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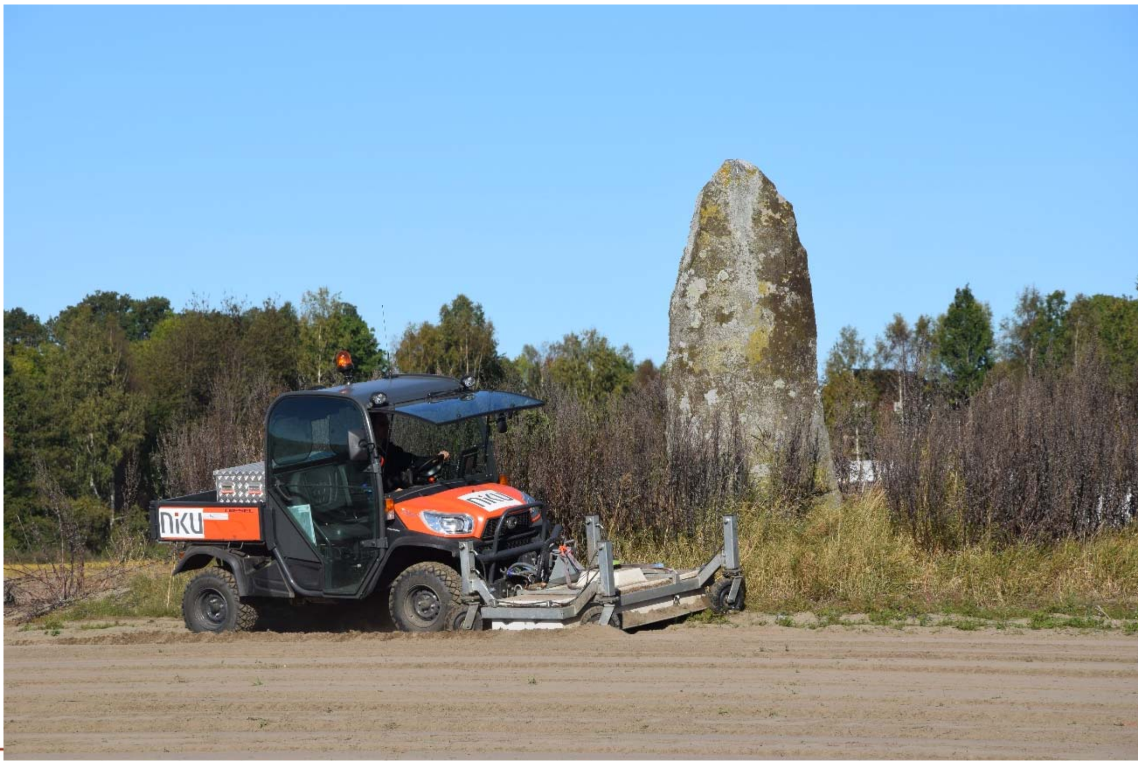
ARCHAEOLOGICAL PROSPECTION AT AULI AND SANDENE IN VESTFOLD

Tønsberg and Larvik municipalities, Vestfold

Manuel Gabler, Erich Nau, Lars Gustavsen, Monica Kristiansen



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Sammendrag

NIKU in cooperation with the LBI ArchPro conducted motorized GPR surveys at Auli and Sandene in Vestfold . Both sites are previously known for their archaeological potential due to several metal detecting finds. Vestfold fylkeskomune and Riksantikvaren wants to clarify if archaeological structures are still remaining in the ground which might show connections to the metal finds. In two days in September and October 2016, 10,2 hectares have been surveyed with the MIRA3 system in total. The results show a large number of archaeological structures in the ground which have been previously unknown. This confirmed the archaeological importance of these places, indicated already from the metal detector finds. The presented results will be further analysed together with the metal detecting finds to put them into a broader cultural historical context. This further analyse will be conducted by Vestfold fylkeskommune and is not included in this report. Nevertheless the initial results demonstrate the large potential of combining different survey techniques to get a broader understanding of an archaeological site.

Emneord

Georadar, arkeologi, gravhauger, jernalder, Auli, Sandene, metallsøk

Avdelingsleder

Knut Paasche

Forord

NIKU wants to thank all the involved organisations for their excellent cooperation within the project. In particular the professional preparation from Vestfold fylkeskommune guaranteed a fast and efficient measurement. As NIKU was rather limited on resources at this time, we are very grateful for the cooperation and support from the LBI ArchPro which helped us in the field as well with data processing. Last but not least a special thanks to the landowners Jan Eivind Ellefsen and Svein Kristen Sandene who gave us access to their fields and prepared them for best measurement conditions.

Content

1 Aims of the survey

Vestfold fylkeskommune and the Norwegian Riksantikvaren started a project to evaluate if and to what extend metal detector finds can represent an area as automatic protected cultural heritage zone. Within that project the Norsk Institutt for Kulturminneforskning (NIKU) together with the Ludwig Boltzmann Institute for Archaeological Prospection and Virtual Archaeology (LBI ArchPro) conducted archaeological geophysical prospection with motorized ground penetrating radar (GPR) over selected areas where archaeological finds have been collected through metal detecting earlier. GPR measurements offer the opportunity of non-destructive mapping and interpreting of detectable traces of human-made activities ranging from single pits and postholes to graves, building remains, cemeteries, settlements and other man-made structures of archaeological interest. The aim for this particular GPR investigation is to evaluate if archaeological structures are still present in the ground which can be connected to the metal detector finds although the finds are already in the disturbed plough layer. Additionally, should the results help to evaluate to which grade metal detecting finds can help to categorize an area as cultural heritage zone.

In this regard two areas Vestfold (Auli and Sandene) have been selected for the investigations (Fig.2) where NIKU in cooperation with the LBI ArchPro carried out the motorized GPR measurements in September and October 2016. This report is dealing with the geophysical prospection results. Further necessary analysis of the results in a wider cultural-historical context together with the metal detector finds and further sources will be conducted by Vestfold fylkeskommune.

Figure 1: Motorized geophysical prospection using the MIRA3 GPR system at Sandene, Foto: Klara Sauter / LBI ArchPro.

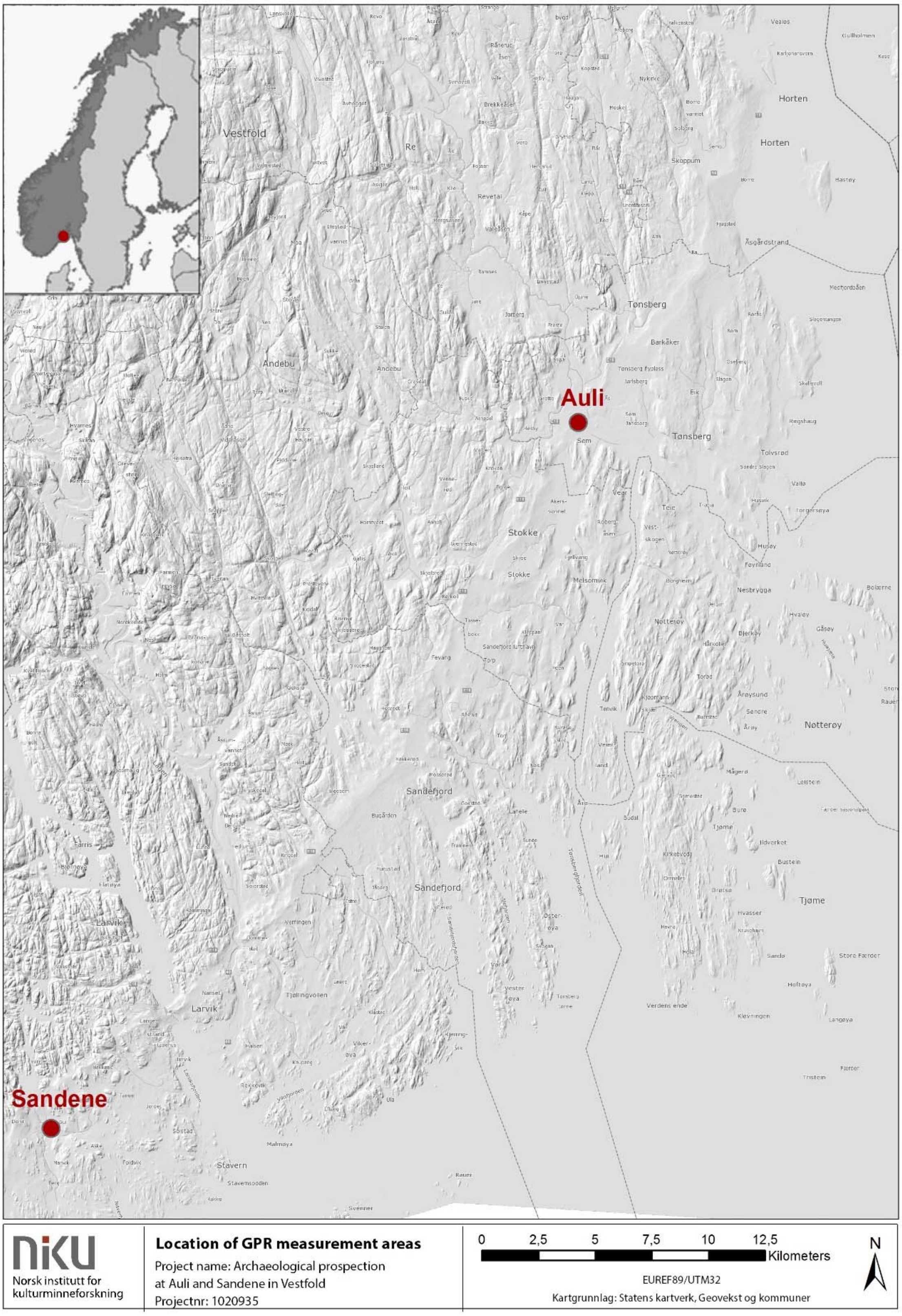


Figure 2: Overview map. The areas at Auli and Sandene are marked with red dots. Map source: Statens kartverk, Geovekst og kummuner.

2 Survey areas

Auli, Tønsberg:

Auli is situated in Tønsberg municipality in Vestfold approximately 3km east of Tønsberg. The measurement area is flat farmland about 25m above MSL. It lies north and east of the farm from Jan Eivind Ellefsen at Semslinna 41, 3170 Sem (Fig. 4). Approximately 100 meter north-east of the survey area the river Aulielva is running towards Byfjorden. The area has first been identified as cultural assets in 2011 through metal detector finds (Askeladden ID 171006). A second metal detector survey has been conducted in 2014 and in total 24 metal finds have been collected in an area of approximately 4,4 hectares (Fig. 3).

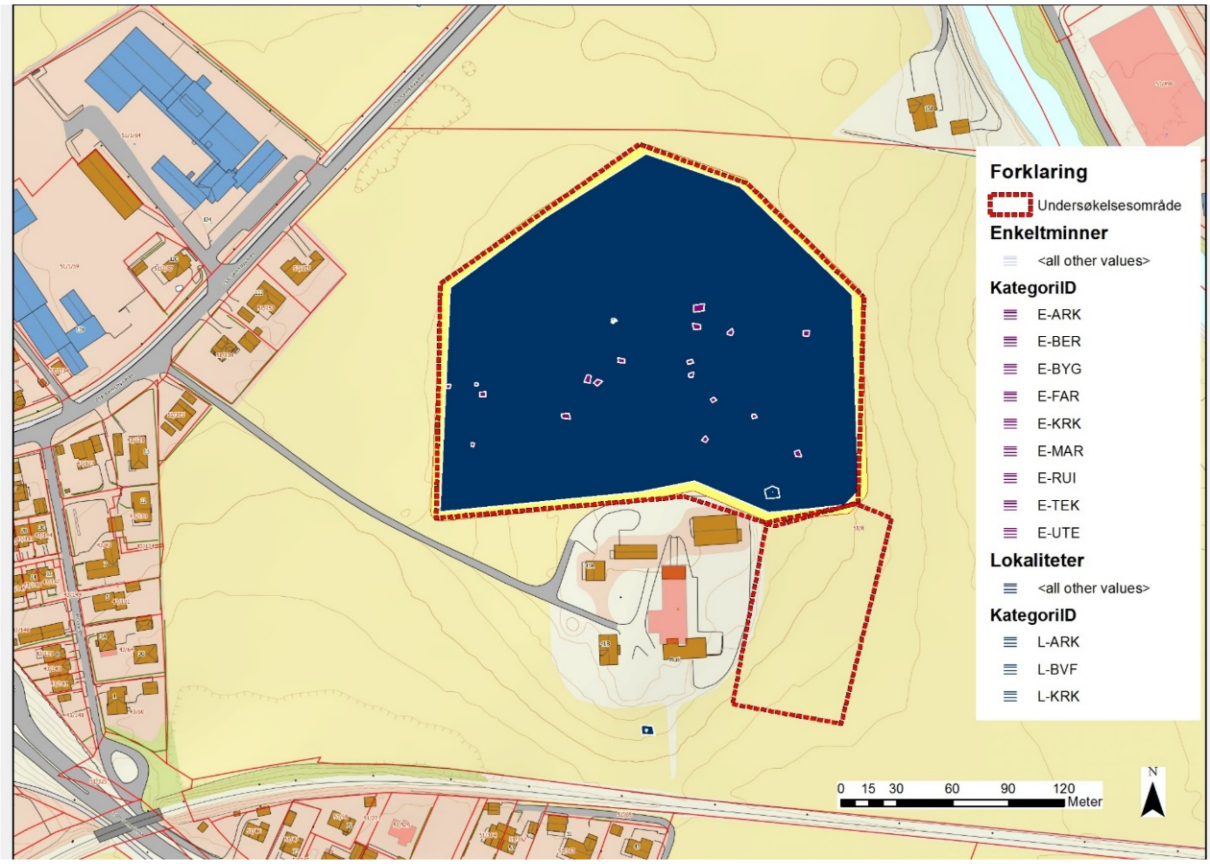


Figure 3: Askeladden ID 171006, Auli with marked metal detector finds. The red dotted line shows the planned area to be surveyed using GPR. Total area: 4,37 hectares. Map: Christer Tonning / Vestfold fylkeskommune).

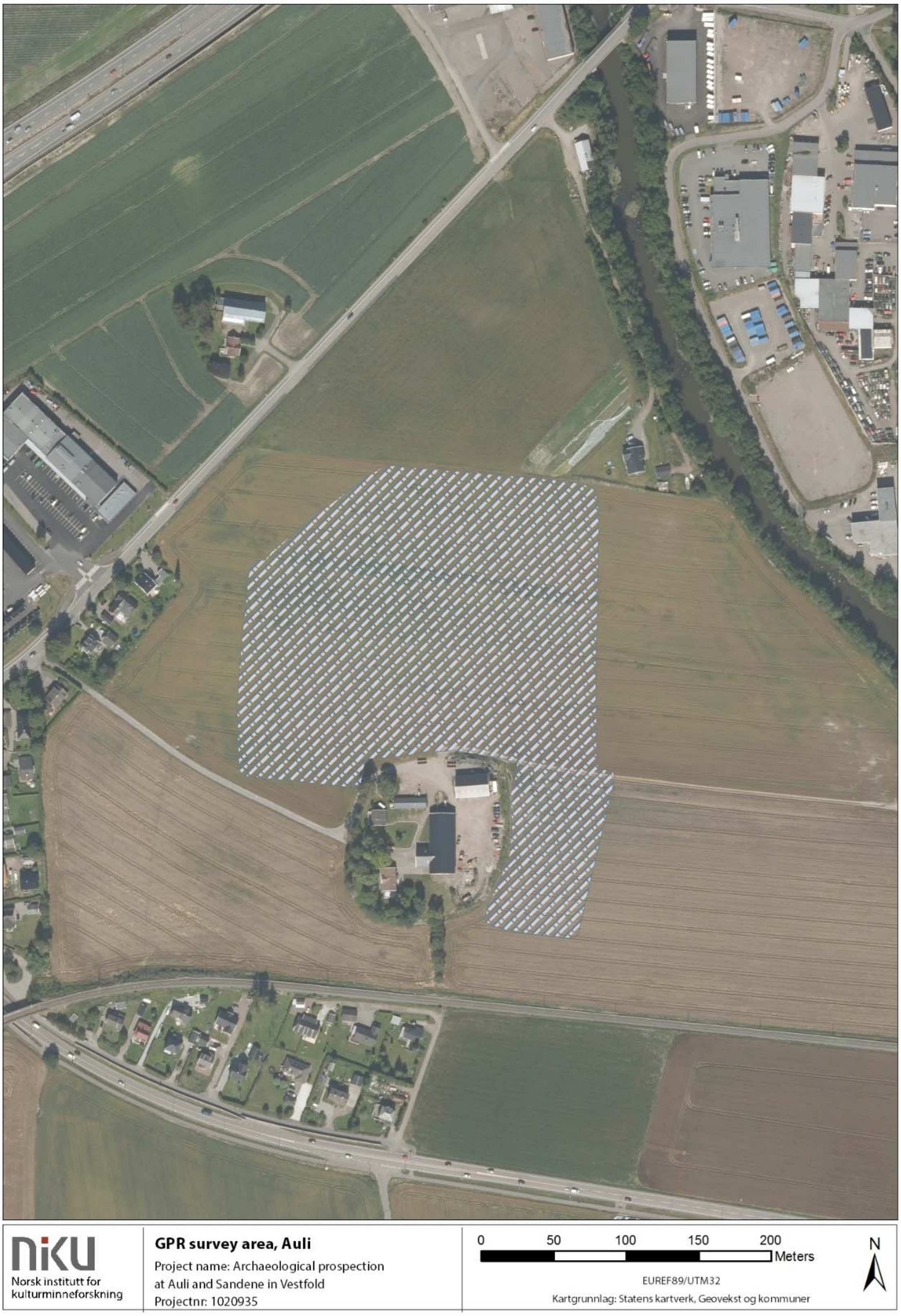


Figure 4: Map of the GPR survey area at Auli. Total area 5,4 hectares. Map source: Statens kartverk, geovekst og kommuner.

