Ntcc
.5 .5

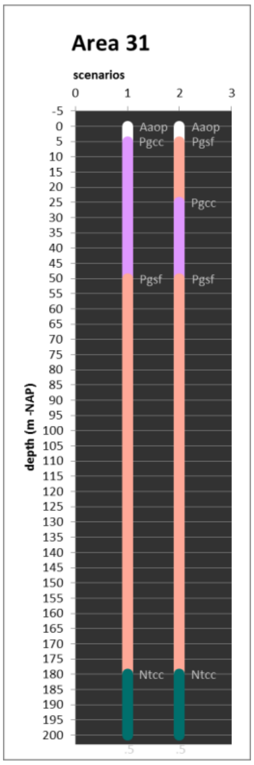

Area 26
scenarios
depth (m -NAP)
Aaop
Pgsf
1

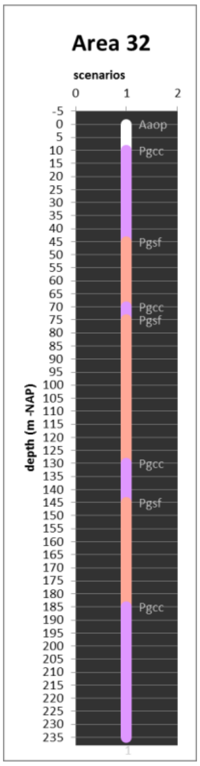

Area 27
scenarios
depth (m -NAP)
Aaop
Pgcc
Pgcc
Pgsf
Ntcc
1

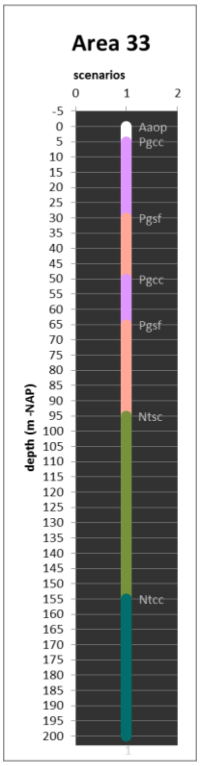

Area 28
scenarios
depth (m -NAP)
Aaop
Pgcc
Pfsc
Ntsc
Ntcc
1

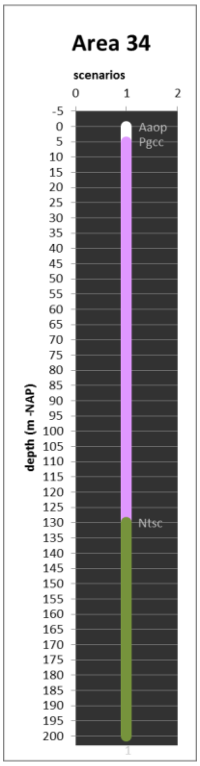

Area 29
scenarios
depth (m -NAP)
Aaop
Pgcc
Pgsf
Pgcc
Pgsf
Ntsc
Ntcc

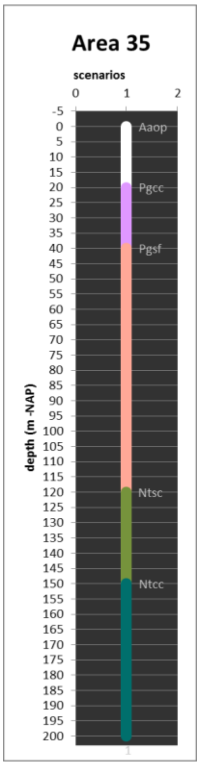

Area 30
scenarios
depth (m -NAP)
Aaop
Aaop
Aaop
Aaop
Pgcc
Pgcc
Pgcc
Pgcc
Pgsf
Pgsf
Pgcc
Pgsf
Pgsf
Pgsf

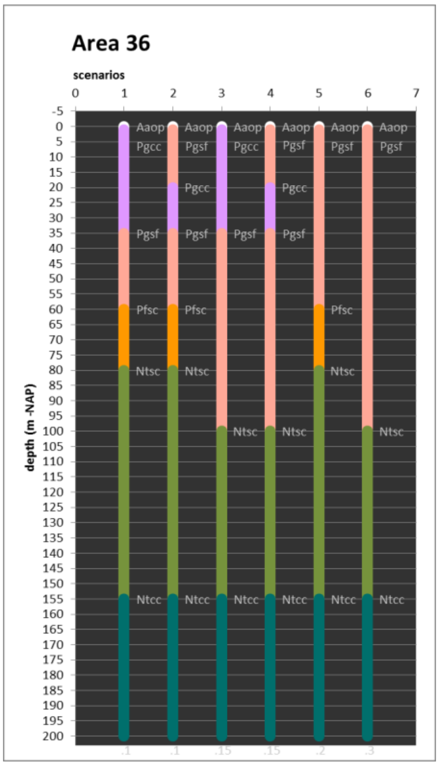

Area 31
scenarios
depth (m -NAP)
Aaop
Aaop
Pgcc
Pgsf
Pgcc
Pgsf
Pgsf
Ntcc
Ntcc

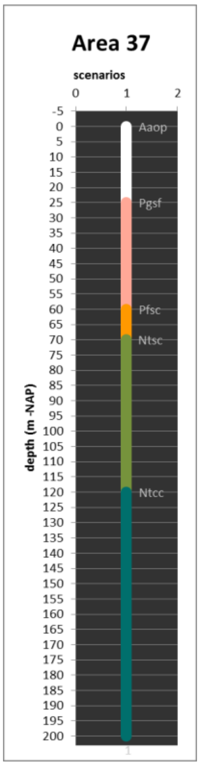

Area 32
scenarios
depth (m -NAP)
Aaop
Pgcc
Pgsf
Pgcc
Pgsf
Pgcc
Pgsf
Pgcc

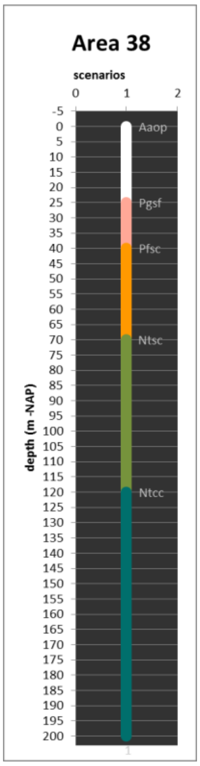

Area 33
scenarios
depth (m -NAP)
Aaop
Pgcc
Pgsf
Pgcc
Pgsf
Ntsc
Ntcc

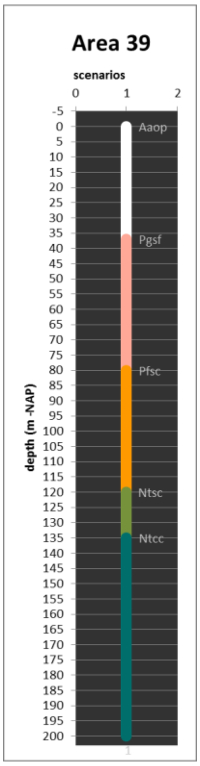

Area 34
scenarios
depth (m -NAP)
Aaop
Pgcc
Ntsc

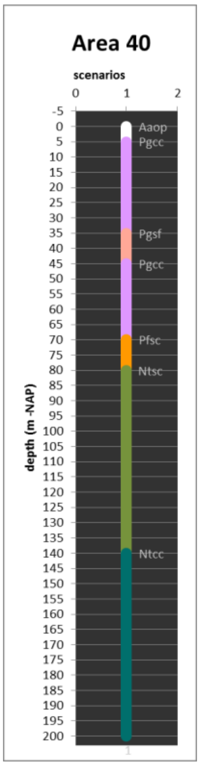

Area 35
scenarios
depth (m -NAP)
Aaop
Pgcc
Pgsf
Ntsc
Ntcc

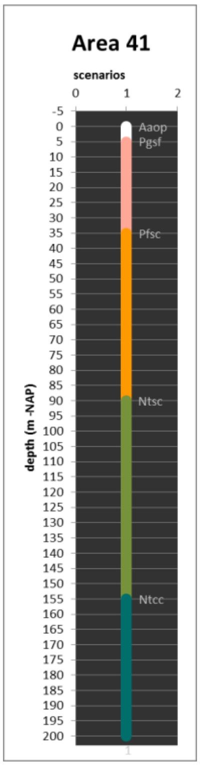

Area 36
scenarios
depth (m -NAP)
Aaop
Aaop
Aaop
Aaop
Aaop
Aaop
Pgcc
Pgsf
Pgcc
Pgsf
Pgsf
Pgsf
Pgcc
Pgcc
Pgsf
Pgsf
Pgsf
Pgsf
Pfsc
Pfsc
Pfsc
Ntsc
Ntsc
Ntsc
Ntsc
Ntsc
Ntsc
Ntcc
Ntcc
Ntcc
Ntcc
Ntcc
Ntcc