Sandene, Larvik:

Sandene is situated at Larvik commune in Vestfold approximately 7,5km southwest from Larvik. The measurement area is flat open farmland about 3m above MSL. It lies east of the farm from Svein Kristen Sandene at Sanniveien 40, 3257 Larvik (Fig. 6). The area is long time known as cultural asset (Askeladden ID 214666) due to the monolith "Bautasten" (Askeladden ID 71014) which stands in the center of the survey area. Since 2014 several metal detector surveys have been conducted, resulting in 23 archaeological finds in an area of approximately 3,4 hectares (Fig. 5). Due to additional known archaeological finds and remains in the close by area that place is highly interesting from a cultural heritage perspective.

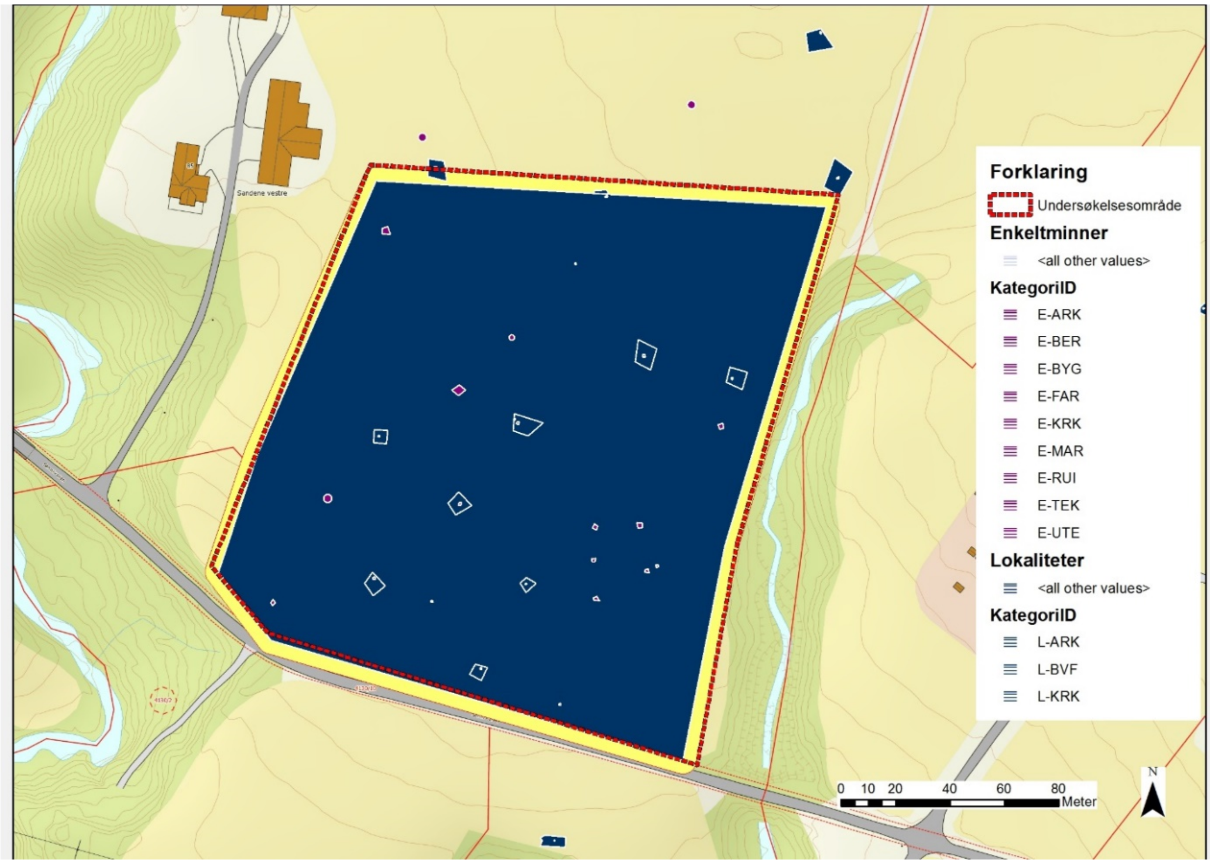


Figure 5: Askeladden ID 214666 marked in the map with additional single finds from metal detecting. The red dotted line shows the planned area which have to be measured with GPR. Total area 3,4 hectare. Map: Christer Tonning / Vestfold fylkeskomune.

Figure 6: Map of the prospected area with GPR at Sandene. Total area 4,8 hectare. Map source: Statens kartverk, geovekst og kommuner.

3 Methodology

Over the past years geophysical prospection methods have developed to become an indispensable set of tools in archaeology and have seen increasing popularity. From the numerous available methods, in particular magnetic prospection, earth resistance and GPR (ground penetrating radar) measurements have proven to be of particular use for archaeological applications. These methods permit the detection and mapping of buried man-made structures by measurement of the physical properties of the subsurface. In the case of archaeological prospection applications, dedicated measurement configurations are used for the spatial, gridded sampling with dense sample spacing for the investigation of several hectares of area in a short period of time. The data analysis and visualisation is conducted using specially developed processing algorithms and software.

The potential of the methods used is primarily determined by the contrast of the physical properties of the soil in comparison to the present archaeological structures. From experience, under suitable conditions, the magnetic prospection method is able to detect a diverse range of structures of archaeological interest (for example pits, postholes, trenches, hearths, furnaces, walls, track ways, palisade trenches).

GPR prospection can be used to detect stratigraphic interfaces, trenches, pits and post holes, masoned architecture and stone structures (e.g. walls, hearths, stone lining in post holes) as well as modern utilities in three dimensions. The GPR method can be adversely affected by high soil humidity and soils rich in clay, or in dry climates where the topsoil can be rich in minerals due to evaporation. While traditional GPR measurements are conducted using single antenna systems, with coverage rates of some 2,500 square metres per day at 25 cm crossline spacing, modern motorized surveying systems permit a considerably increased spatial coverage at very dense profile spacing.

Both in the case of magnetic and GPR measurements, a preliminary data analysis is possible on site for quality control and further planning of the survey. For detailed data analysis, powerful computer and special processing software are used. The visualised data of the individual measurements are combined in the form of georeferenced images that are subsequently interpreted archaeologically including all available information (e.g. terrain models, aerial images, previously registered archaeological remains, soil maps, written sources etc.) in the framework of a Geographical Information System (GIS) by experienced experts. Experiences gained during the last years throughout the county of Vestfold have shown that high resolution GPR prospection achieves the best results and was therefore chosen to be used for the investigations.

3.1 Principles of ground penetrating radar

The GPR method is a variant of radar technology based on the reflection of electromagnetic waves in the subsurface. An electromagnetic pulse with maximum amplitude of a certain frequency is emitted into the subsurface using a transmitter antenna. This pulse is travelling through the ground with a velocity dependent on the traversed material, and it is reflected from individual objects or interfaces with differing physical properties (i.e. dielectric permittivity, electric conductivity). The returning part of the emitted signal is recorded with a receiver antenna and digitized in form of a so-called reflection trace. When many of these single traces are recorded next to each other a vertical GPR profile is produced along the line the antennas where moved. The changes in signal amplitude and frequency carry information about the composition of the subsurface (soil humidity, porosity, clay content) and contained structures. The traveltime of the electromagnetic signal is proportional to the distance of reflecting objects or interfaces.

It is mainly the dielectric permittivity of the medium, its electric conductivity, the radiation characteristics of the antennas used, and the frequency content of the emitted GPR pulse that govern its propagation in the subsurface (maximum signal penetration depth, vertical and horizontal resolution).

The contrast of the dielectric permittivity of two media determines the amount of energy reflected from objects or at layer interfaces. In the upper soil layers strong reflection coefficients are caused by changes in the substrate, by strong inhomogenities due to varying soils humidity, and by contained anthropogenic objects or structures (e.g. utilities, foundation walls).

The absorption of the electromagnetic energy transmitted into the ground depends on the transversed medium (material dependent absorption loss). The reduction in signal amplitude of the transmitted energy pulse depends mainly on the electrical conductivity of the medium and the travelled distance, with the conductivity being the determining factor for the actual penetration depth of the electromagnetic pulse. By comparing amplitudes it is possible to differentiate areas according to their absorption properties.

GPR antennae emitting a low frequency signal (e.g. 100 - 200 MHz) permit a greater depth of investigation at reduced resolution, due to the longer wavelength of the signal. High-frequency signals (e.g. 800 - 1000 MHz) offer the greatest resolution, but only limited signal penetration (< 1 m). GPR antennas commonly used for archaeological prospection typically operate with signal frequencies between 400 - 500 MHz, offering penetration depths of 1.5 - 3 m and sufficient vertical resolution.

Material	ϵ_r	σ [mS/m]	v [m/ns]
Air	1	0	0.30
Sweet water	81	1 – 300	0.03
Salt water	81	4000	0.03
Dry sand	3 – 5	0.5 – 1.5	0.13 – 0.17
Wet sand	20 – 30	5 – 20	0.05 – 0.17
Dry clay	10 – 50	20 – 200	0.08 – 0.17
Wet clay	2 – 30	10 – 100	0.05 – 0.07
Peat	20 – 40	100 – 300	0.04 – 0.06
Granite	4 – 6	0.3 – 2	0.11 – 0.16
Limestone	4 – 8	0.1 – 2	0.1 – 0.14
Sandstone	4 – 12	1 – 10	0.08 – 0.13

Table 1: Approximate values of the relative dielectric permittivity ϵ_r, the electric conductivity δ and the GPR signal velocity v for several common materials (modified from Davis and Annan 1989).

In general, GPR data are very substantial and contain a large amount of information. The visualisation of GPR data is commonly realized in the form of greyscale images showing the amplitudes of the recorded signals as a function of space and time.

Within the individual GPR sections, representing vertical cuts through the subsurface, typical reflection and diffraction patterns of the signals can be observed that are generally very difficult to interpret. However, the use and visualisation in the form of vertical GPR sections is today rather uncommon in geophysical archaeological prospection and outdated, with exception of special applications.

The individual GPR sections collected manually or with motorized survey systems are merged after the fieldwork in the computer using specially developed software solutions. Through interpolation a virtual three-dimensional data volume is generated. If the velocity of the GPR signal in the subsurface is known or estimated (a value commonly used is a constant velocity for the entire subsurface of 10 cm/ns; however, variations between 5 and 15 cm/ns can be encountered), it is possible to convert the vertical axis of the data volume from time to depth.

This digital block of data can be cut into horizontal slices, so called GPR time-slices or GPR depth-slices. Slices of different thickness can be computed, e.g. at 5 cm, 10 cm, 20 cm, 30 cm, 40 cm and 50 cm, averaging variable amounts of information contained in the data volume.

Using these slices it is possible to map and image archaeological structures that occur at approximately the same depth, considerably facilitating their archaeological interpretation since the spatial context becomes clear to the observer. By scrolling through a stack of thin GPR depth- or time-slices in form of a quick succession of images or an animation, it becomes possible to understand the spatial extent of structures contained in the data. While the relative depth of structures imaged using the GPR method is correctly imaged, it should be kept in mind that the absolute depth of the structures can vary by approximately +/- 20% due to the lack of knowledge of the exact GPR signal velocity distribution in the imaged volume.

4 Fieldwork and Equipment

The fieldwork was carried out on September 30th at Auli and on October 3rd at Sandene. At Auli an area of 5,4 ha and at Sandene an area of 4,8 ha hectare was prospected (total area 10,2 ha). Due to a high workload at NIKU at that time the project has been conducted together with the LBI ArchPro. The field and weather conditions were good with dry ground and sun with light wind on both measurement days. The driving direction in the field was chosen along the ploughing direction allowing a faster surveying speed and better ground contact of the radar antennas. At Auli the field was a compact stubble field. At Sandene the field underground was recently harrowed, soft and sandy.

4.1 GPR instrumentation

A motorized 16-channel GPR array (MIRA 3) has been applied for the fieldwork at both areas. The MIRA 3 ground penetrating radar system is a high-resolution multichannel radar system based on the *MALÅ Imaging Radar Array* (MIRA). The GPR array consists of 8 receiver and 9 transmitter antennas with a centre frequency of 400 MHz. Transmitters and receivers are mounted in two rows with an offset of half an antenna width in a ruggedized box. Each receiver antenna records the signal of the two neighbouring transmitter antennas. The cross line spacing between the resulting 16 channels therefore amounts to 10.5 cm. In total a 178 cm wide swath of 16 single GPR sections is recorded for each driven line. The antenna box is mounted to the front hydraulics of a Kubota RTV-X900, which allows a floating position and hence ideal ground contact of the antenna box during the entire survey. The prospection was conducted with each channel constantly recording 40 single measurements per second leading to an average in-line trace spacing of 4 cm depending on the actual driving speed (usually between 7 and 9 km/h). The resulting minimum spatial resolution for this measurement therefore amounts to 10.5 x 4 cm. Each recorded GPR trace is averaged from 4 actually measured traces (4 stacks). The record time of the system was set to 70 ns allowing for a maximum penetration depth of 3.5 m (at an assumed GPR signal velocity of 0.1 m/ns). A ruggedized industrial computer (TANK-700) equipped with software products MIRAsoft (MALÅ Geoscience), NetView (Javad) and LoggerVIS (LBI ArchPro) is mounted in the Kubota RTV and is used for data acquisition, measurement control and navigation. The centimetre accuracy for positioning and navigation is provided by a Javad Sigma GNSS system with CPOS subscription.

Figure 7: MIRA 3 at Auli. The MIRA box is mounted in front of a Kubota RTV. The RTK-GPS is mounted on top of the MIRA box. Foto: Manuel Gabler / NIKU.

4.2 Processing

A first processing of the GPR data was carried out immediately after fieldwork in order to control for data quality and sufficient coverage. Further processing and visualization steps were carried out using the software ArchProSoft, developed by ZAMG *ArcheoProspections®* and the LBI ArchPro. A 3D data block was created from the individual GPR sections. This data block was then cut into horizontal slices (GPR depth-slices) of 5 cm thickness displayed as greyscale images. A constant GPR signal velocity of 0.085 m/ns was used for the time - depth conversion according to the results of a hyperbola adaption analysis of several single GPR sections carried out in Reflexw, leading to a maximum recorded depth of 260 cm. Due to GPR signal attenuation there are no more features visible below a depth of c. 130 – 150 cm. It has to be considered that the GPR signal velocity may vary throughout different parts of the area, therefore an error of +/- 20% in the calculated depth information is possible.

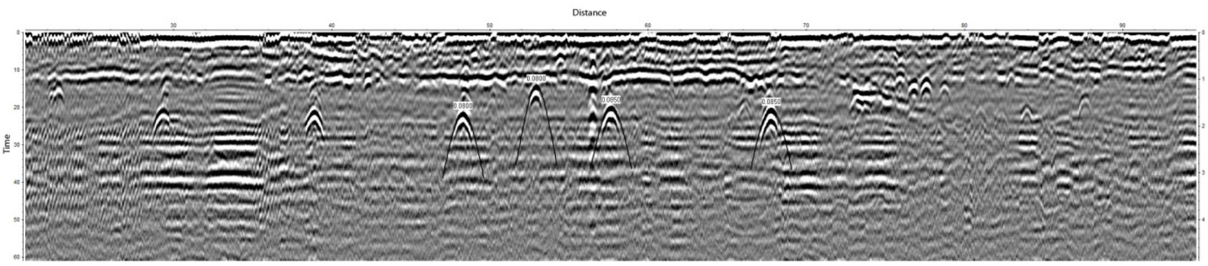


Figure. 8: Cross-section view of survey line 002 / channel 08, showing clear reflection hyperbolas used for the velocity adaption analysis.

Various common GPR processing steps (trace interpolation; band-pass frequency filtering; spike removal; de-wow filter; average-trace-removal; amplitude gain correction; amplitude balancing and Hilbert transformation) have been applied with different settings prior to the 3D data block computation, leading to different result images. Archaeological structures might therefore be clearly visible in one of these datasets, whereas they could be almost invisible on another one. That is why all resulting images need to be analysed and used for the interpretation. The two subareas were processed separately, but were eventually combined to produce the final images.

The resulting images were embedded into an ArcMap (ESRI) geodatabase. Data analysis, archaeological interpretation and the creation of maps were conducted in the framework of the GIS using the ETRS1989 UTM zone 32N coordinate reference system and a special ArcMap extension developed for the archaeological interpretation of geophysical data (ArchaeoAnalyst, LBI ArchPro).

5 Results

5.1 Auli

5.1.1 Paleoenvironmental observations

The larger parts of the geological background in the measurement area consists of maritime sediment as well moraine material. The soil type is mainly silty sand which changes to more clayish soil in the western part of the survey area (jordsmonndatabasen, NGU). In the GPR depth slices the geological background appears as changing absorbing and reflecting areas in irregular patterns. In the western part of the measured area a linear band in north south direction with a width of ca. 25-30 meter is visible in the GPR data as partly absorbing and reflecting anomaly. The anomaly is shifting slightly towards west with increasing depth. It is probably caused by the change of the soil material to a more clayish one in the western part. It can be observed that in the whole prospected area at a depth from c. 50 - 120cm a large number of small (c. 20-50cm diameter), round features are all over the measurement area (visible as reflective anomalies in the GPR data). The most likely interpretation is that these features are natural stones. It could be that some of these anomalies are smaller archaeological objects such as post holes. Nevertheless, as it is not possible to see bigger archaeological structures such as house remains within the huge amount of these small features, it is not possible to differentiate possible archaeological objects from natural stones.

5.1.2 Modern features

A large number of straight linear features can be observed all across the investigated area. These features generally appear at a depth between 30 and 140 cm, but are most distinguishable at a depth of c. 70–100cm. Most of them show a two-way appearance: At a depth of c. 30-60cm they show absorbing properties, displayed as white or light grey in the depth-slices. In the lower slices they switch to reflective properties displayed in dark grey or black. Due to their appearance and spatial distribution these features are interpreted as drainage diches and pipes. Other linear feature with a width of c. 1m are visible in a depth of c. 30-60cm. As known from older air images these are remains of older paths. In the southern end some fine parallel linear features in a depth between 20-40cm in east-west direction are interpreted as probably older field borders.

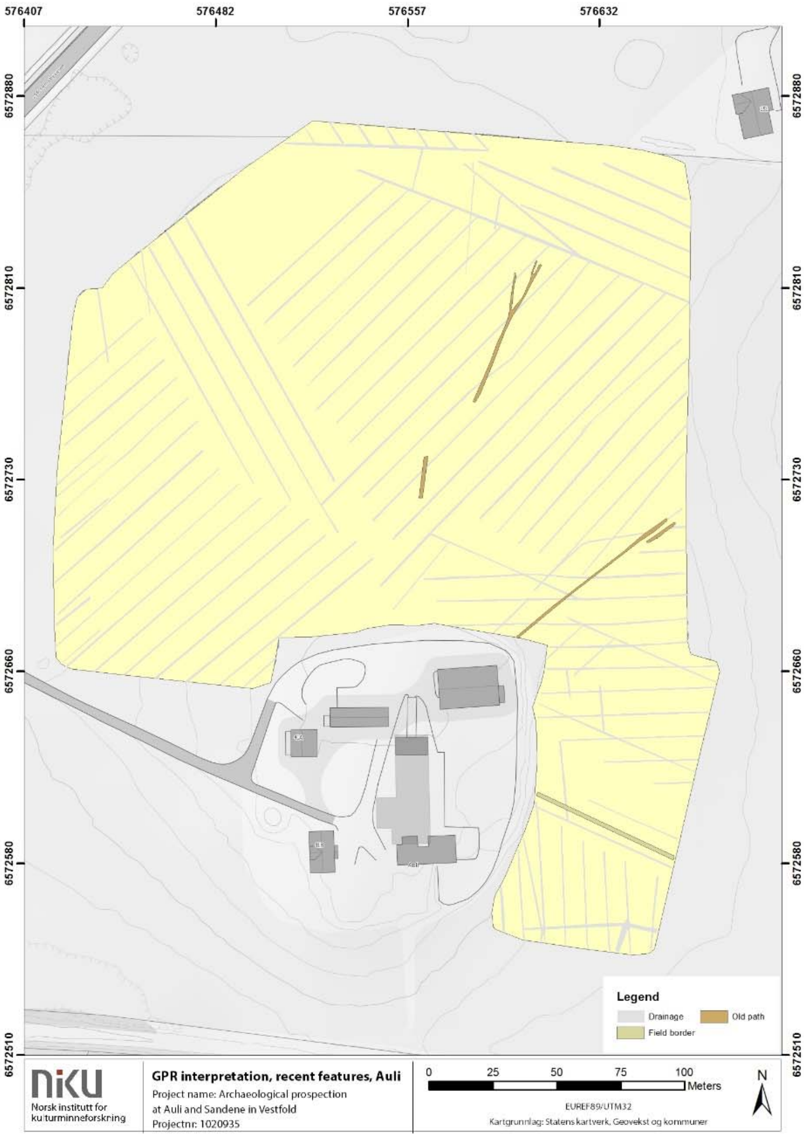


Figure 9.: GPR interpretation of modern features at Auli. Map source: Norge I Bilder, Geovekst.

5.1.3 Archaeology

Within the investigated areas several anomalies in the GPR data can be interpreted as archaeological objects and/or structures which will be described closer below.

Stone –packing's

Over the whole area several larger round or rectangular features are visible. They appear as reflecting anomalies and are visible from 50–180cm depth. The size ranges from ca. 2,2x1m up to 4,5x3,5m for the rectangular ones. The round ones range from 1,5m to 4,5m diameter. Through their appearance in the GPR depth slices, these features are interpreted as stone packing's. As their form and depth differs from the geological background it is most likely that these features are anthropogenic pits filled with stones.

Pits and deposits

Next to the large stone packing's, several round features with a diameter from 1–1,5m are observed in the data which differs from the geological background. They appear mostly in a depth from 50–80cm partly as reflecting and partly as absorbing anomaly. The features are clearly a disturbance of the natural layering in that area and are potentially caused by human activities. Some kind of archaeological pits (cooking pit, storage pit, etc.) are a conceivable interpretation. However, other rather recent human activities like stone extraction for clearance purposes could also cause such anomalies.

Burial mounds

Mound 1

In the north- eastern part of the measurement area a fragmented circular feature with an outer dimension of c. 11m and a width of c. 0,5m can be observed. It is visible in the depth between 20 and 50cm and appears as absorbing anomaly. The structure is interpreted as the fragments of a ring ditch of a possible burial mound. The fragmented appearance indicates that the entire mound is destroyed and only few parts of the ring ditch are preserved.

Mound 2

In the central part of the measurement area a circular feature with an outer dimension of c. 13m and a width of c. 0,5-1m can be observed. It is visible in the depth between 20 and 70cm and appears as reflecting anomaly in the northern part and absorbing anomaly in the southern part. The structure is interpreted as the fragments of a ring ditch of a burial mound. The appearance indicates that the entire mound is destroyed and only the ring ditch is preserved.

Mound 3

In the south western part of the measurement area a fragmented circular feature with an outer dimension of c. 10m and a width of c. 1m can be observed. It is visible in the depth between 30 and 50 cm and appears as reflecting anomaly. The structure is interpreted as the fragments of a ring ditch of a possible burial mound. The appearance indicates that the entire mound is destroyed and only the ring ditch is partly preserved.

Mound 4

In the southern more central part of the measurement area a fragmented circular feature with an outer dimension of c. 5m and a width of c. 0,4m can be observed. It is visible in the depth between 20 and 50cm and appears as absorbing anomaly. Directly connected to this feature a partly circular reflective anomaly is visible at the same depths. The structures are interpreted as the fragments of a ring ditch and parts of a burial mound construction. An interesting aspect is that from ca 60-80cm depth the anomalies disappear in the GPR slices. And beginning from 80cm depth another round feature with a diameter of 4m appear under the center of the mentioned mound. This circular anomaly appears as strong reflective signal in the GPR data and goes down to a depth of c. 200cm and reduces its diameter with greater depth. The structure is interpreted as a possible stone packing or even a chamber grave connected to the over ploughed grave mound.

Mound 5

In the south - eastern part of the measurement area a fragmented circular feature with an outer dimension of c. 7,5m and a width of approximately 0,5-1m can be observed. It is visible in the depth between 20 and 50cm and appears as absorbing anomaly. The structure is interpreted as the fragments of a ring ditch of a possible burial mound. The appearance indicates that the entire mound is destroyed and only fragments of the ring ditch are preserved.

Possible house

In the south - western part of the measurement area a bent linear feature with a width of 0,5m is visible. Due to its form it could be a possible fragmented wall fundament from a house. As the feature is rather weak visible in the data it is a relative unsecure interpretation.

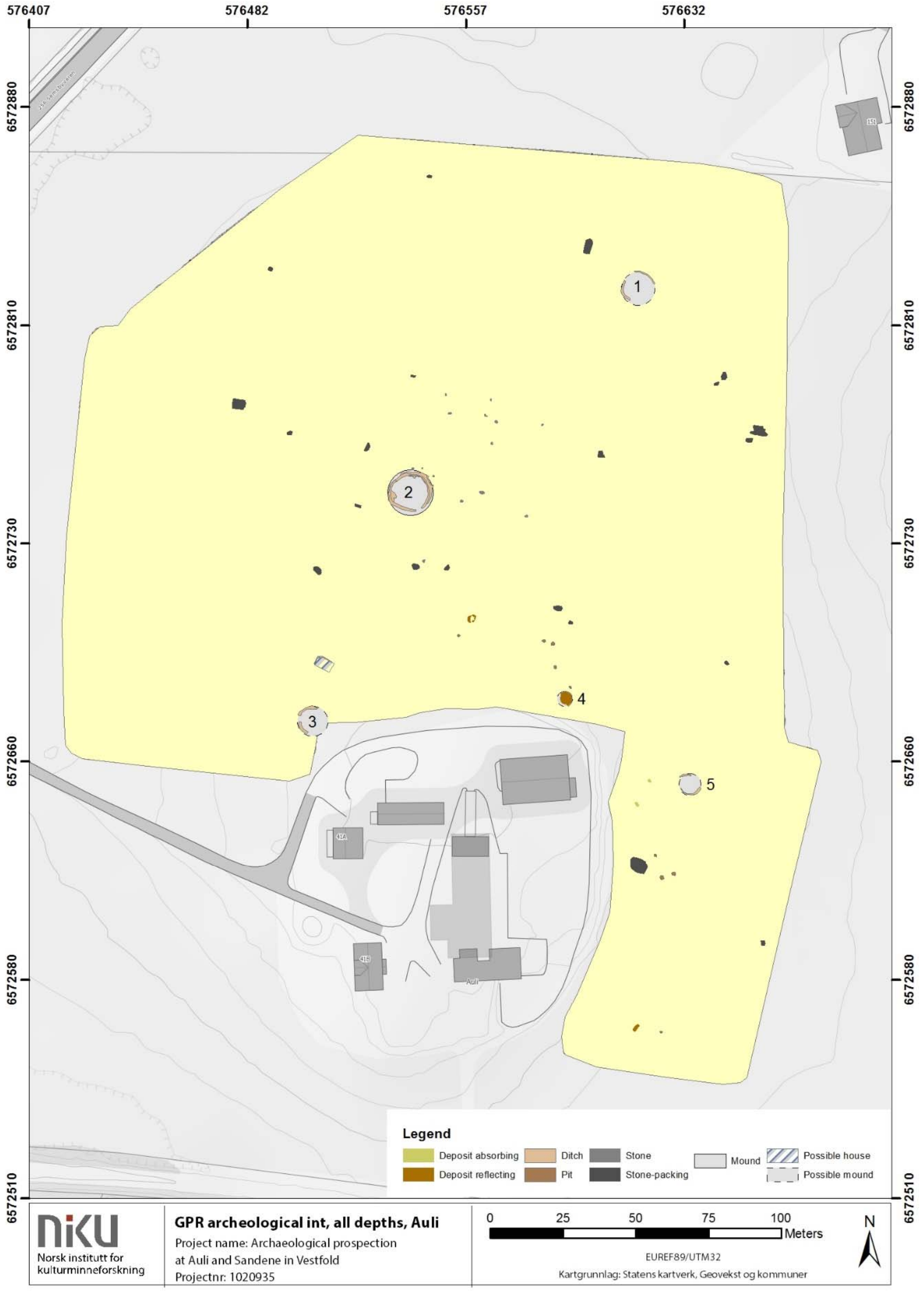


Figure 10: GPR interpretation of archaeological features from all depth slices at Auli. Map source: Norge I Bilder, Geovekst.

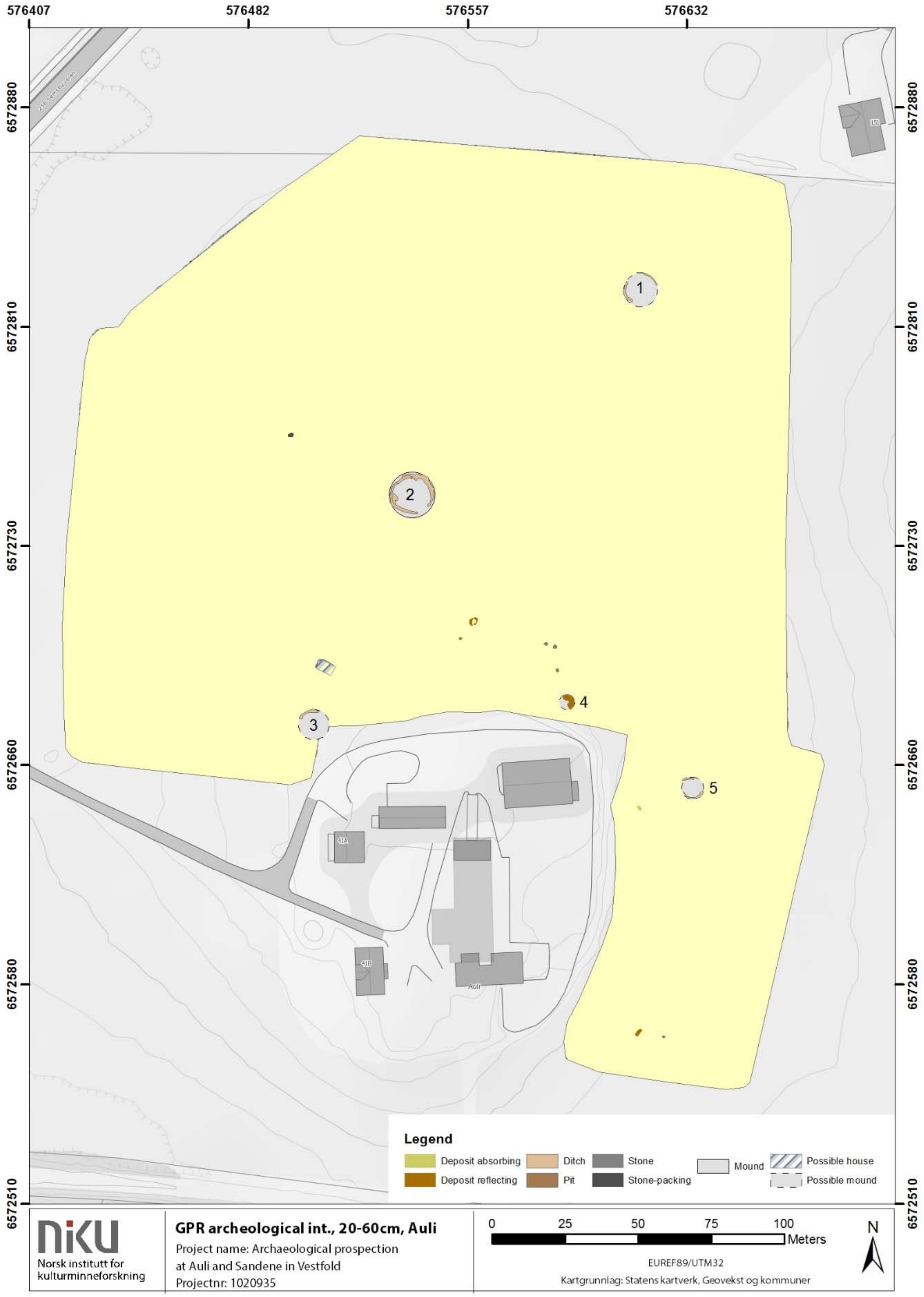


Figure 11: GPR interpretation of archaeological features from 20-60cm depth at Auli. Map source: Norge I Bilder, Geovekst.