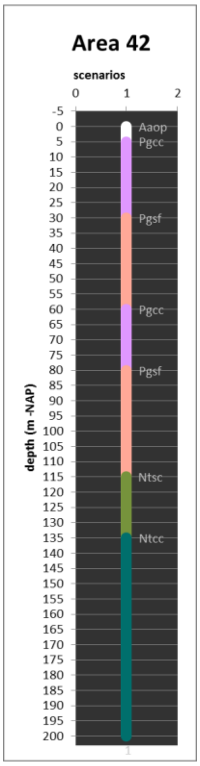

Area 37
scenarios
depth (m -NAP)
Aaop
Pgsf
Pfsc
Ntsc
Ntcc

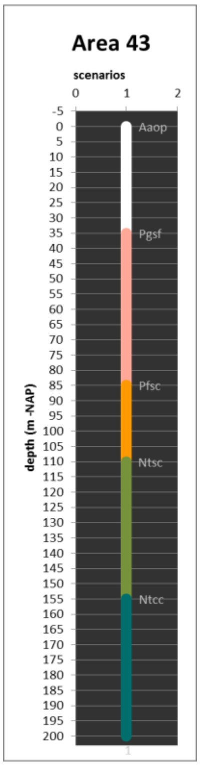

Area 38
scenarios
depth (m -NAP)
Aaop
Pgsf
Pfsc
Ntsc
Ntcc

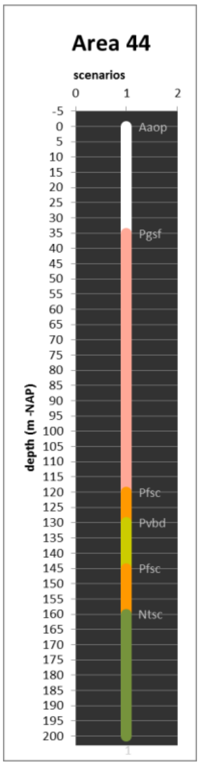

Area 39
scenarios
depth (m -NAP)
Aaop
Pgsf
Pfsc
Ntsc
Ntcc

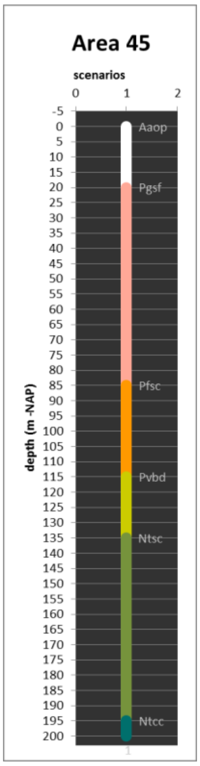

Area 40
scenarios
depth (m -NAP)
Aaop
Pgcc
Pgsf
Pgcc
Pfsc
Ntsc
Ntcc

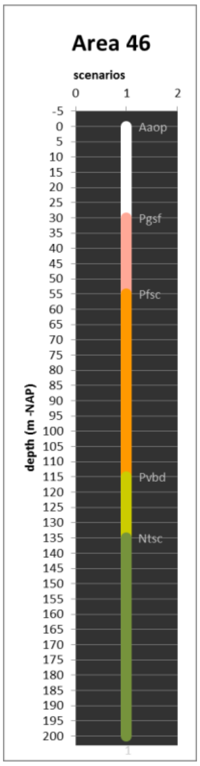

Area 41
scenarios
depth (m -NAP)
Aaop
Pgsf
Pfsc
Ntsc
Ntcc

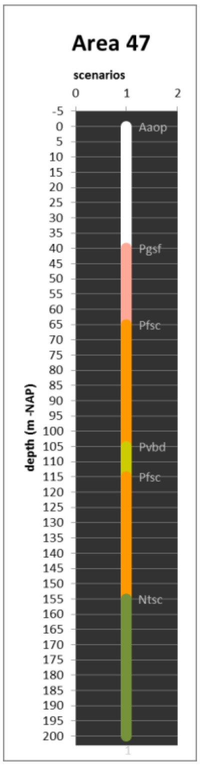

Area 42
scenarios
depth (m -NAP)
Aaop
Pgcc
Pgsf
Pgcc
Pgsf
Ntsc
Ntcc

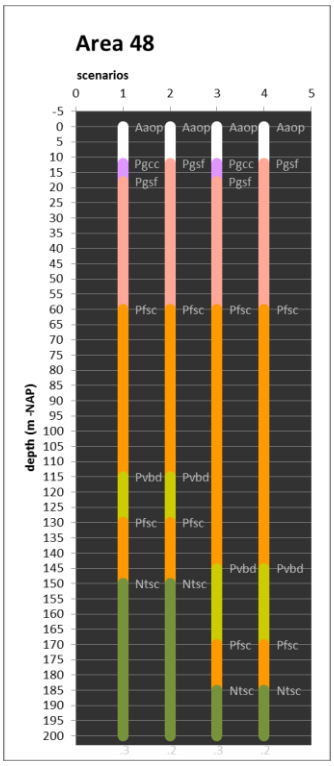

Area 43
scenarios
depth (m -NAP)
Aaop
Pgsf
Pfsc
Ntsc
Ntcc

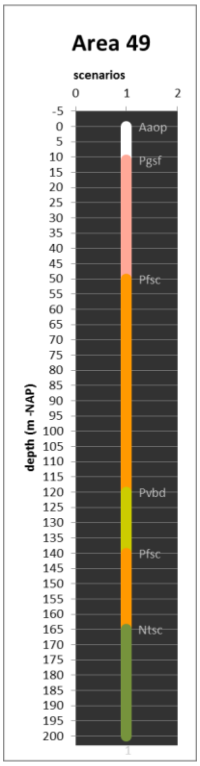

Area 44
scenarios
depth (m -NAP)
Aaop
Pgsf
Pfsc
Pvbd
Pfsc
Ntsc

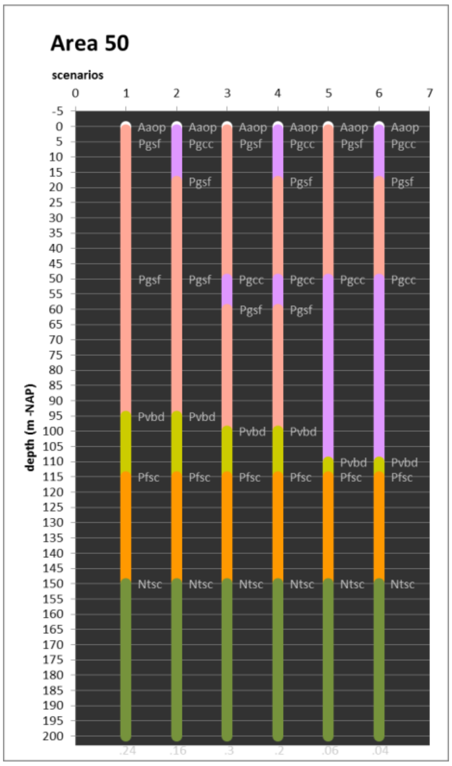

Area 45
scenarios
depth (m -NAP)
Aaop
Pgsf
Pfsc
Pvbd
Ntsc
Ntcc

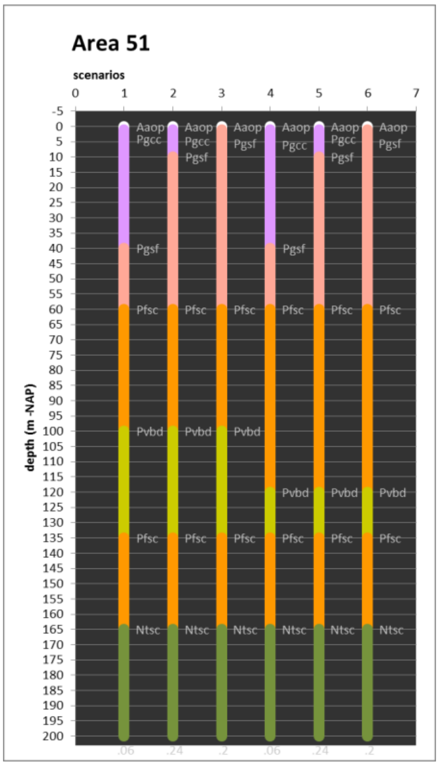

Area 46
scenarios
depth (m -NAP)
Aaop
Pgsf
Pfsc
Pvbd
Ntsc

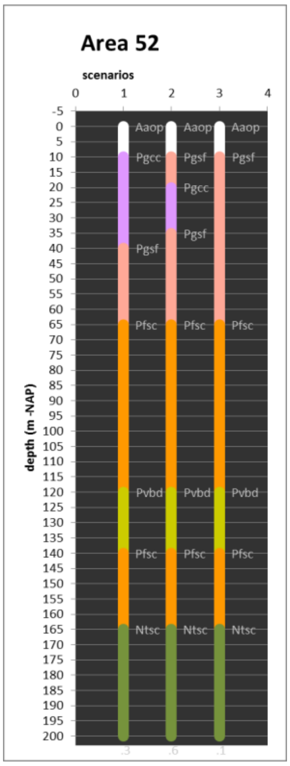

Area 47
scenarios
depth (m -NAP)
Aaop
Pgsf
Pfsc
Pvbd
Pfsc
Ntsc

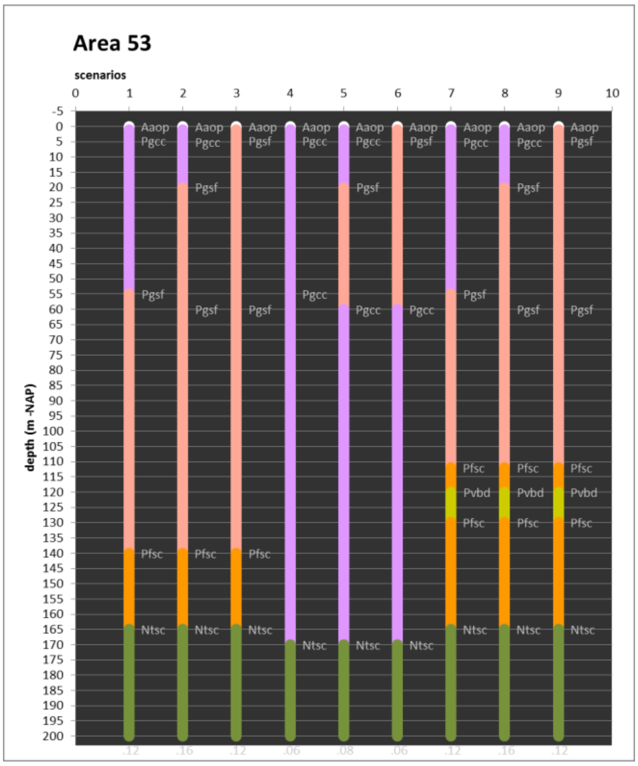

Area 48
scenarios
depth (m -NAP)
Aaop
Pgcc
Pgsf
Pfsc
Pvbd
Ntsc

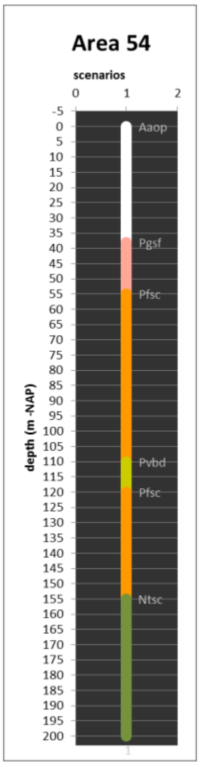

Area 49
scenarios
depth (m -NAP)
Aaop
Pgsf
Pfsc
Pvbd
Pfsc
Ntsc

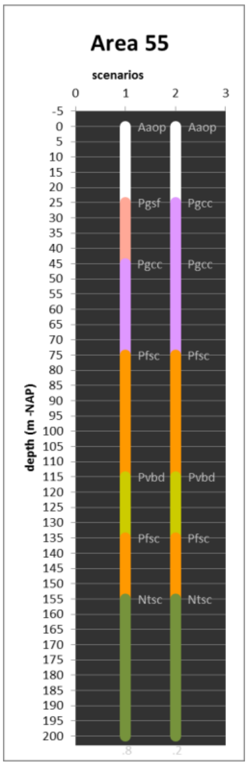

Area 50
scenarios
depth (m -NAP)
Aaop
Pgsf
Pgcc
Pvbd
Pfsc
Ntsc

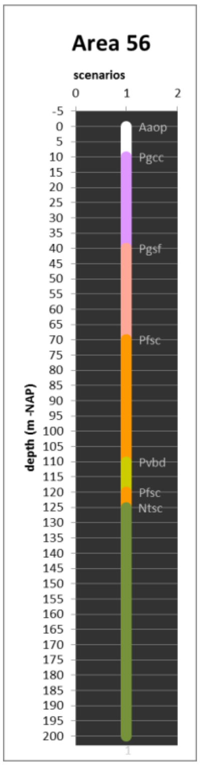

Area 51
scenarios
depth (m -NAP)
Aaop
Pgcc
Pgsf
Pfsc
Pvbd
Ntsc

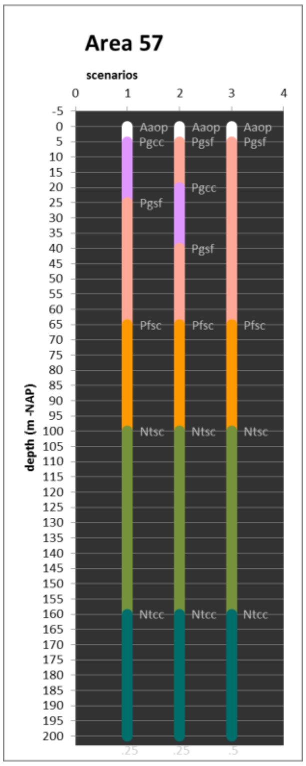

Area 52
scenarios
depth (m -NAP)
Aaop
Pgcc
Pgsf
Pfsc
Pvbd
Ntsc

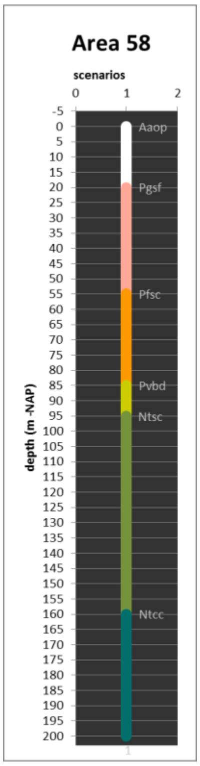

Area 53
scenarios
depth (m -NAP)
Aaop
Pgcc
Pgsf
Pfsc
Pvbd
Ntsc

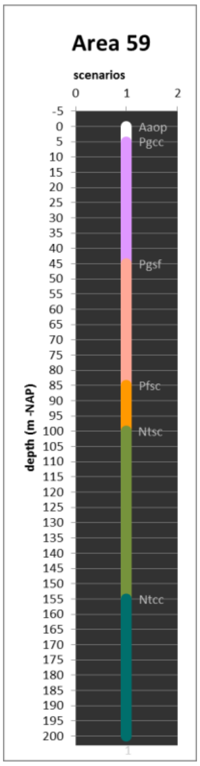

Area 54
scenarios
depth (m -NAP)
Aaop
Pgsf
Pfsc
Pvbd
Ntsc

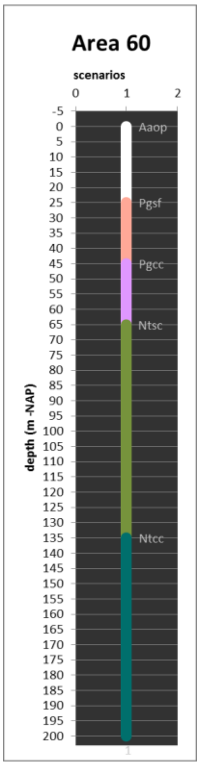

Area 55
scenarios
depth (m -NAP)
Aaop
Pgsf
Pgcc
Pfsc
Pvbd
Ntsc

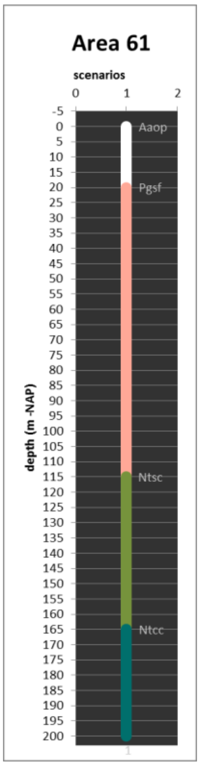

Area 56
scenarios
depth (m -NAP)
Aaop
Pgcc
Pgsf
Pfsc
Pvbd
Ntsc

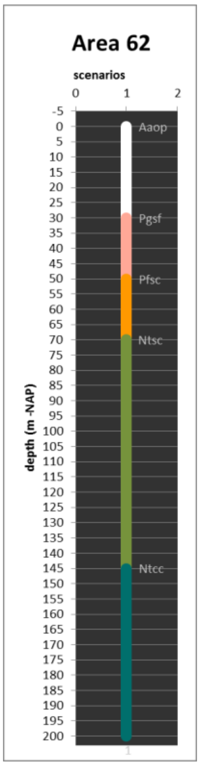

Area 57
scenarios
depth (m -NAP)
Aaop
Pgcc
Pgsf
Pfsc
Ntsc
Ntcc

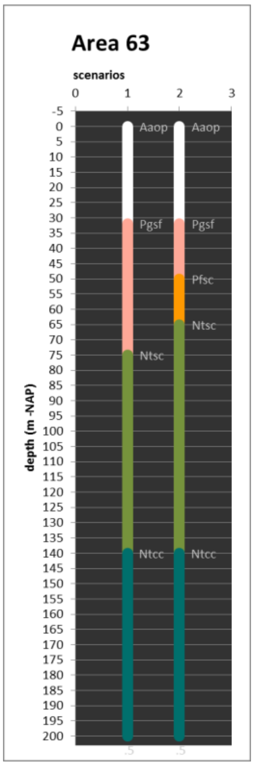

Area 58
scenarios
depth (m -NAP)
Aaop
Pgsf
Pfsc
Pvbd
Ntsc
Ntcc