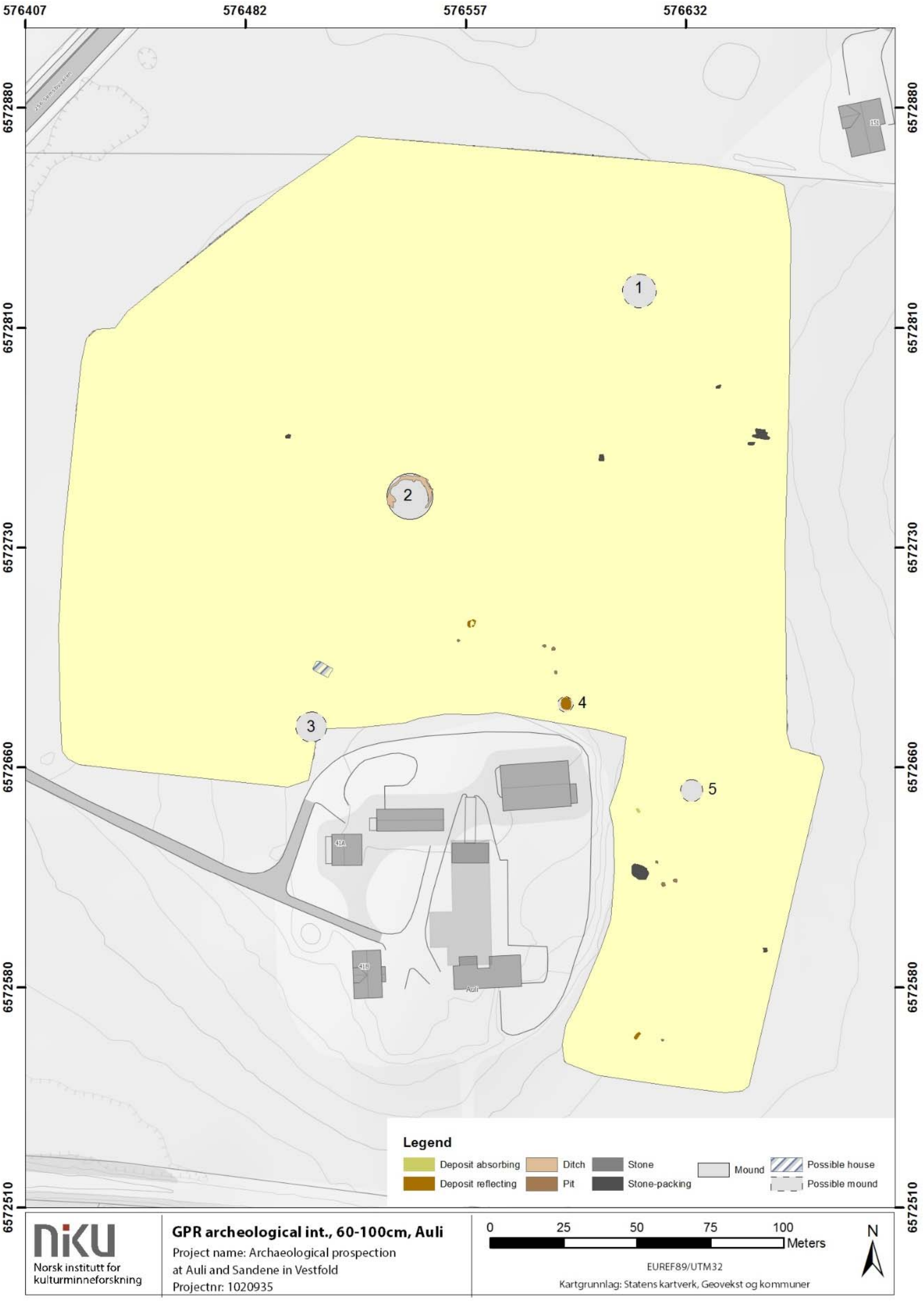


Figure 12: GPR interpretation of archaeological features from 60-100cm depth at Auli. Map source: Norge I Bilder, Geovekst.

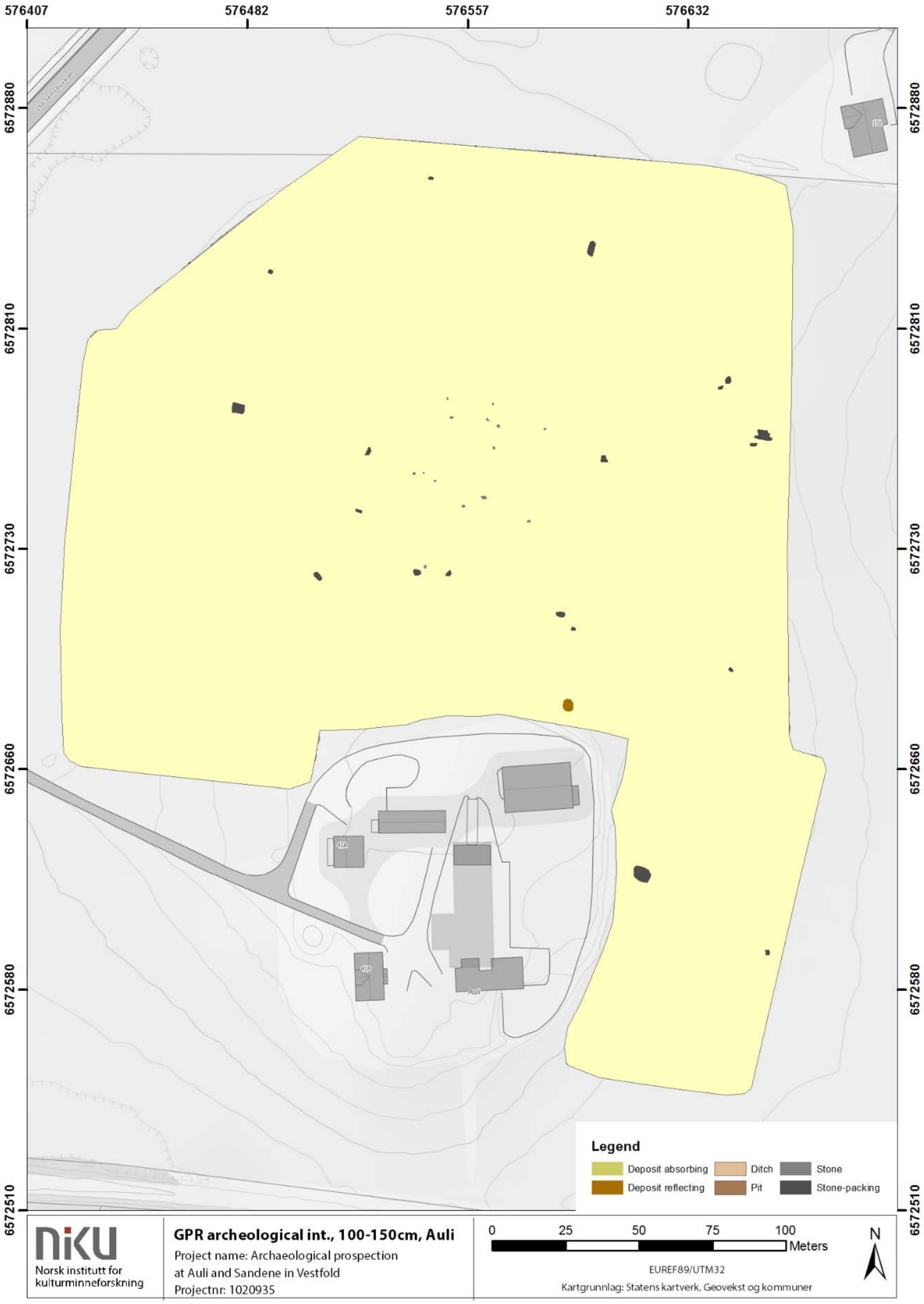


Figure 13: GPR interpretation of archaeological features from 100-150cm depth at Auli. Map source: Norge I Bilder, Geovekst.

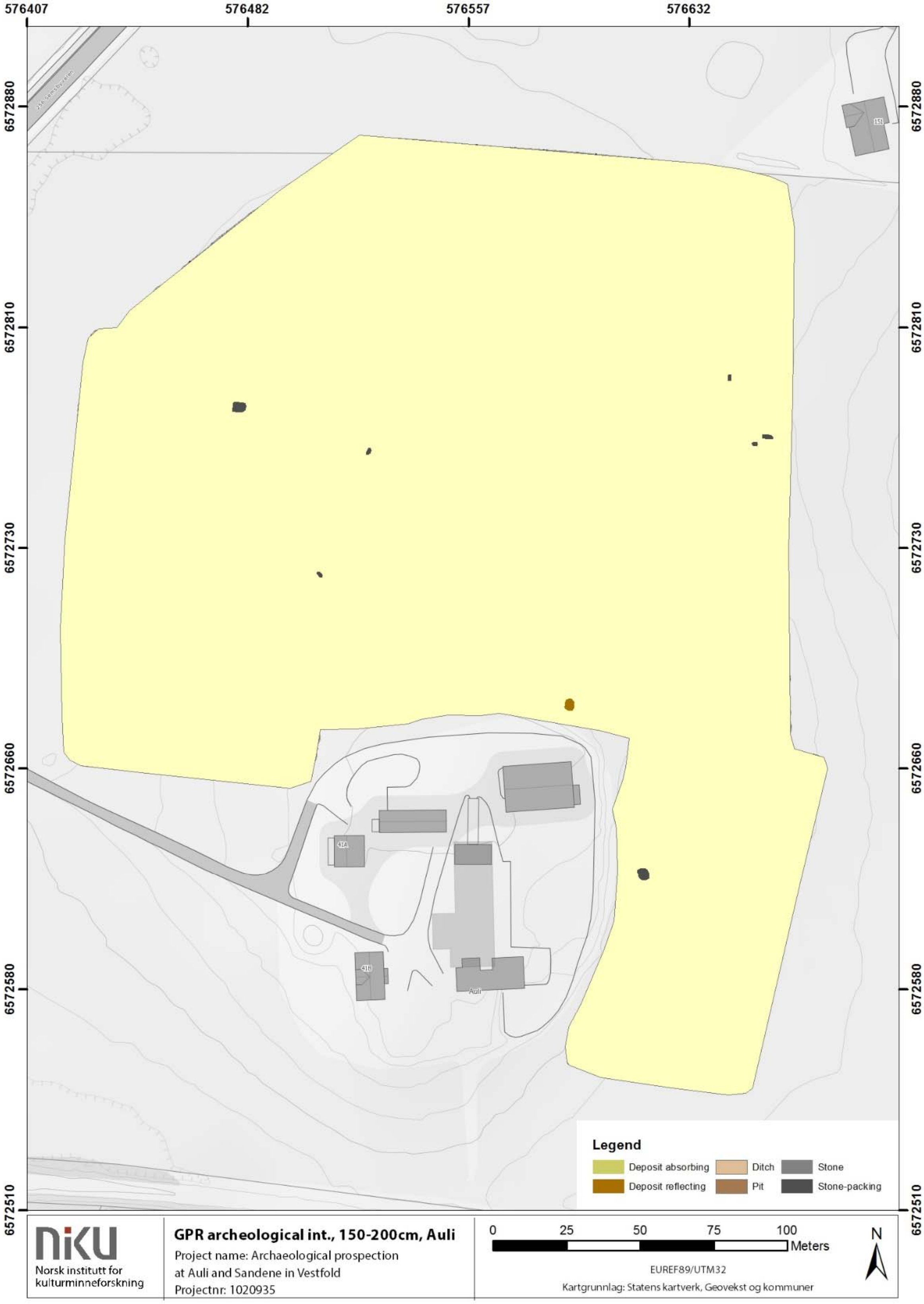


Figure 14: GPR interpretation of archaeological features from 150-200cm depth at Auli. Map source: Norge I Bilder, Geovekst.

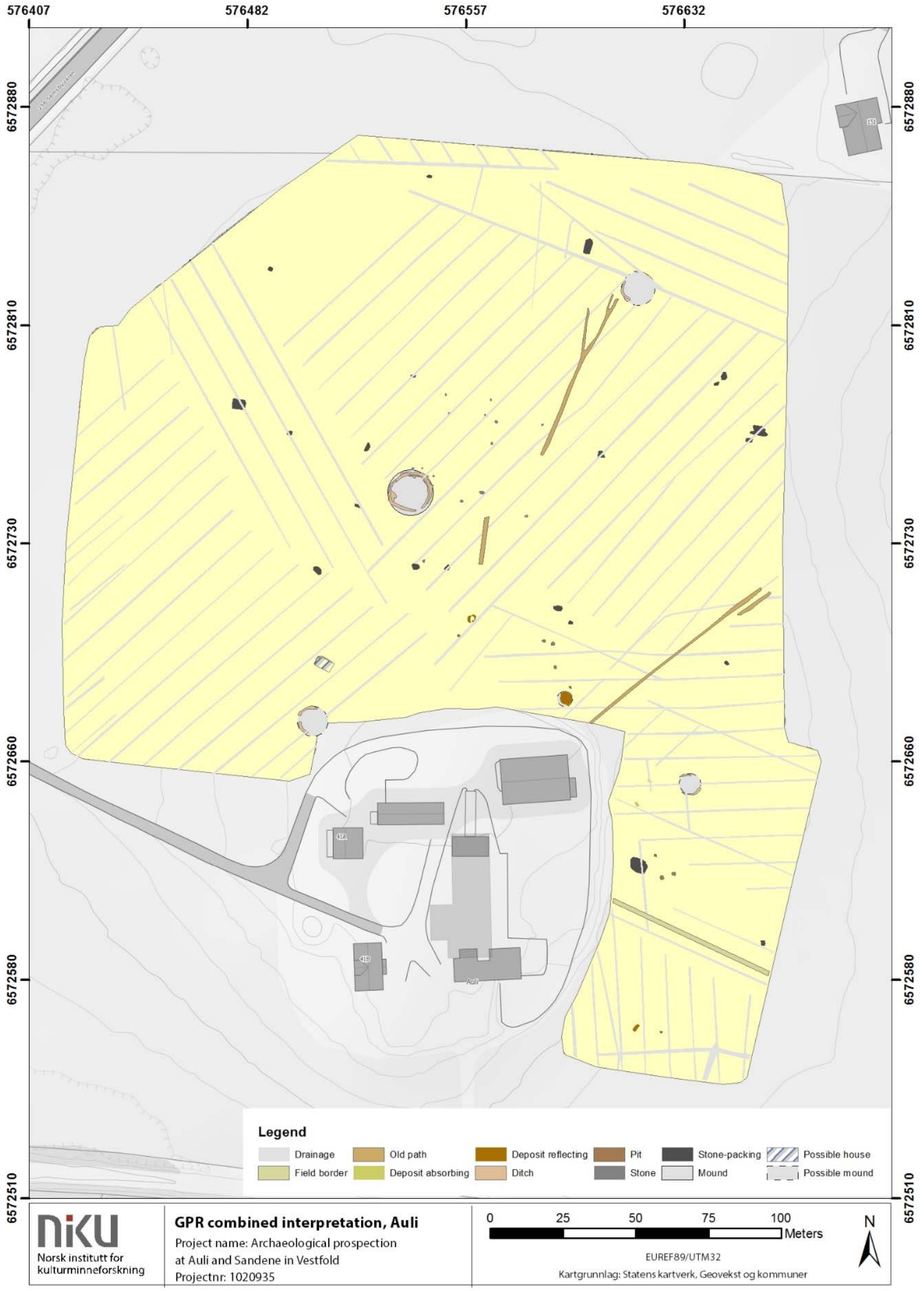


Figure 15: GPR interpretation of all features at Auli. Map source: Norge I Bilder, Geovekst.

5.2 Sandene

5.2.1 Palaeoenvironmental observations

The geological background in the area are maritime beach deposits consisting of silty fine sandy soil. In the western part of the measurement area the remains of a palaeochannel cut into the marine sediment can be observed in c. north-south direction. The geological background appears in the GPR data as very thin alternating reflective and absorbing bands which change their position gently with increasing depth. At the northern and south western end of the prospected area the appearance of the GPR appearance of the geology changes and larger areas of absorbing and reflecting material are overlaying the maritime sediment in irregular pattern.

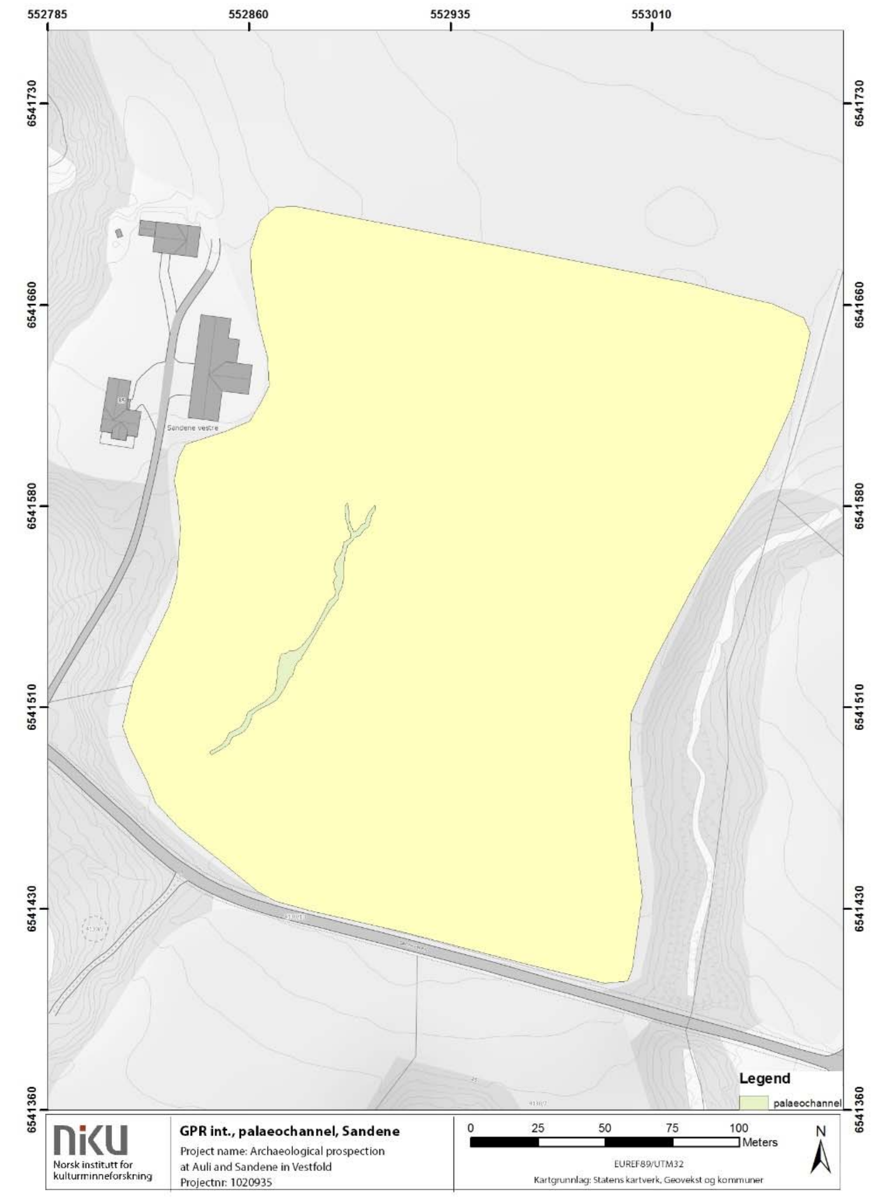


Figure 16: GPR interpretation of an palaeochannel at Sandene. Map source: Norge I Bilder, Geovekst.