Area 59
scenarios
depth (m -NAP)
Aaop
Pgcc
Pgsf
Pfsc
Ntsc
Ntcc


Area 60
scenarios
depth (m -NAP)
Aaop
Pgsf
Pgcc
Ntsc
Ntcc


Area 61
scenarios
depth (m -NAP)
Aaop
Pgsf
Ntsc
Ntcc


Area 62
scenarios
depth (m -NAP)
Aaop
Pgsf
Pfsc
Ntsc
Ntcc


Area 63
scenarios
depth (m -NAP)
Aaop
Aaop
Pgsf
Pgsf
Pfsc
Ntsc
Ntsc
Ntcc
Ntcc

P Maps of borehole record density at various depth levels

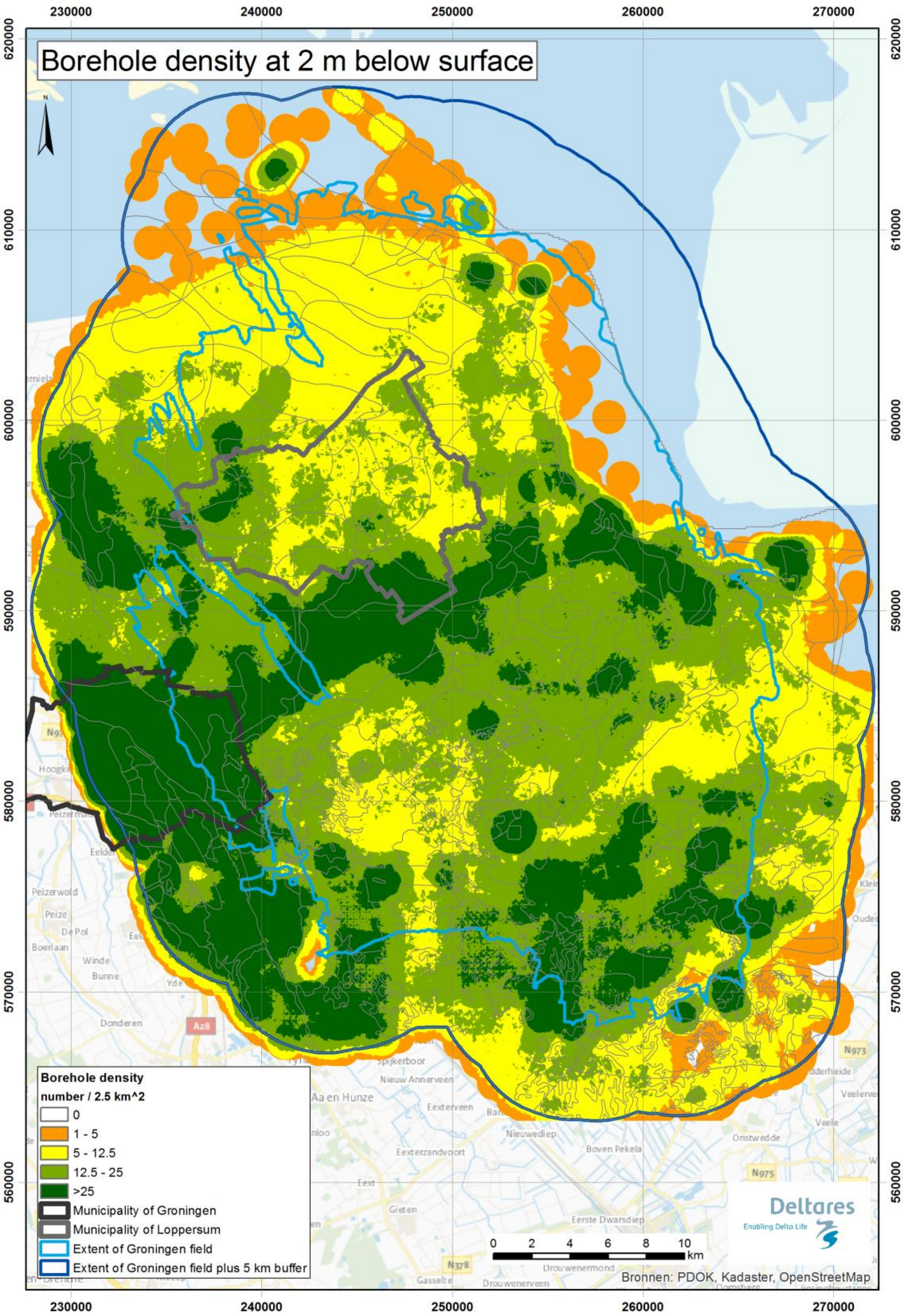


Figure P.1 Density of borehole records from DINO at 2 m below the surface expressed as number per 2.5 km^2. The outlines of geological areas for the surface to NAP-50 m depth range are indicated by pale grey lines.

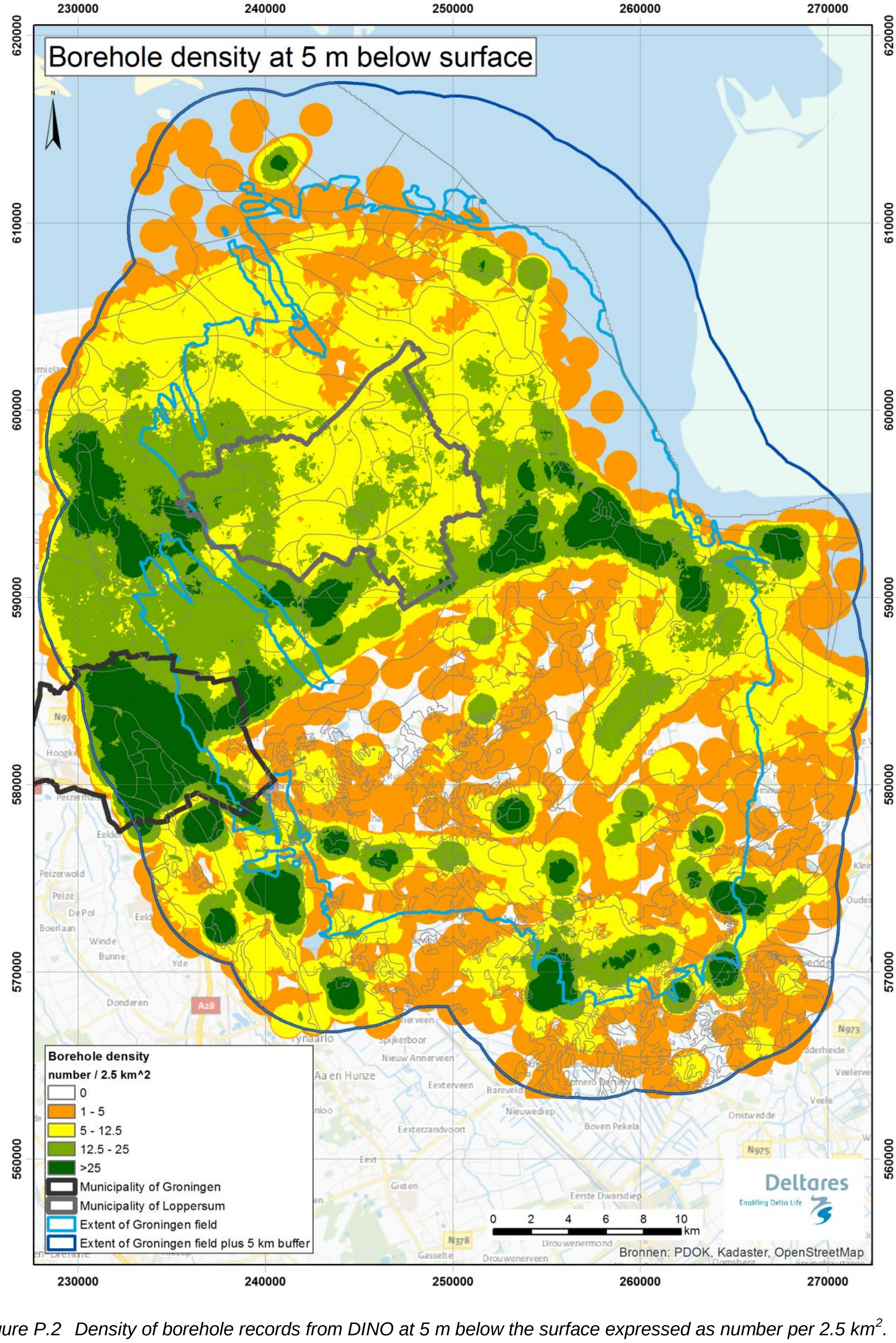


Figure P.2 Density of borehole records from DINO at 5 m below the surface expressed as number per 2.5 km^2. The outlines of geological areas for the surface to NAP-50 m depth range are indicated by pale grey lines.

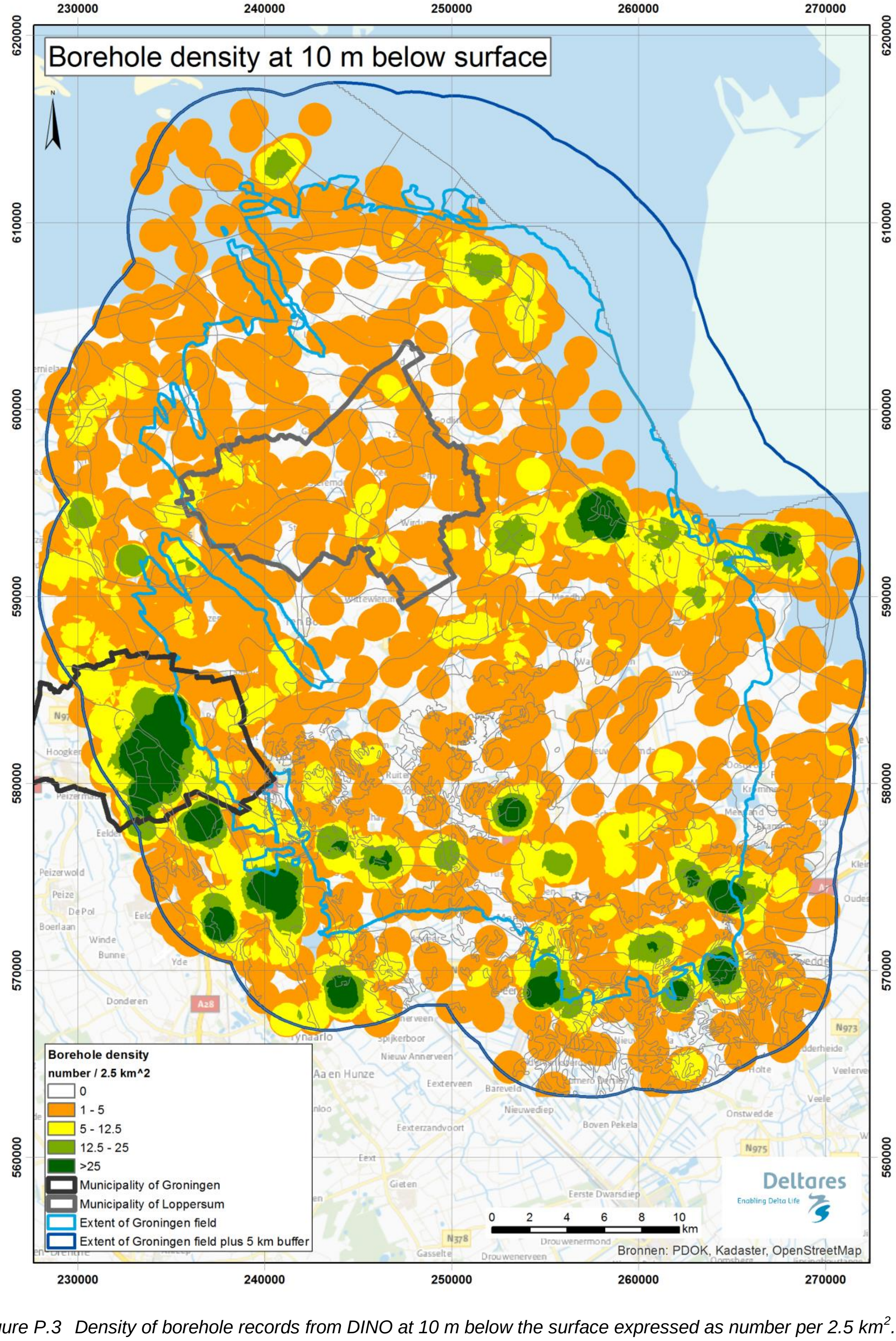


Figure P.3 Density of borehole records from DINO at 10 m below the surface expressed as number per 2.5 km^2. The outlines of geological areas for the surface to NAP-50 m depth range are indicated by pale grey lines.