5.2.2 Modern features

A large number of straight linear features can be observed all across the investigated area. These features generally appear at a depth between 30 and 140cm, but are most distinguishable at a depth of c. 70–100cm. Most of them show a two-way appearance: At a depth of c. 30-60cm they show absorbing properties, displayed as white or light grey in the depth-slices. In the lower slices they switch to reflective properties displayed in dark grey or black. Due to their appearance and spatial distribution these features are interpreted as drainage diches and pipes. Another linear feature with a width of c. 1m is visible in the southern part in a depth of ca. 40-100cm running southwest-northeast. It is interpreted as an older path or hollow way.

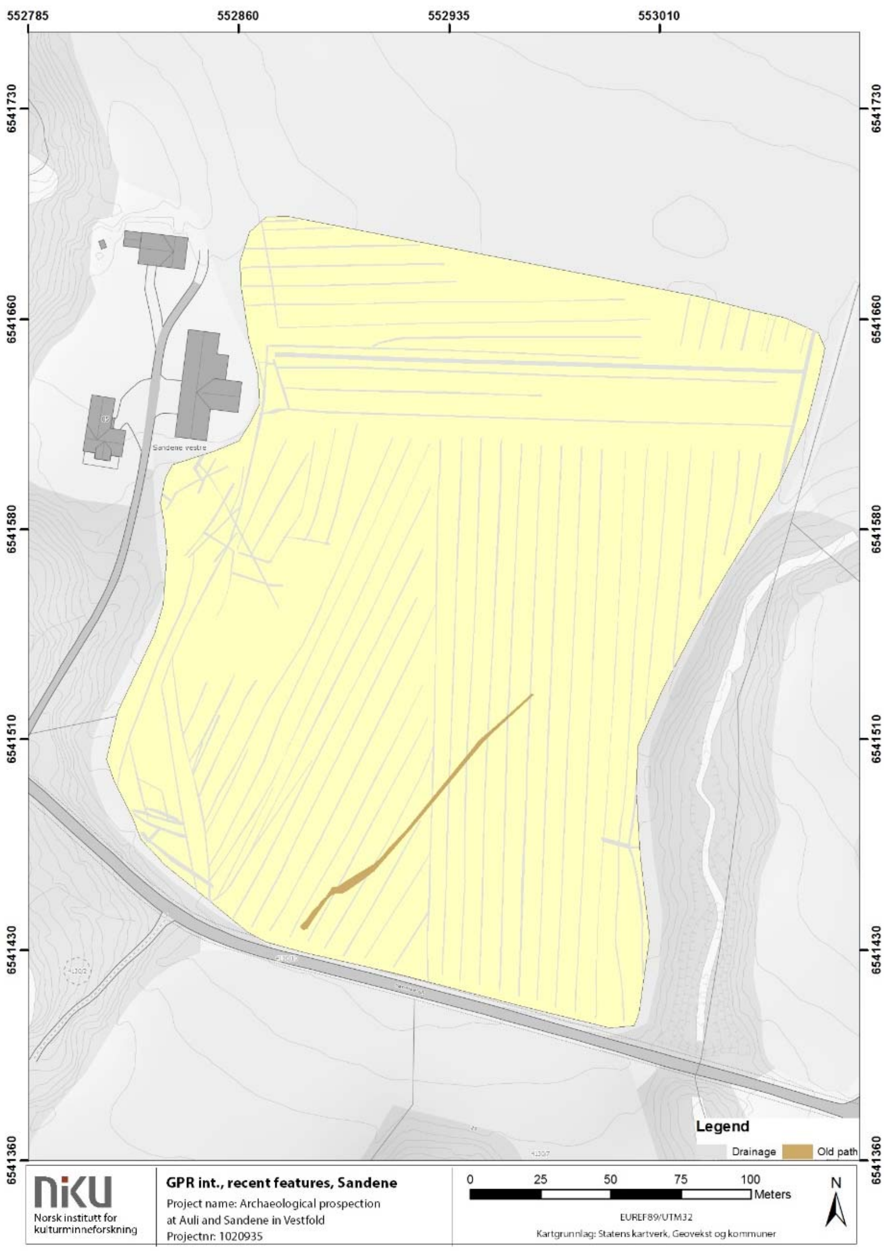


Figure 17: GPR interpretation of modern features at Sandene. Map source: Norge I Bilder, Geovekst.

5.2.3 Archaeology

Burial mounds

At the western part of the measurement area, 11 circular features with a width of ca 0,5-1m could be observed. Most of them are visible in a depth of 20-50 cm and a few go even deeper down to 80cm. They appear partly absorbing and partly as reflecting features and have diameters from 6,4 to 15,5m. The structures are interpreted as the fragments of ring ditches of burial mounds. The appearance indicates that the entire mounds are destroyed and only the ring ditches are partly preserved.

Within mound 6, 7 and 8 structures are visible. On the eastern end of mound 6 a very prominent rectangular feature with a size of 4,4x2,4 m appears from 50-150cm depth. It is visible as reflecting anomaly. A pipe or drainage is ending at this feature visible in depths of 50-80cm. The appearance of the feature indicates it as possible stone structure. Due to position and structure this feature can be a possible chamber grave but also parts of a former building as closer described further down. In mound 7 a very prominent circular feature with a diameter of 3,5m appears from 20-220cm depth. From 20-100cm depth it is visible as changing absorbing and reflecting anomaly. From 100cm down it is visible as strong reflective anomaly. Due to position and structure this feature can be a possible chamber grave. In mound 8 two round reflective anomalies in the eastern part of the mound are visible. They have a diameter of ca. 0,8m and are visible in the depth from 20-50cm. They are interpreted as pits probably connected to the over ploughed mound.

In the central northern part of the prospected field two additional fragmented circular features with a width of 0,5m are visible (mound 12 and 13). The show a rather weak contrast and appear at a depth from 20-50cm as partly reflective and partly absorbing feature with a diameter of c. 7,7 and 10m. The structures are interpreted as the fragments of ring ditches of a possible burial mound. The appearance indicates that the mounds are destroyed and only the ring ditches are partly preserved.

Stone packings

In the western area within the grave mounds 5 bigger reflective anomalies are visible. It shows that all of them go rather deep. The start partly from 20cm and go down to 220cm depth. Their forms are circular, rectangular and one is clearly L-shaped. They all are very prominent features and are visible in great depths. Due to their appearance in the GPR data they are consisting most probably of stones and therefore are mapped as stone packings. The most south and the most east one are situated within over ploughed mounds (mound 6 and 7) and are already described above. The L-shaped and the rectangular one in the east are probably connected with a drainage or pipe. From older aerial images it is known that over these two features a building, belonging to a saw mill, was situated (Fig.18). Nevertheless, regarding the landowner no basement installations are known from that buildings. Also the buildings do not show any other remains in the GPR data which indicate that they were built on plates above the ground and did not disturb the underground layers. A clear archaeological interpretation is therefore tricky. It could be modern remains from the older buildings or it could also be possible chamber graves within the burial mound field.

Possible houses

In the north-eastern part of the measurement area an area with different reflective anomalies are visible from 20-80cm depth. Several smaller round feature with a diameter of ca. 0,3-0,5 m can be observed. Their spatial distribution is following a slightly oval/rectangular structure. Larger reflective features are within that structure. The whole structure formed by these features has a size of c. 37x6,9m. The small round features can be interpreted as possible postholes while the larger features are possible floor levels. Although the features are partly poor visible in the GPR data they differ from the geological background. Due to their spatial distribution they are interpreted as possible remains of a house.

In the south-eastern part of the measurement area six round absorbing features with a diameter of c. 0,4-0,6m are visible from 20-75cm depth. They form a rectangular structure of 7,5x4,2m consisting of two more or less parallel rows of three features each in north-south direction. The round features are interpreted as postholes belonging to a house. Do to their size

Reflective anomalies

In the central-eastern part of the measured area a concentration for reflective anomalies can be observed which cut into the geological background. They appear from 50-150cm in an area of c. 37x20m. They do not form a significant structure which can be clear archaeological interpreted. Due to their irregular pattern they could be a geological phenomenon. Nevertheless, these anomalies correspond partly with older buildings known from the aerial images from 1956 (Fig.18). Therefore, it could also be an anthropogenic feature such as a waste deposit.

Pits

Over the whole measurement area several features with different size from 0,8m up to 3m can be observed. The appear as absorbing anomaly as well as reflecting anomaly in depths from 20-80cm. The features are clearly a disturbance of the natural layering in that area and are potentially caused by human activities. Some kind of archaeological pits (cooking pit, storage pit, etc.) are a conceivable interpretation. However, other rather recent human activities like stone extraction for clearance purposes could also cause such anomalies.

Ditch

In the southern part of the measurement area a large linear feature with a width of c. 1m can be observed from 20-150cm. From 20-80cm it appears as absorbing anomaly and further down it is visible as reflecting anomaly. It separates the area further south from the geological background and is interpreted as ditch. Large areas south of that ditch of both absorbing and reflecting material can be observed from 20-220 cm. Within that area some smaller anomalies can be differentiated such as possible pits and a stone packing. They are inhomogen and change their appearance with depth and do not form any clear archaeological structures. Nevertheless, an anthropogenic explanation might be reasonable. In that area several flattened stones are found by the farmer which might indicate older buildings. Therefore, the anomalies could result from human activities and are a possible cultural layer.

Figure 18: GPR interpretation of all features at Sandene, with an aerial image from 1956 at Sandene. The image shows the buildings belonging to an already removed saw mill which were situated on the measurement area. Map source: Norge I Bilder, Geovekst.

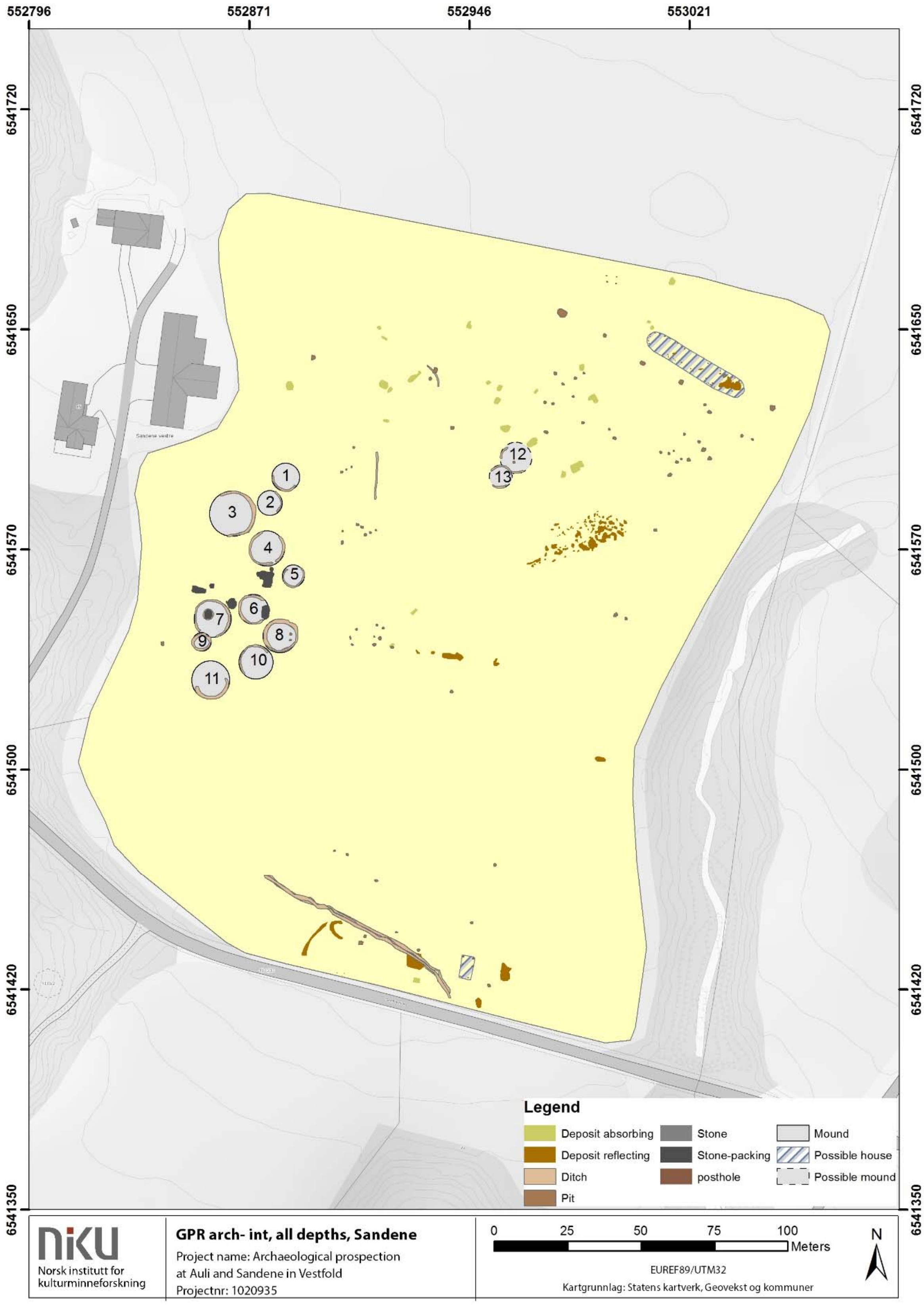


Figure 19: GPR interpretation of archaeological features from all depth slices at Sandene. Map source: Norge I Bilder, Geovekst.

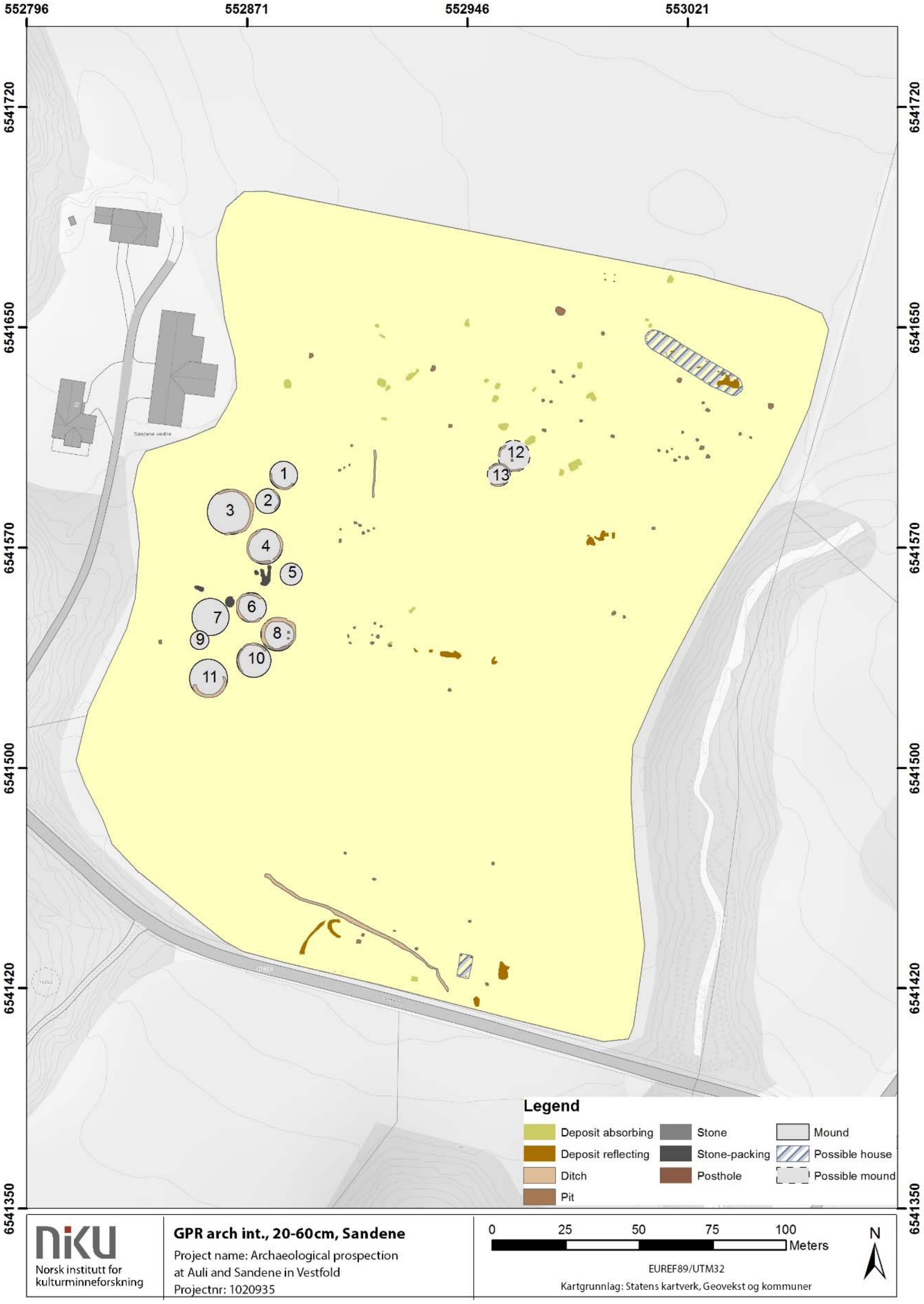


Figure 20: GPR interpretation of archaeological features from 20-60cm depth at Sandene. Map source: Norge I Bilder, Geovekst.