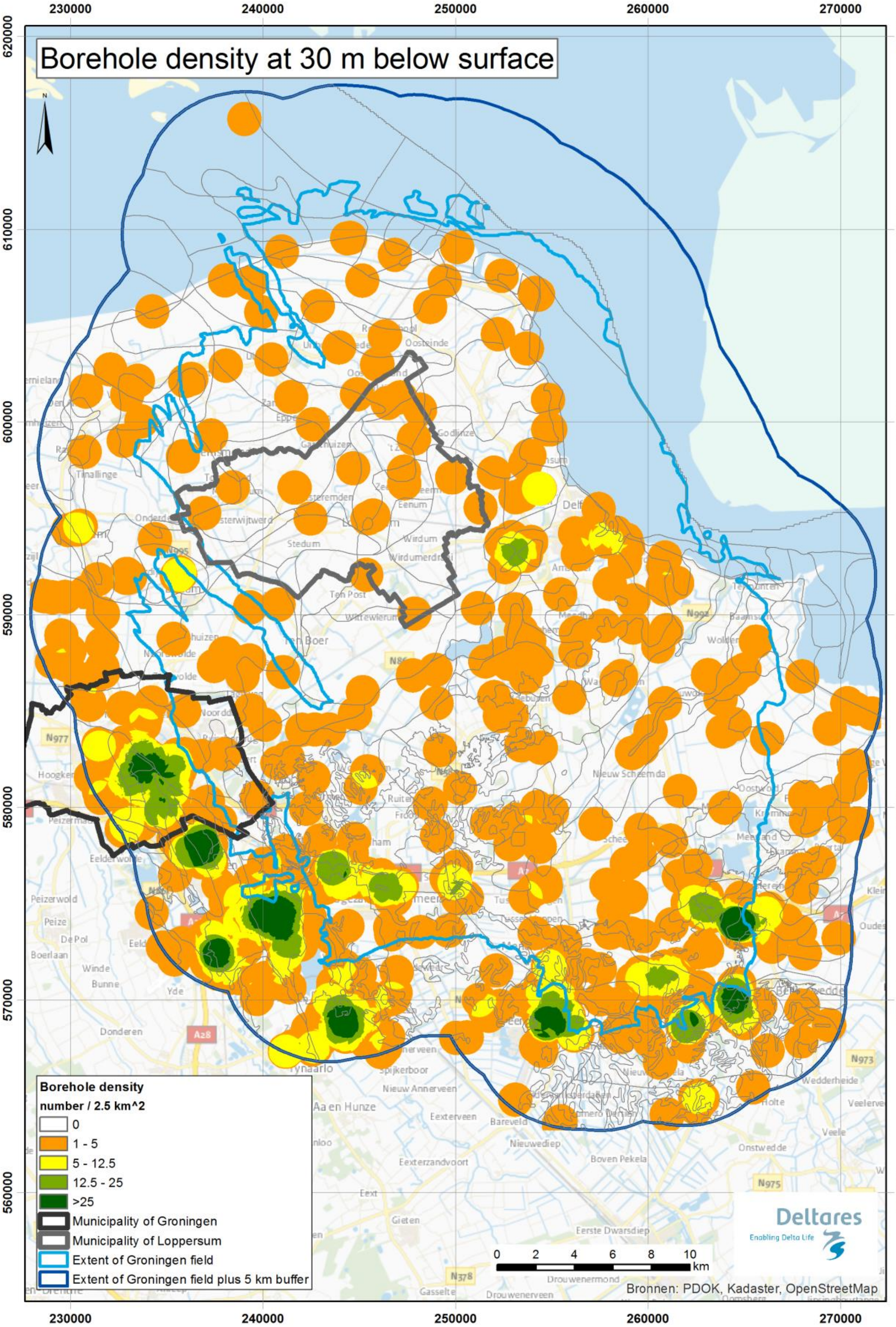


Figure P.4 Density of borehole records from DINO at 30 m below the surface expressed as number per 2.5 km^2. The outlines of geological areas for the surface to NAP-50 m depth range are indicated by pale grey lines.

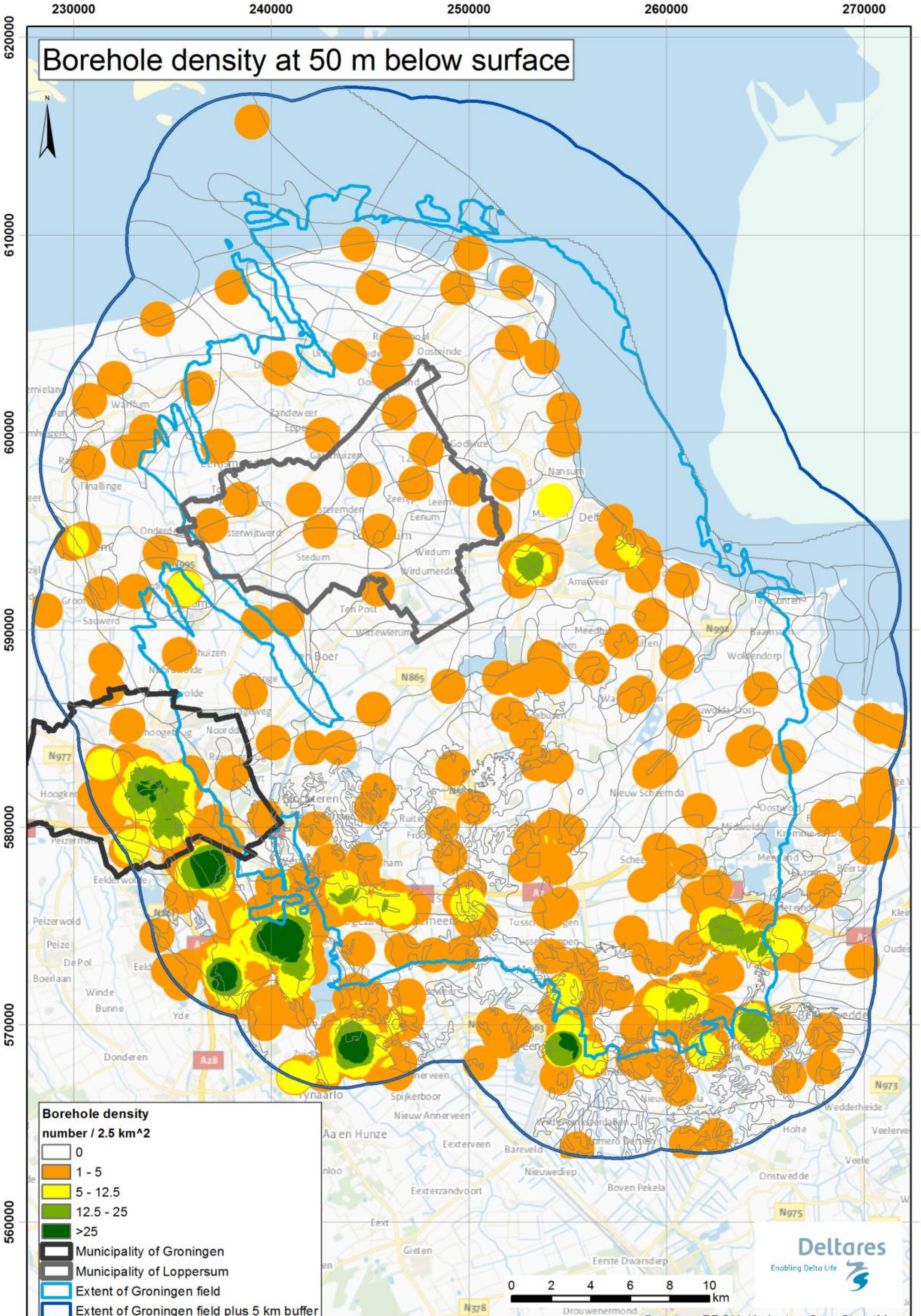


Figure P.5 Density of borehole records from DINO at 50 m below the surface expressed as number per 2.5 km^2. The outlines of geological areas for the surface to NAP-50 m depth range are indicated by pale grey lines.

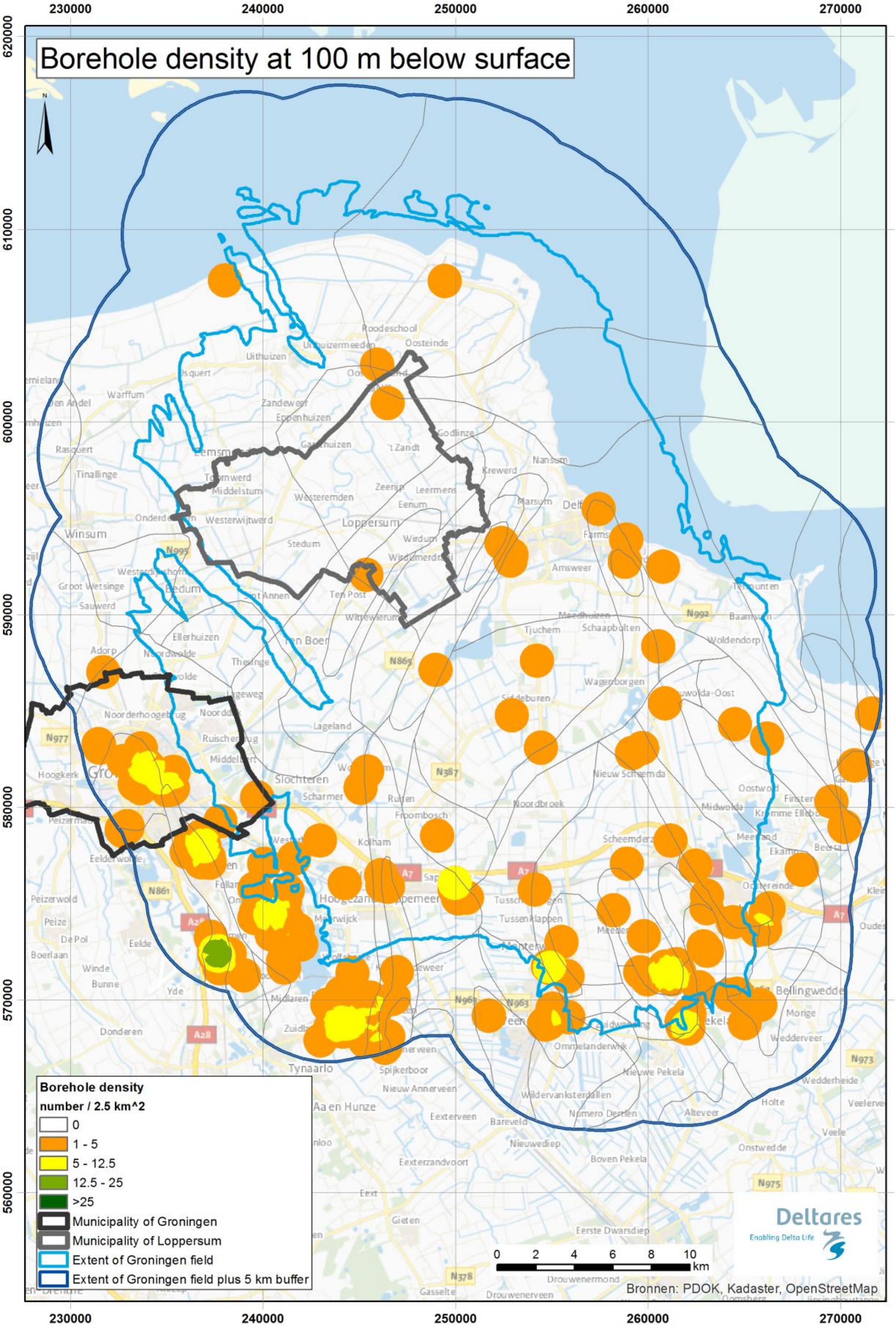


Figure P.6 Density of borehole records from DINO at 100 m below the surface expressed as number per 2.5 km^2. The outlines of geological areas for the NAP-50 m to NAP-200 m depth range are indicated by pale grey lines.

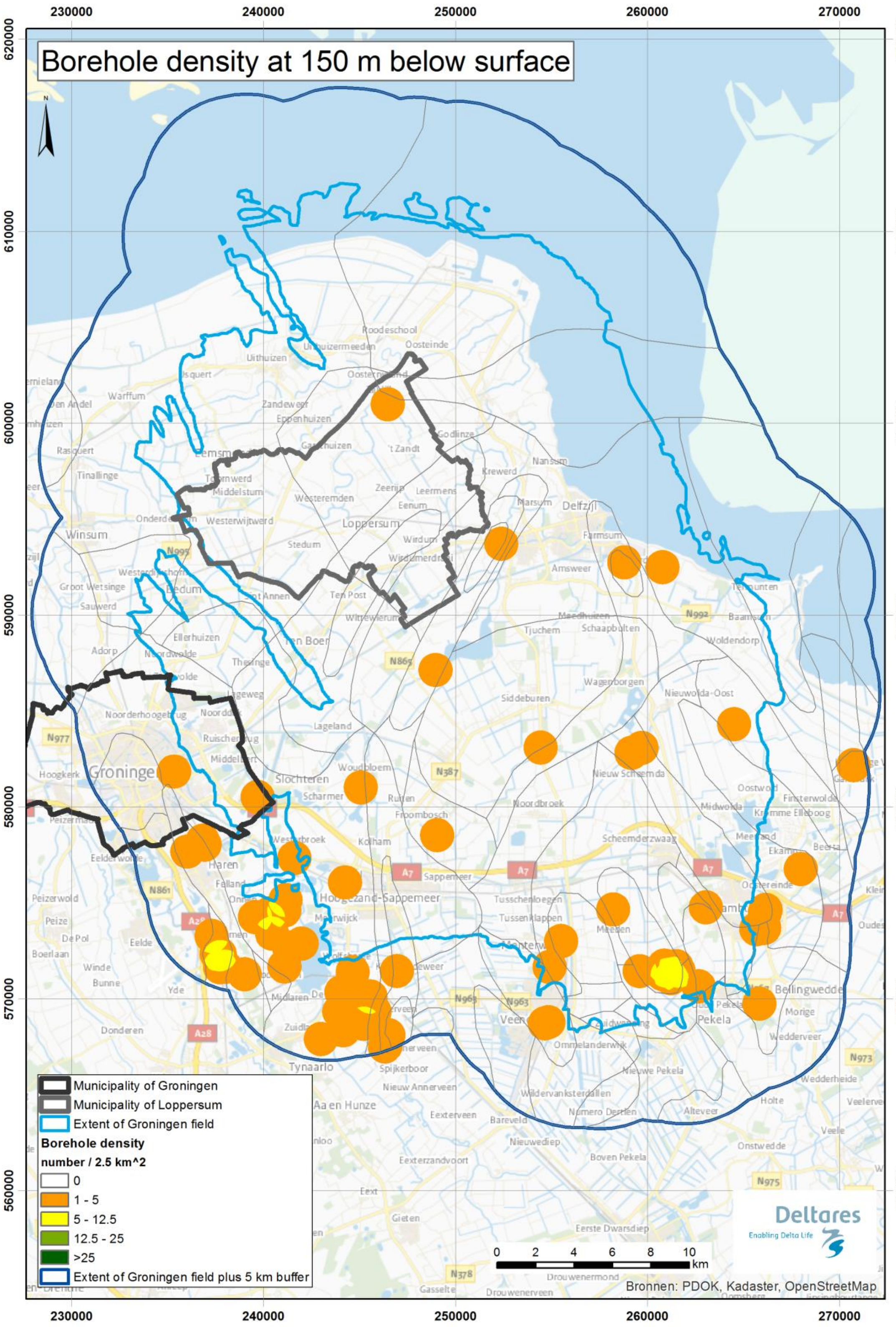


Figure P.7 Density of borehole records from DINO at 150 m below the surface expressed as number per 2.5 km^2. The outlines of geological areas for the NAP-50 m to NAP-200 m depth range are indicated by pale grey lines.

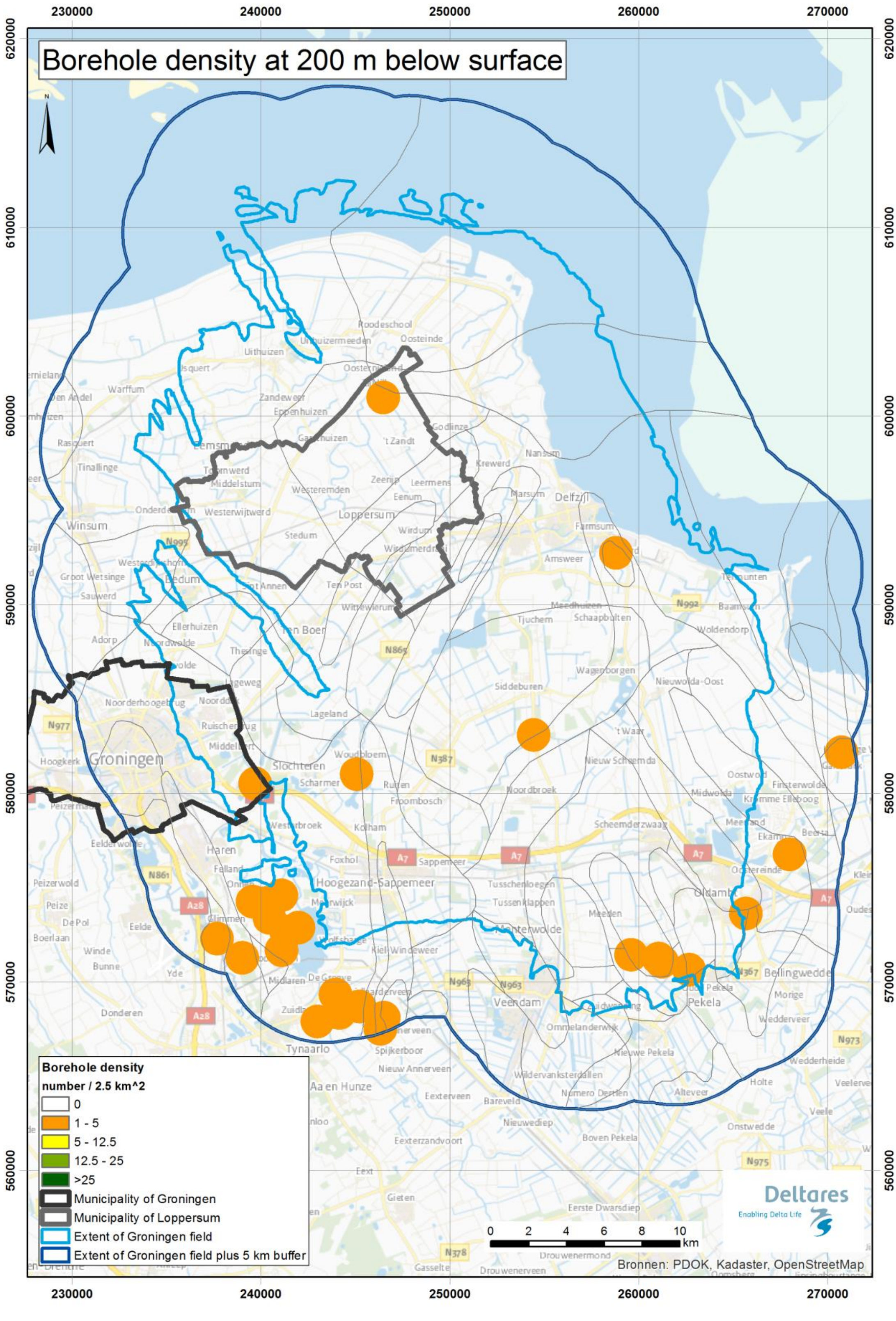


Figure P.8 Density of borehole records from DINO at 200 m below the surface expressed as number per 2.5 km^2. The outlines of geological areas for the NAP-50 m to NAP-200 m depth range are indicated by pale grey lines.