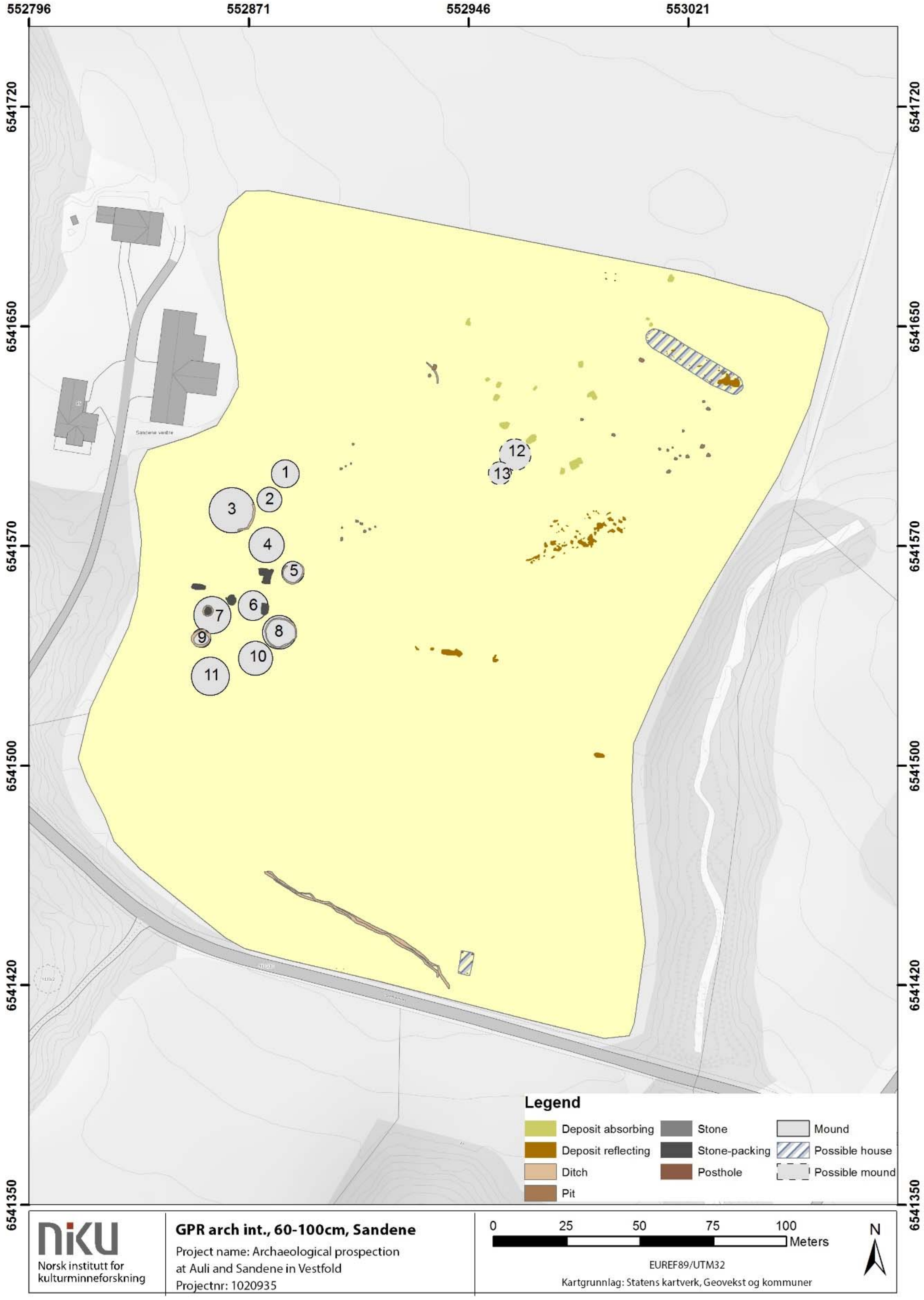


Figure 21: GPR interpretation of archaeological features from 60-100cm depth at Sandene. Map source: Norge I Bilder, Geovekst.

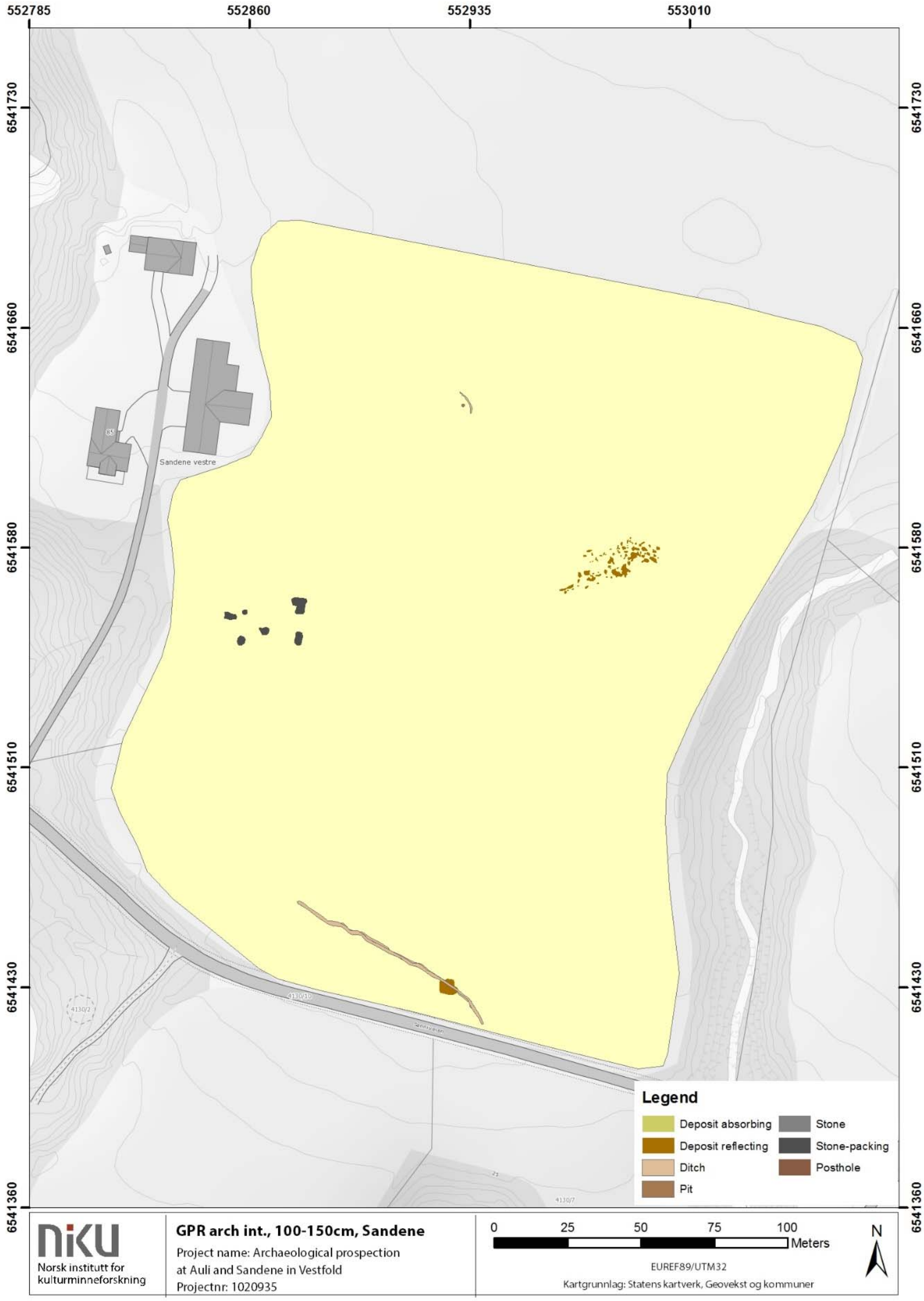


Figure 22: GPR interpretation of archaeological features from 100-150cm depth at Sandene. Map source: Norge I Bilder, Geovekst.

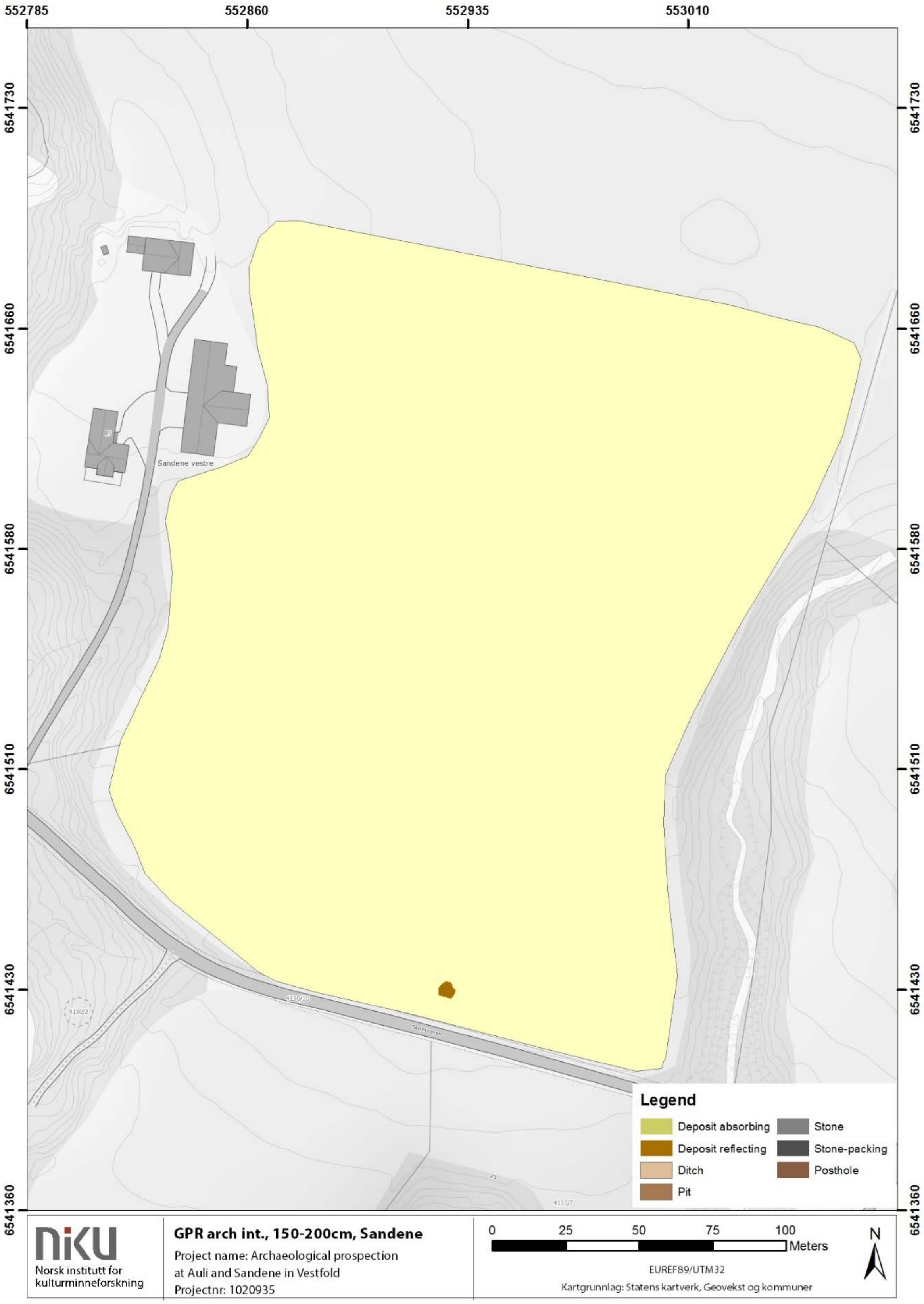


Figure 23: GPR interpretation of archaeological features from 150-200cm depth at Sandene. Map source: Norge I Bilder, Geovekst.

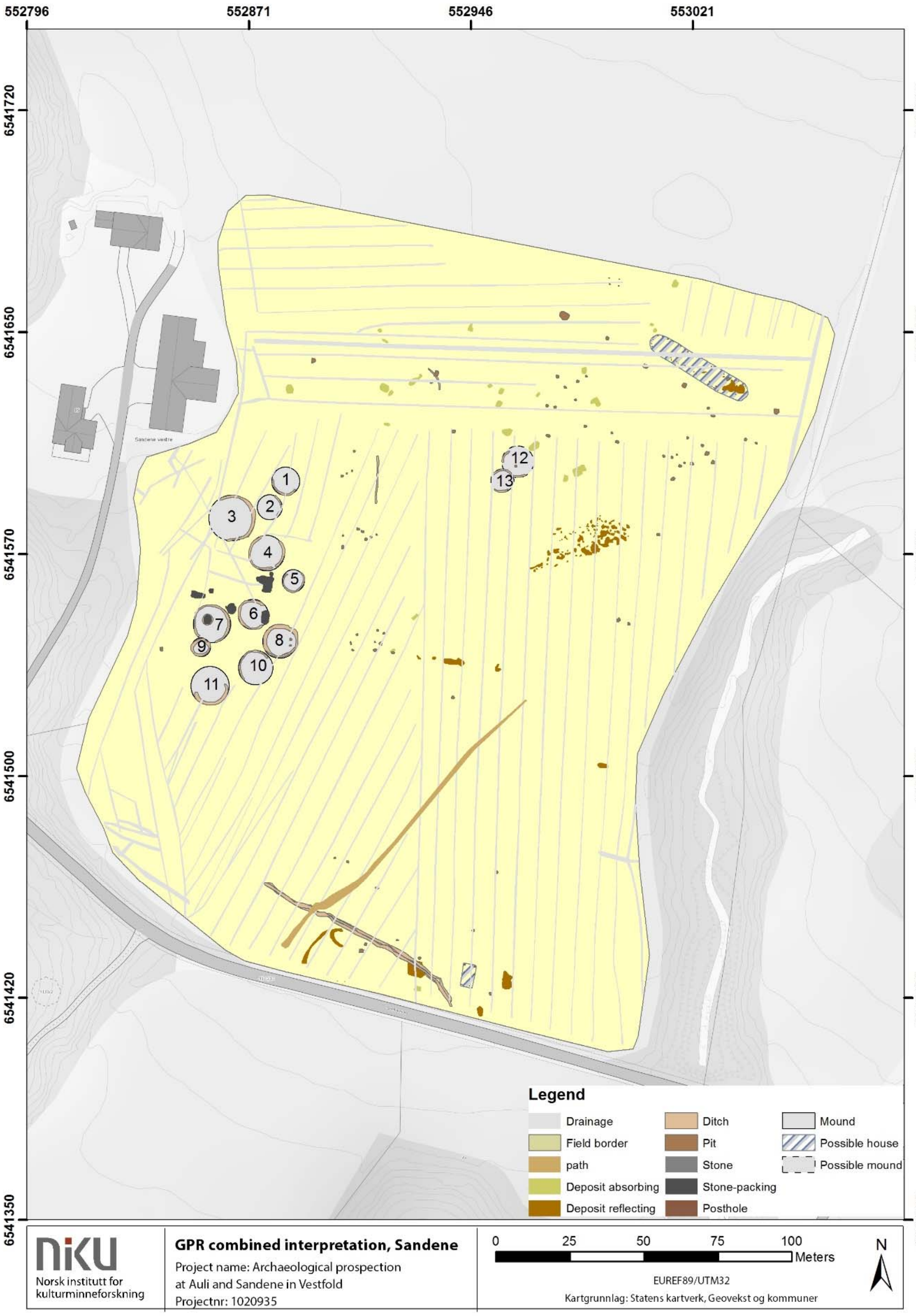


Figure 24: GPR interpretation of all features at Sandene. Map source: Norge I Bilder, Geovekst.

6 Conclusion

In general, the GPR investigations at Auli and Sanden provided good results, the depth-slice images are clear and the positioning is accurate. The large number of archaeological objects and structures, as well as the drainage ditches and pipes show that a strong contrast between the natural soil and human-made structures is present. The maximum reached depth-penetration of 2.5 m is showing good soil conditions for the chosen prospection technique. It shows that in both investigated areas the big amount of metal detector finds have highlight an area with many preserved archaeological remains in the ground. The GPR could map a large quantity of previous unknown archaeological features which gives a solid basis for further archaeological investigations. The detailed analyse of the GPR results with the metal detector finds is not part of this report and will be conducted by the Vestfold fylkeskomune.

Nevertheless, even without the detailed analysation of the metal detector finds this project shows the high potential of combining metal detecting with archaeological geophysical prospection methods. As both methods are working on different physical principles they deliver complementary results. Combining both methods deliver a better knowledge of the site. While GPR can map archaeological features under the surface very efficient the additional knowledge from the metal finds can be used for dating and or deliver a rough information about function and importance of the site.

7 Referanser

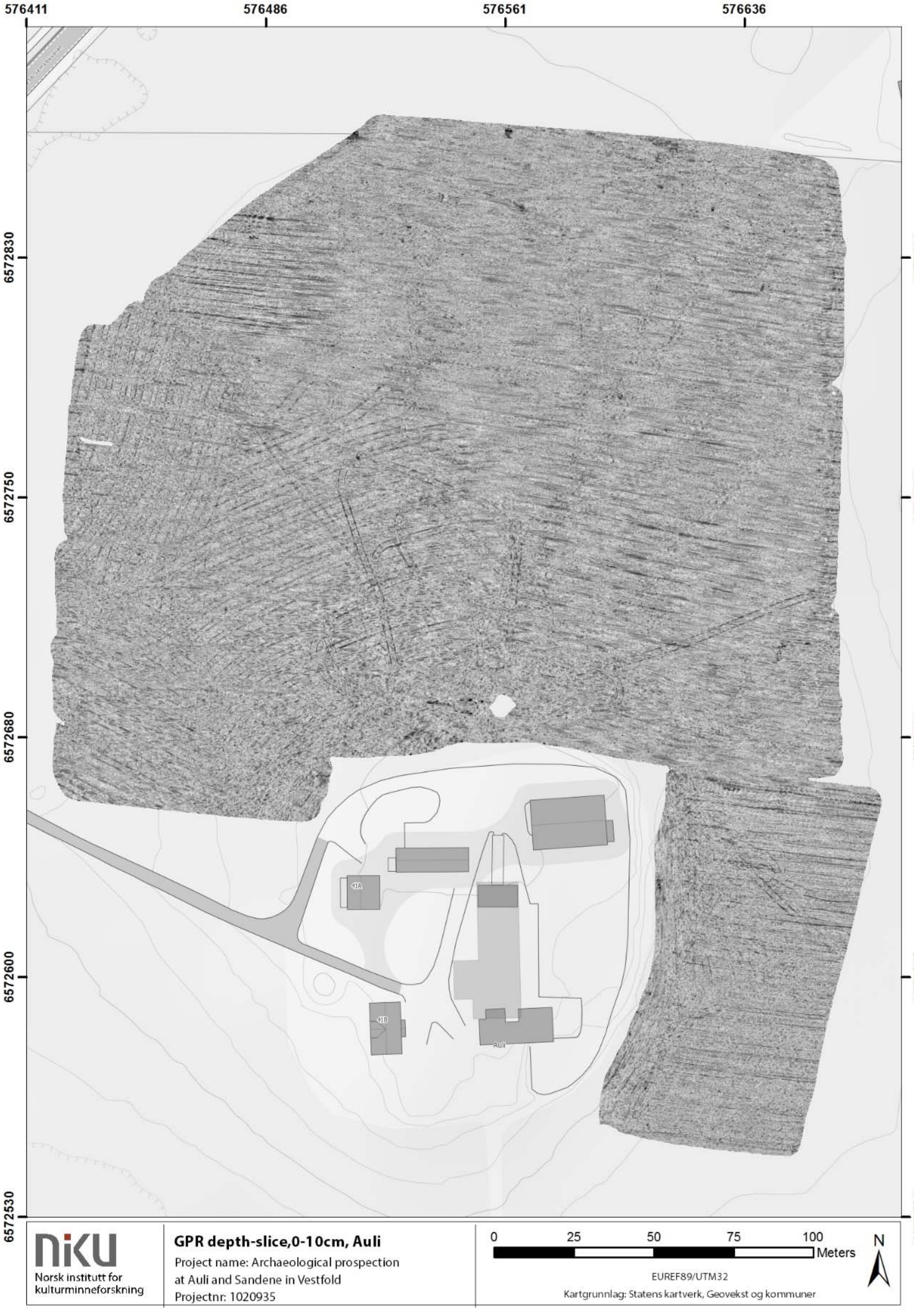
Conyers, L. B. 2012. *Interpreting Ground-penetrating Radar for Archaeology,* Walnut Creek, CA, Left Coast Press, Inc.

Gustavsen, L., Paasche, K. & Risbøl, O. 2013. Arkeologiske undersøkelser: En vurdering av nyere avanserte arkeologiske registreringsmetoder i forbindelse med vegutbyggingsprosjekter. *Statens vegvesens rapporter 192.* Oslo: Vegdirektoratet.

Kartkilder:

Statens kartverk: www.kartverket.no

8 Appendix: GPR depth-slices of 10 cm thickness

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GPR depth-slice,10-20cm, Auli
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Projectnr: 1020935
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Kartgrunnlag: Statens kartverk, Geovekst og kommuner

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GPR depth-slice,20-30cm, Auli