Q Maps of borehole record and CPT density at various depth levels

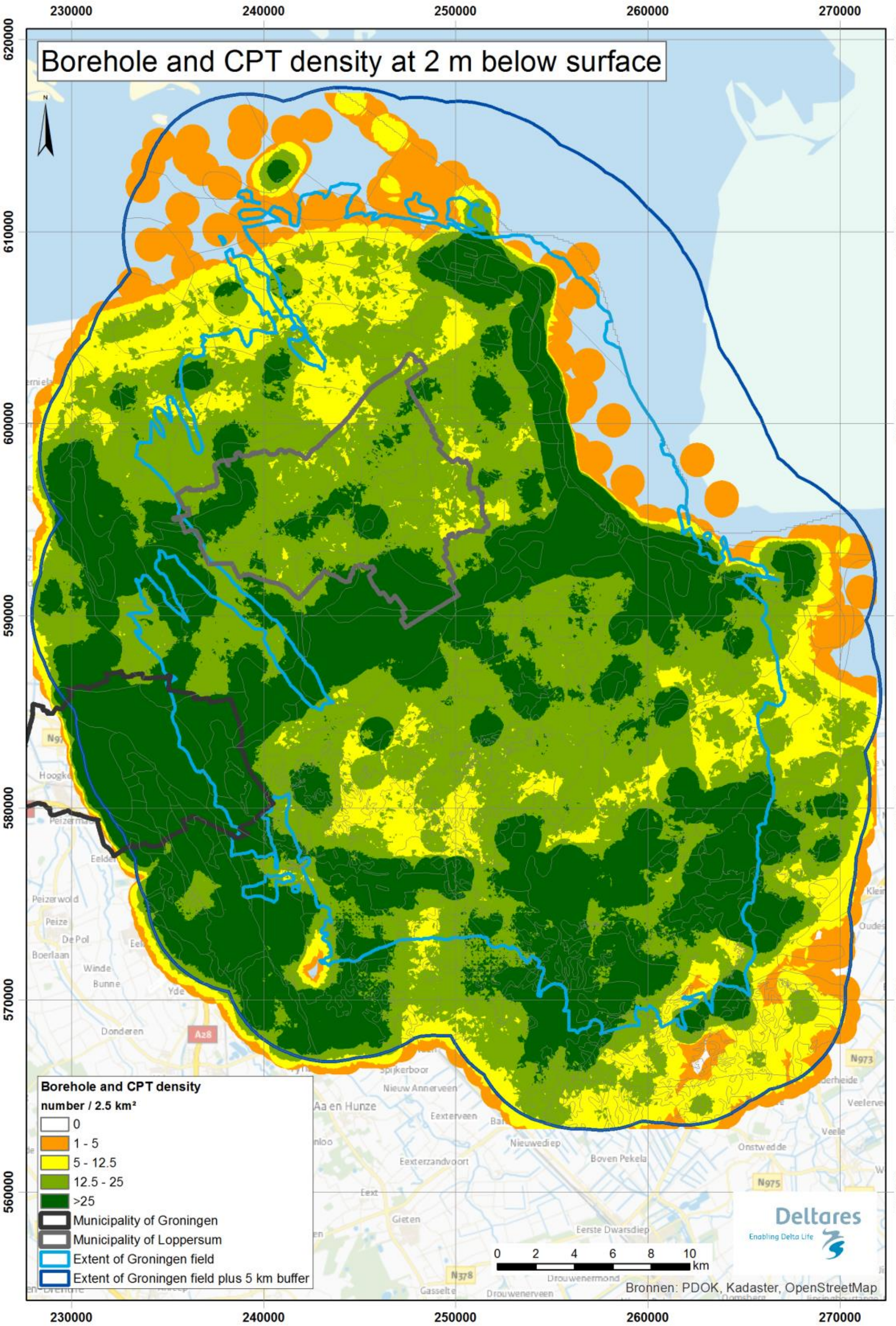


Figure Q.1 Density of borehole records from DINO and CPTs (DINO, Fugro and Wiertsema en Partners) at 2 m below the surface expressed as number per 2.5 km^2. The outlines of geological areas for the surface to NAP-50 m depth range are indicated by pale grey lines.

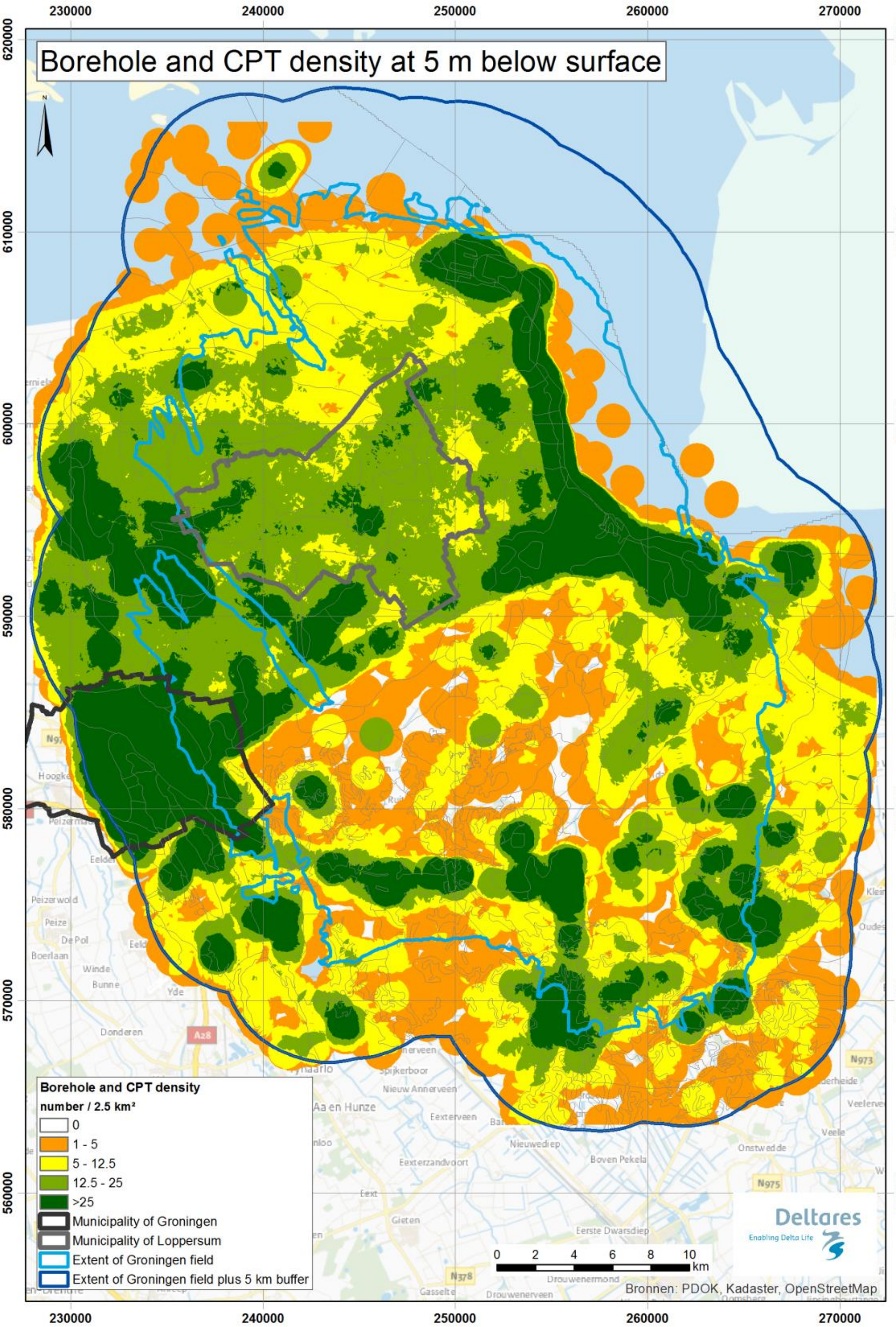


Figure Q.2 Density of borehole records from DINO and CPTs (DINO, Fugro and Wiertsema en Partners) at 5 m below the surface expressed as number per 2.5 km^2. The outlines of geological areas for the surface to NAP-50 m depth range are indicated by pale grey lines.

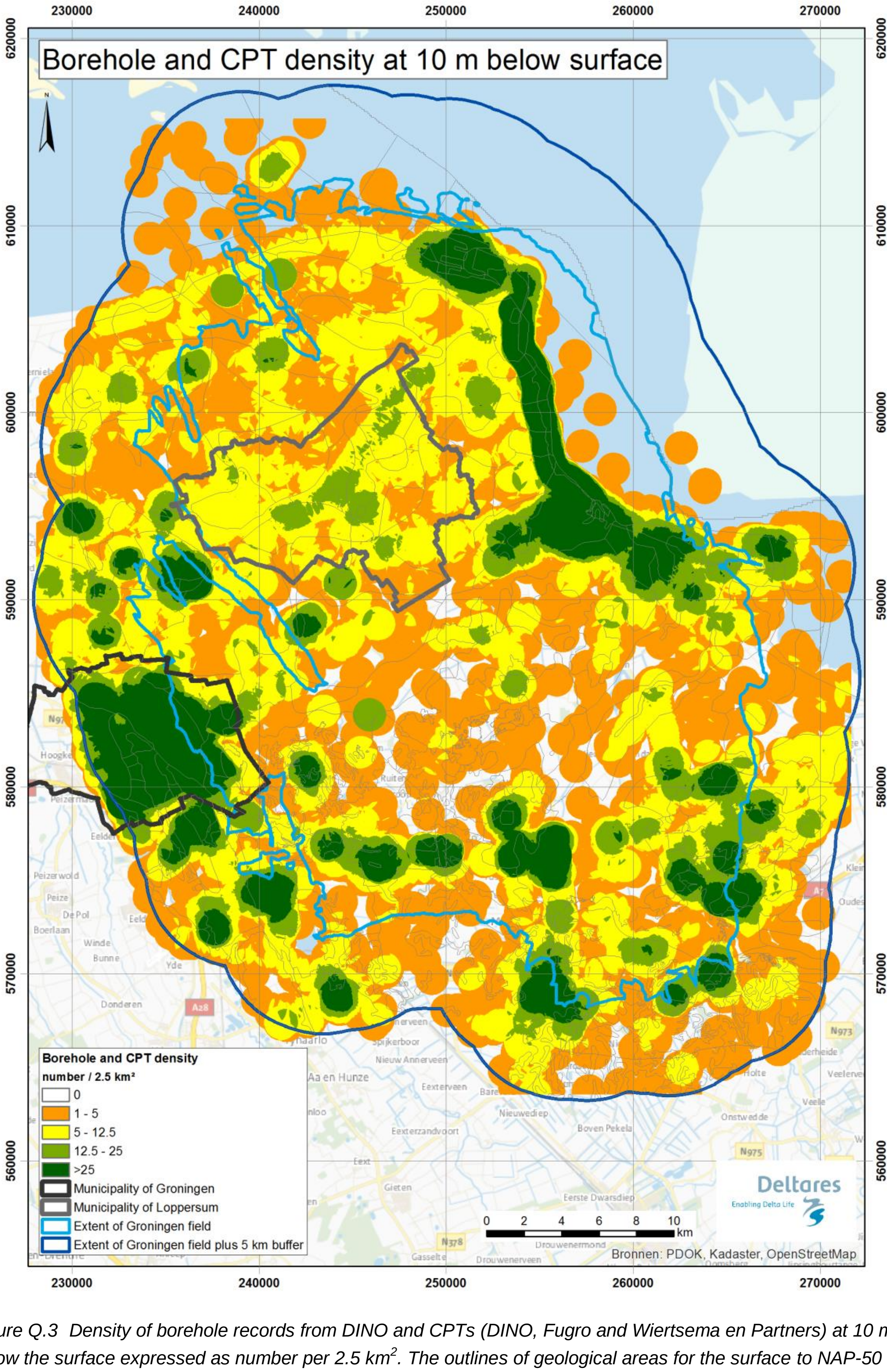


Figure Q.3 Density of borehole records from DINO and CPTs (DINO, Fugro and Wiertsema en Partners) at 10 m below the surface expressed as number per 2.5 km^2. The outlines of geological areas for the surface to NAP-50 m depth range are indicated by pale grey lines.

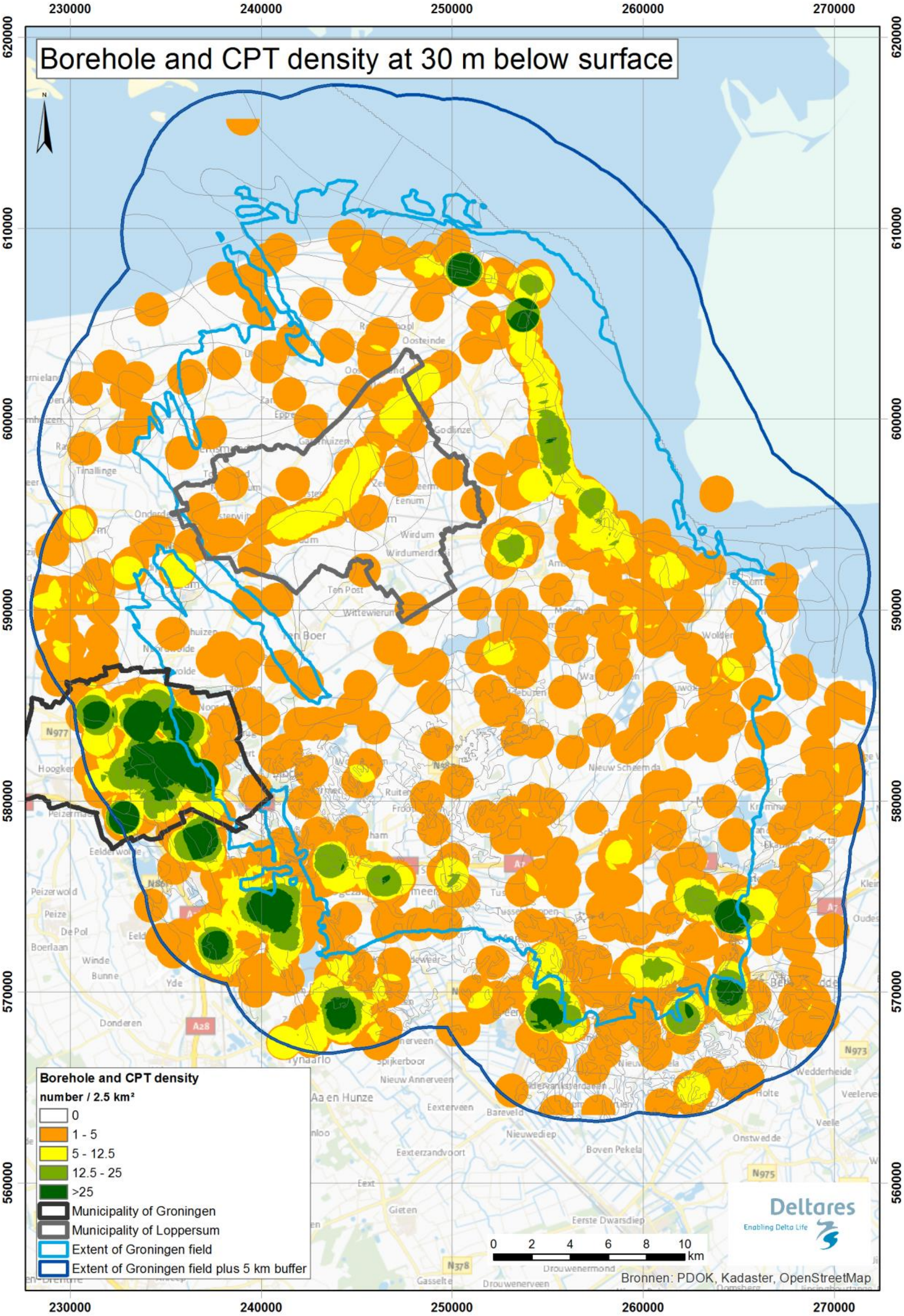


Figure Q.4 Density of borehole records from DINO and CPTs (DINO, Fugro and Wiertsema en Partners) at 30 m below the surface expressed as number per 2.5 km^2. The outlines of geological areas for the surface to NAP-50 m depth range are indicated by pale grey lines.

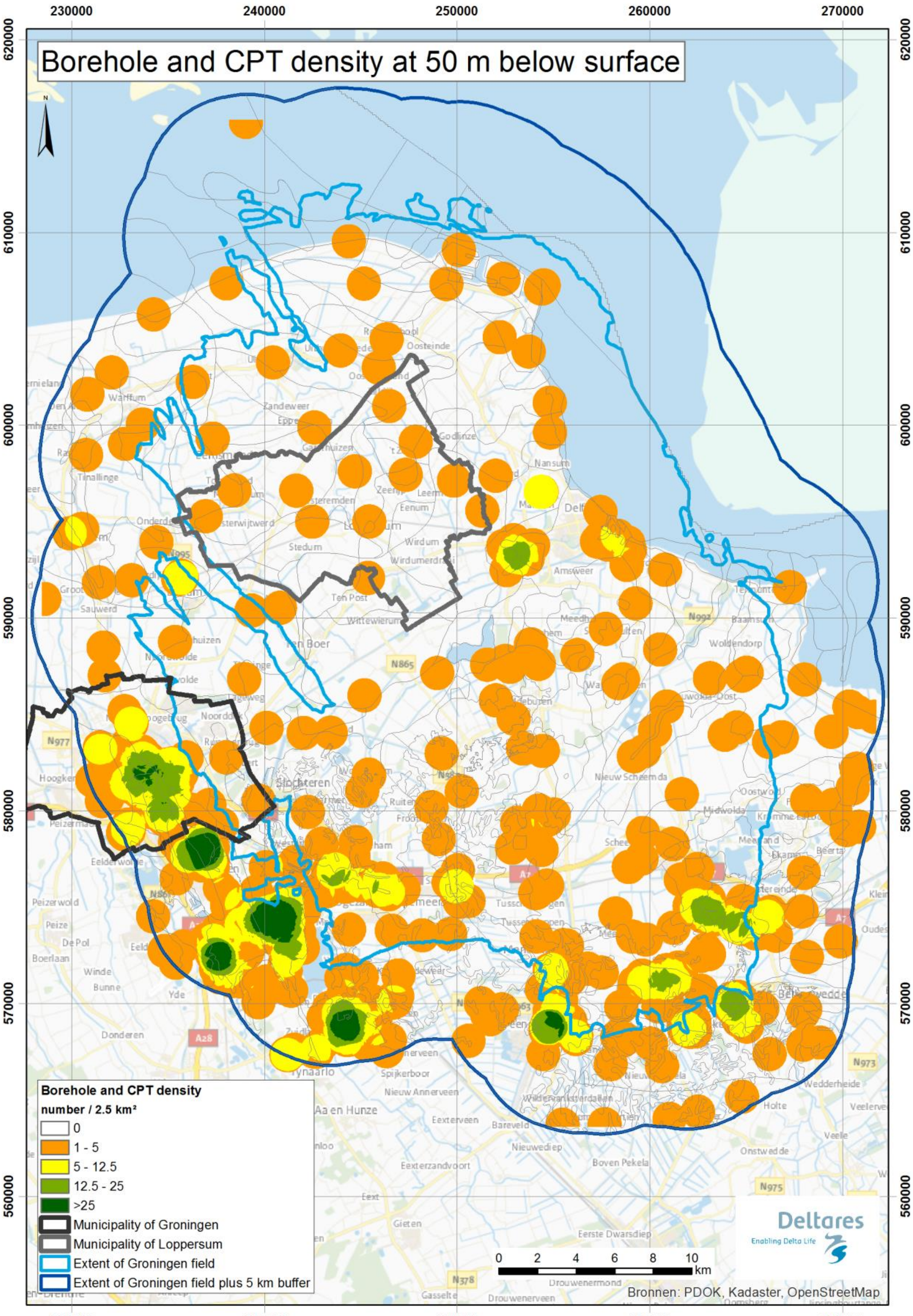


Figure Q.5 Density of borehole records from DINO and CPTs (DINO, Fugro and Wiertsema en Partners) at 50 m below the surface expressed as number per 2.5 km^2. The outlines of geological areas for the surface to NAP-50 m depth range are indicated by pale grey lines.