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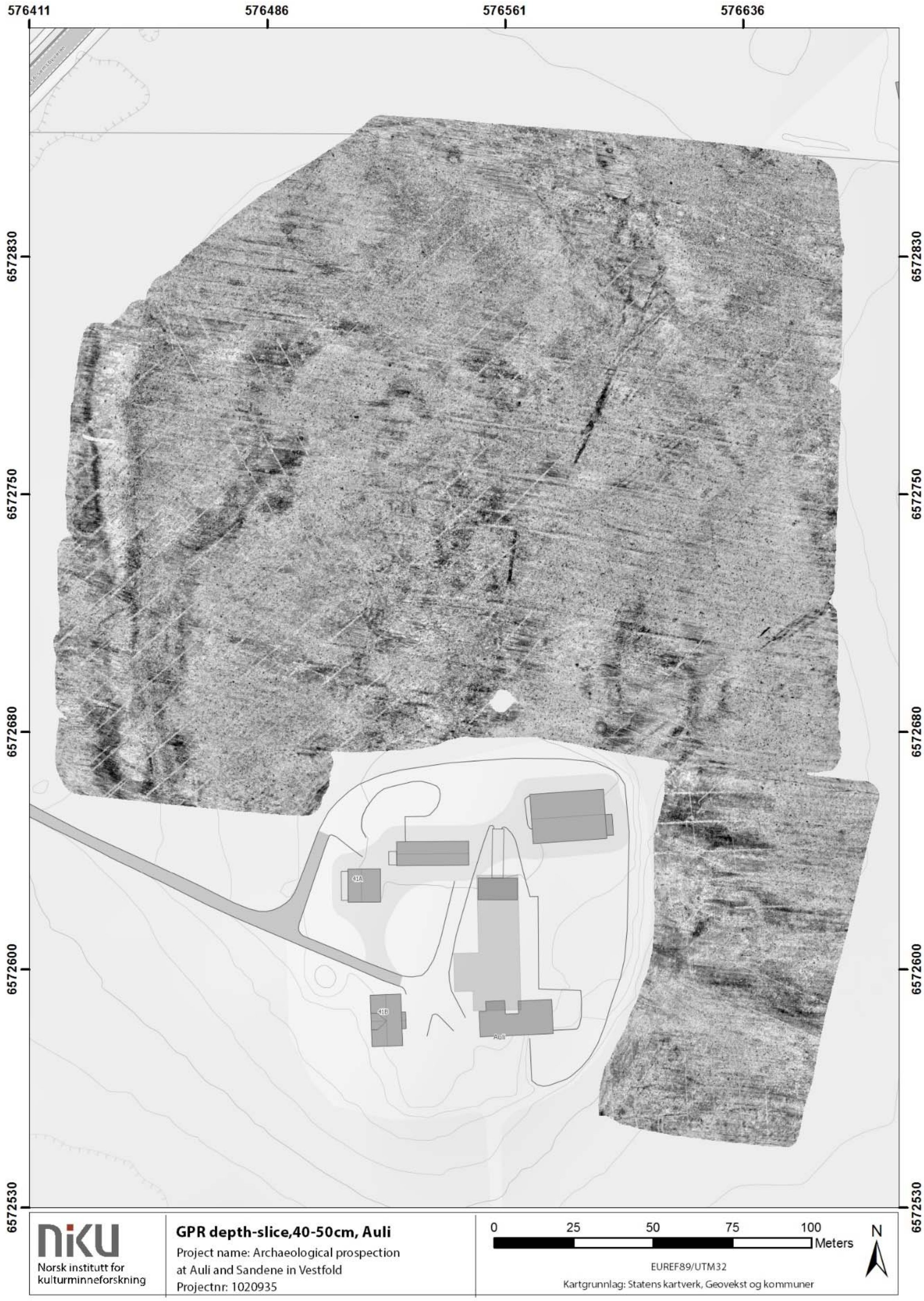
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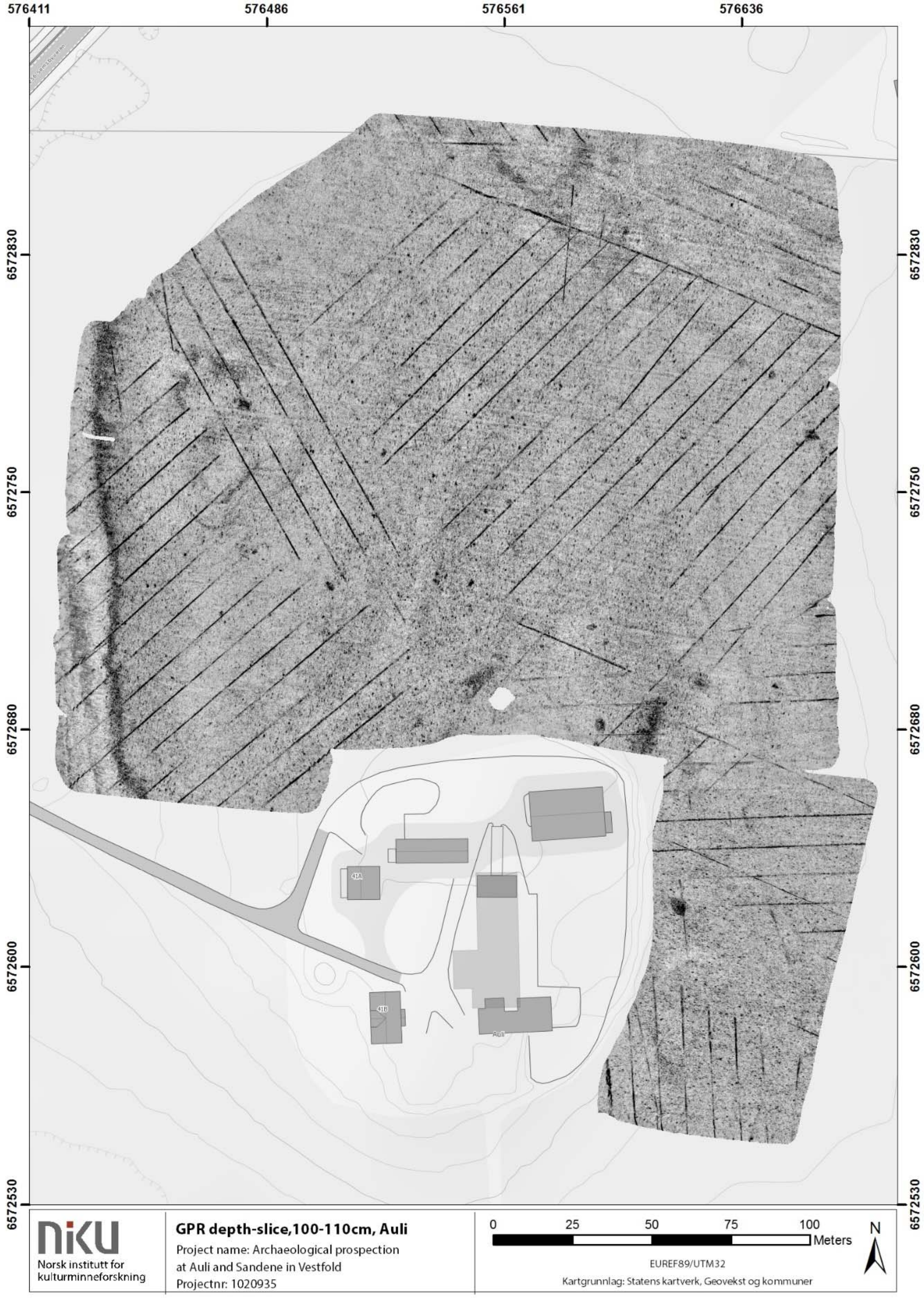
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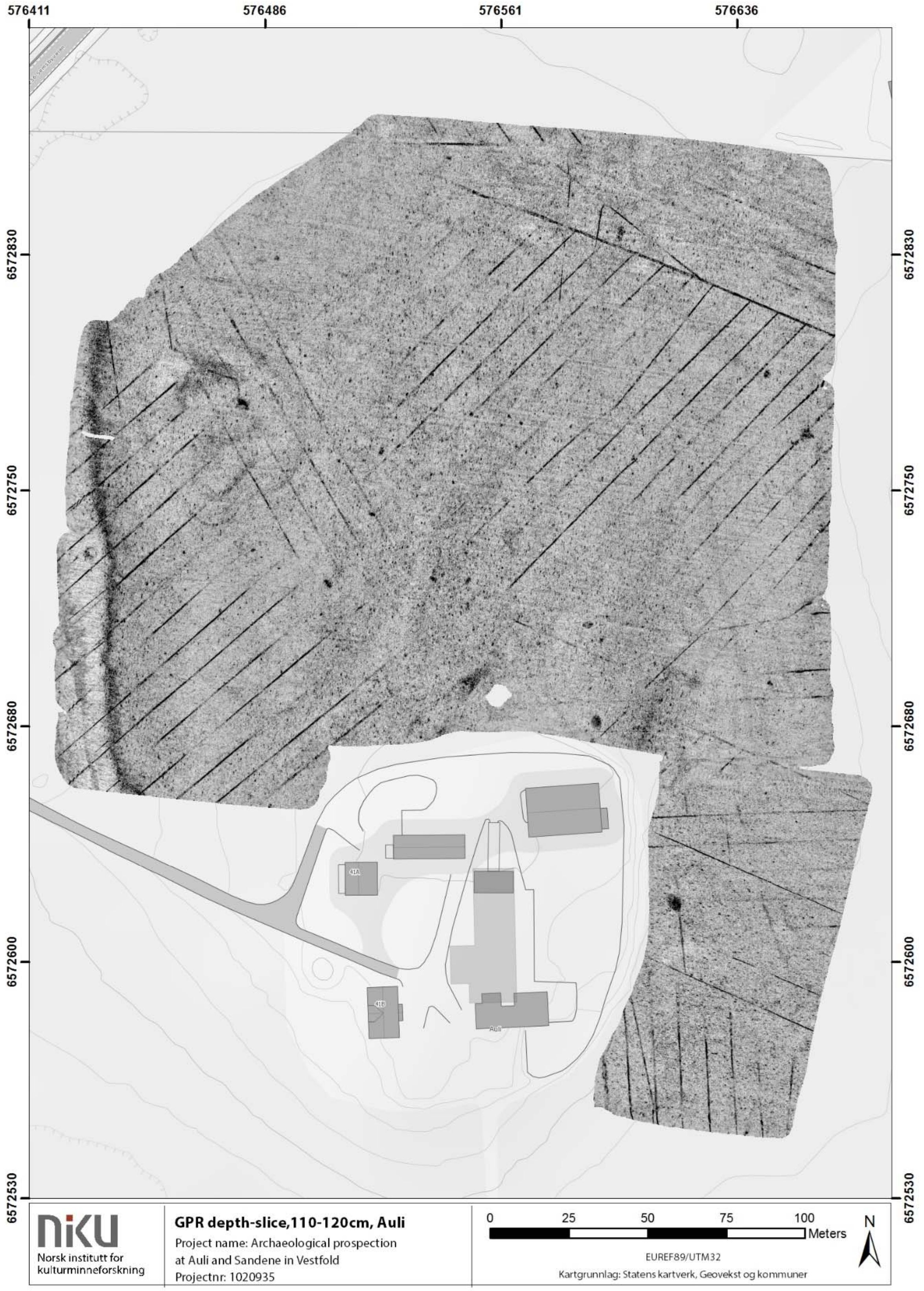
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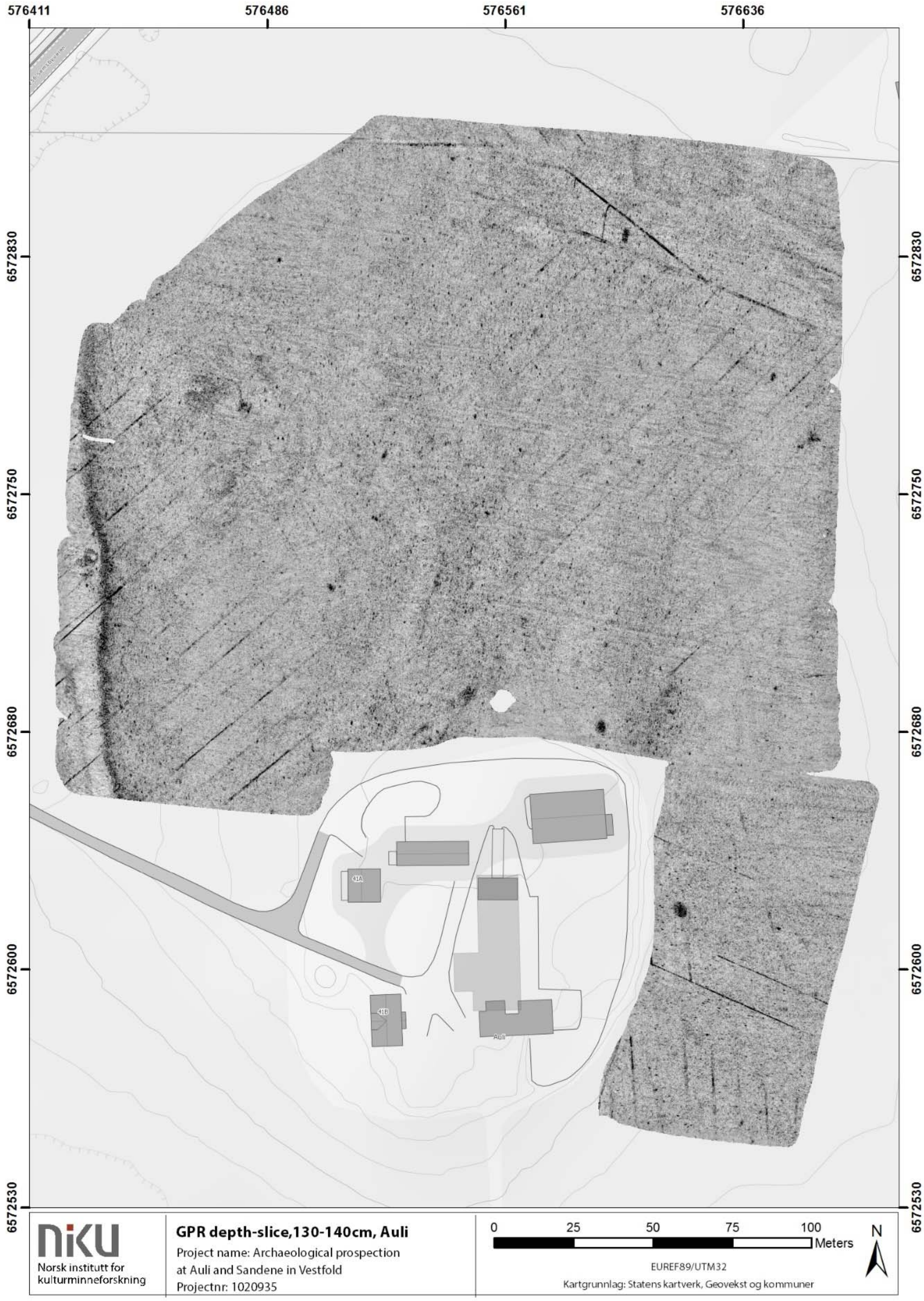
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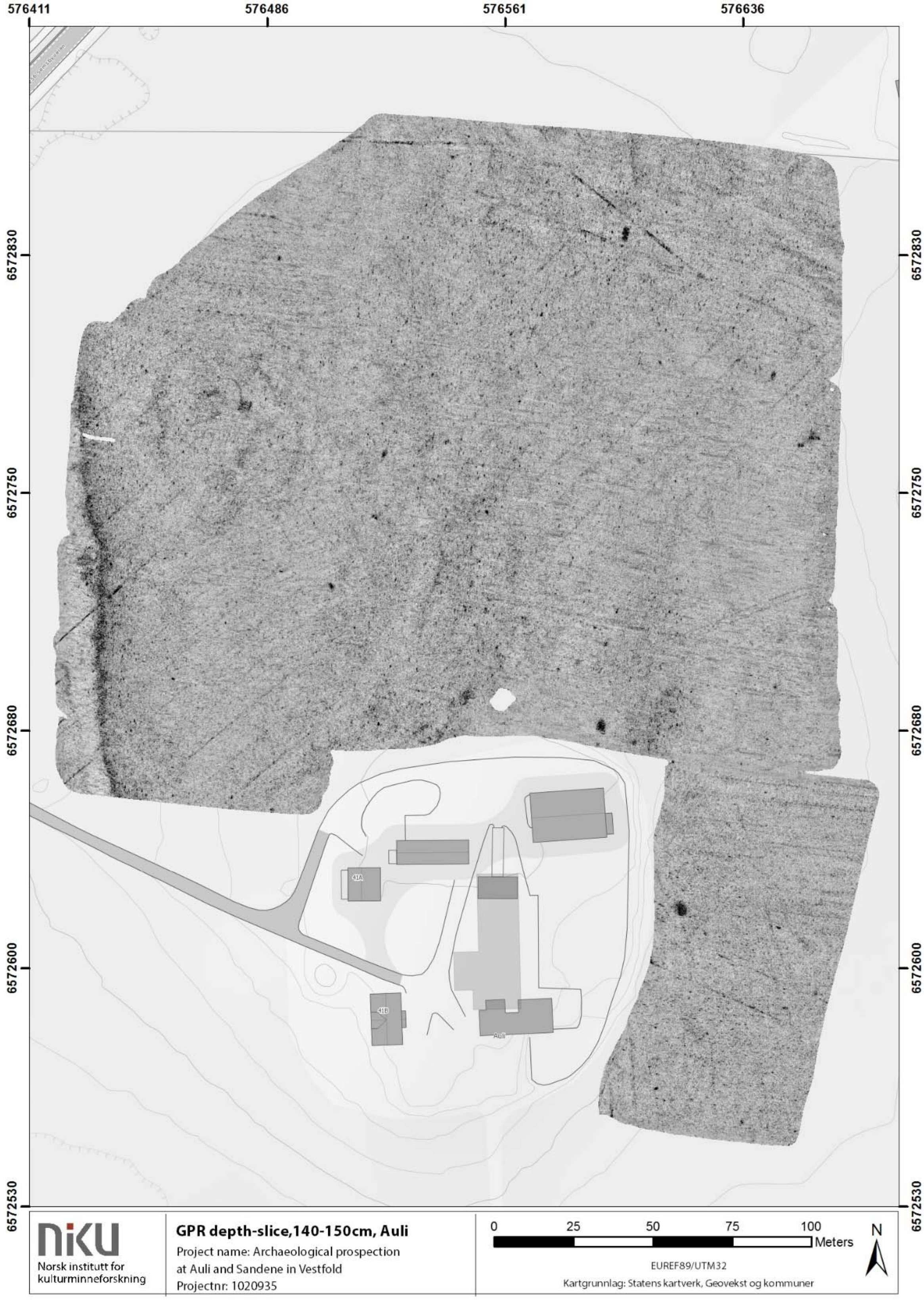
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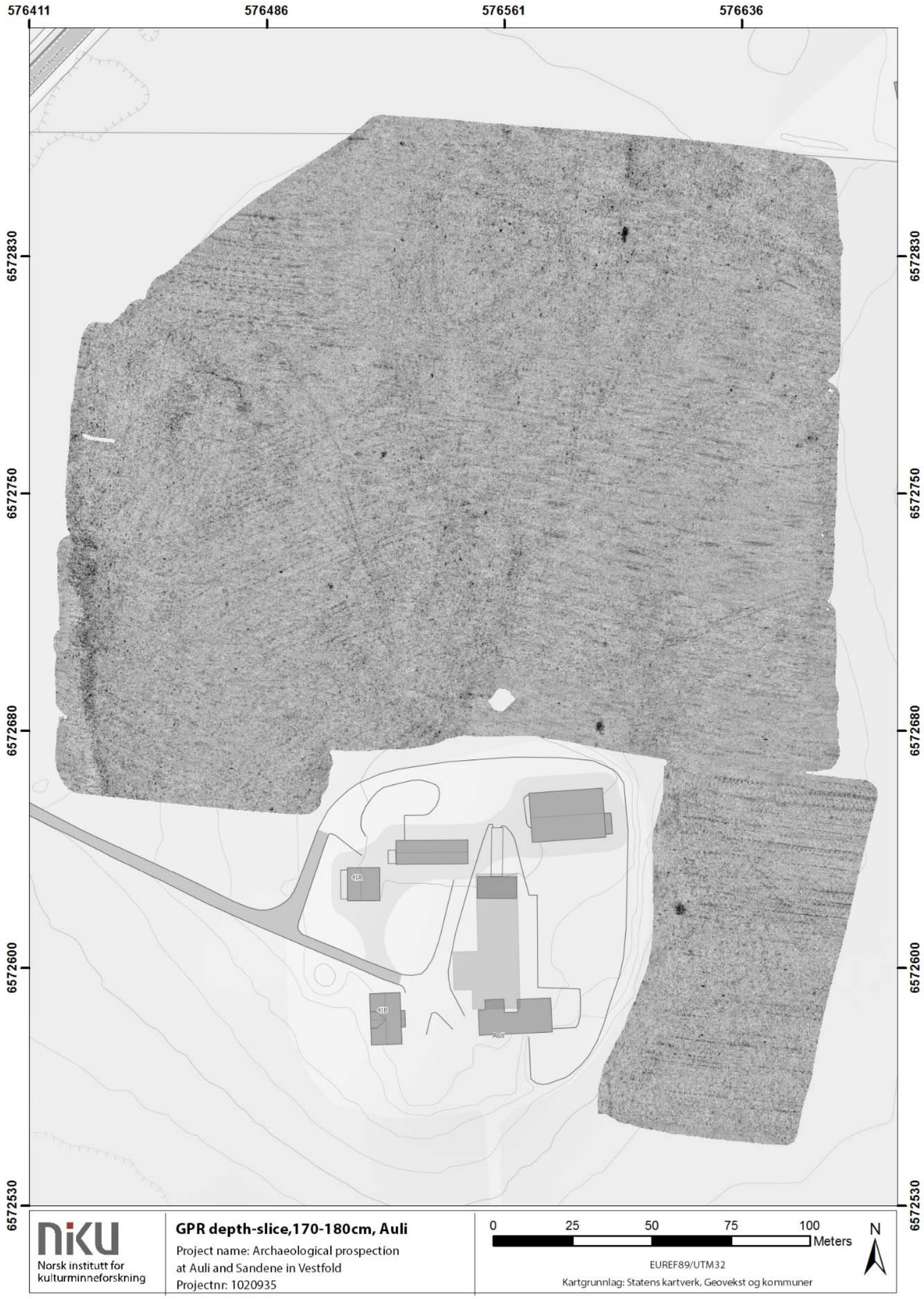
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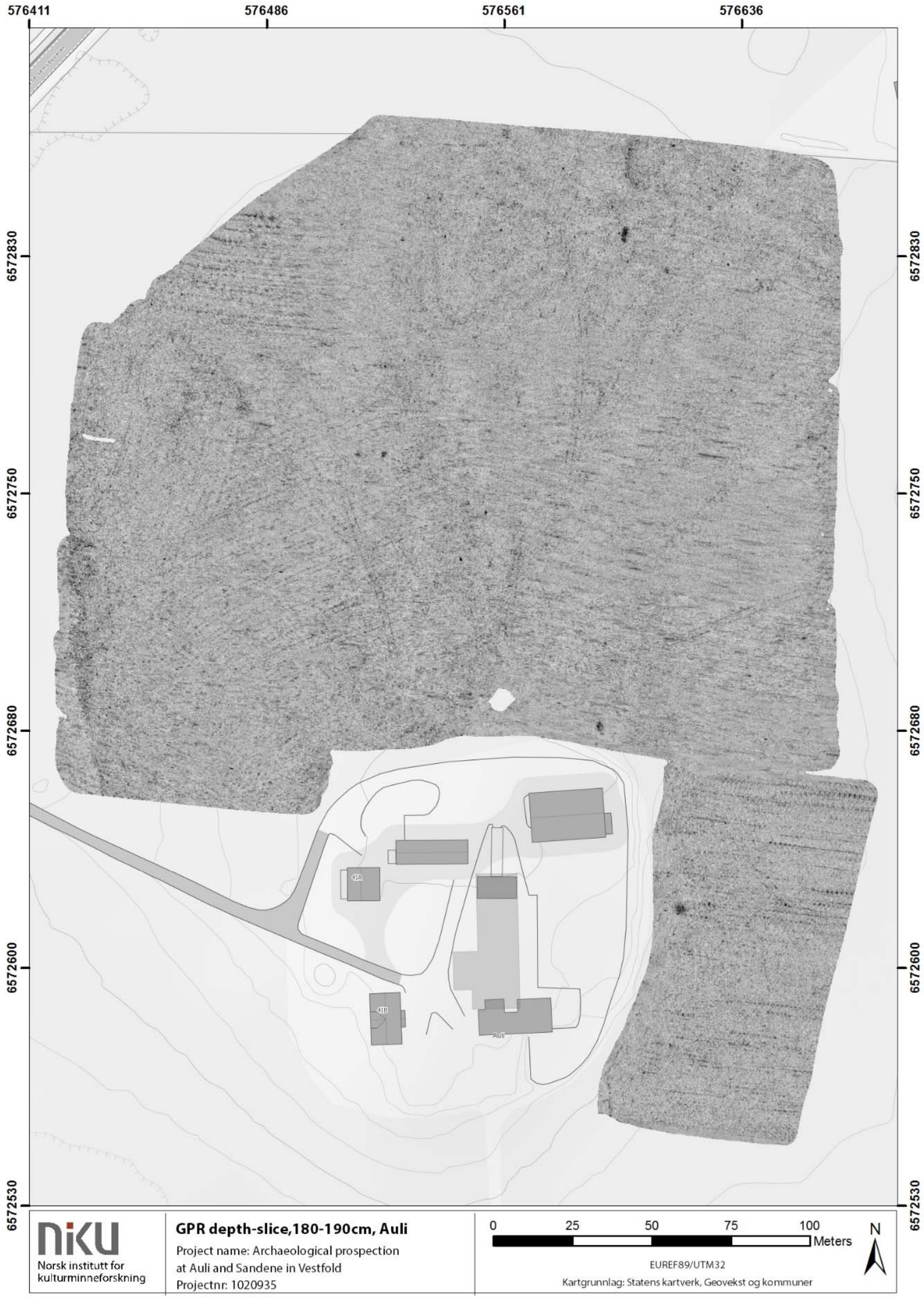
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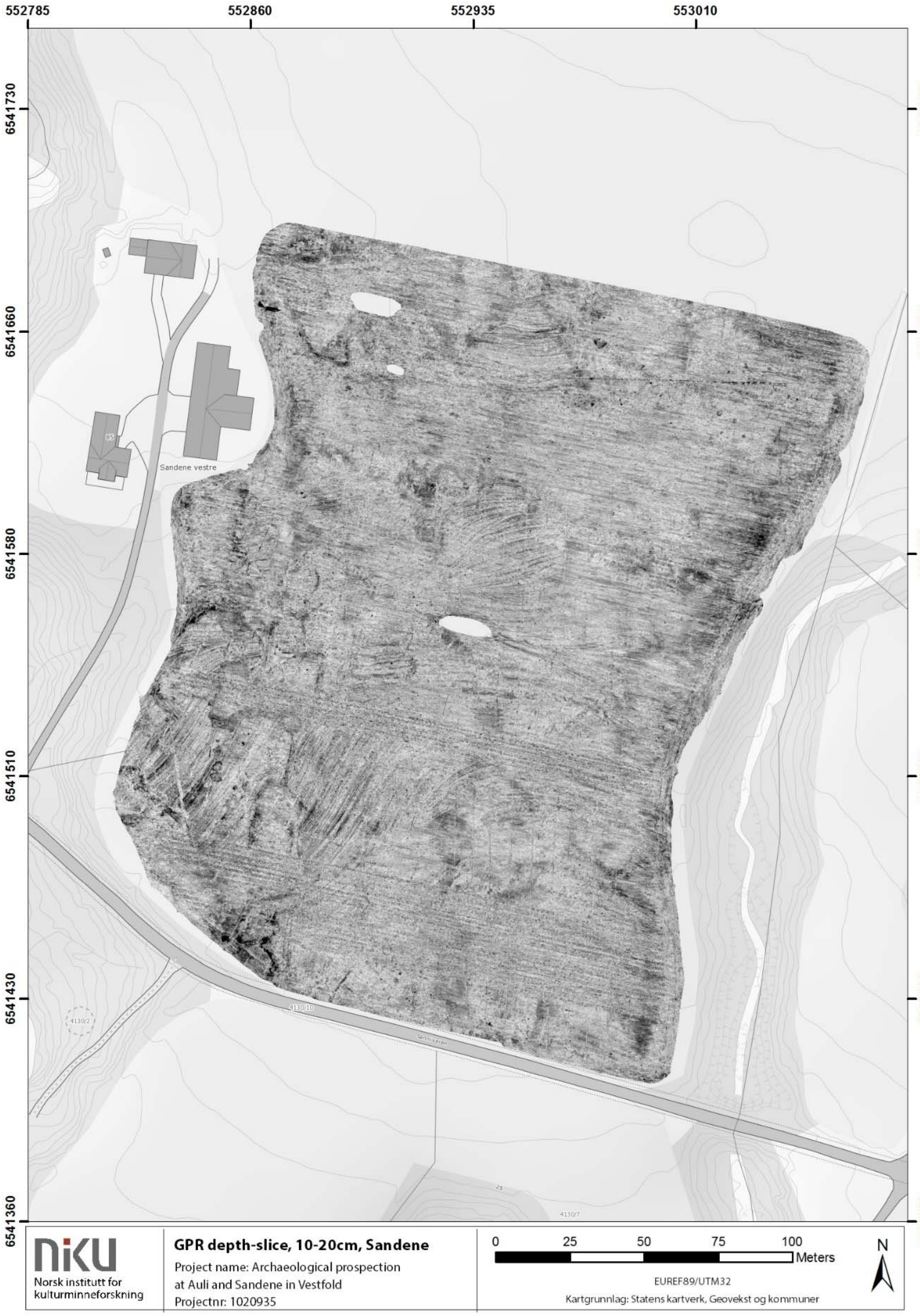
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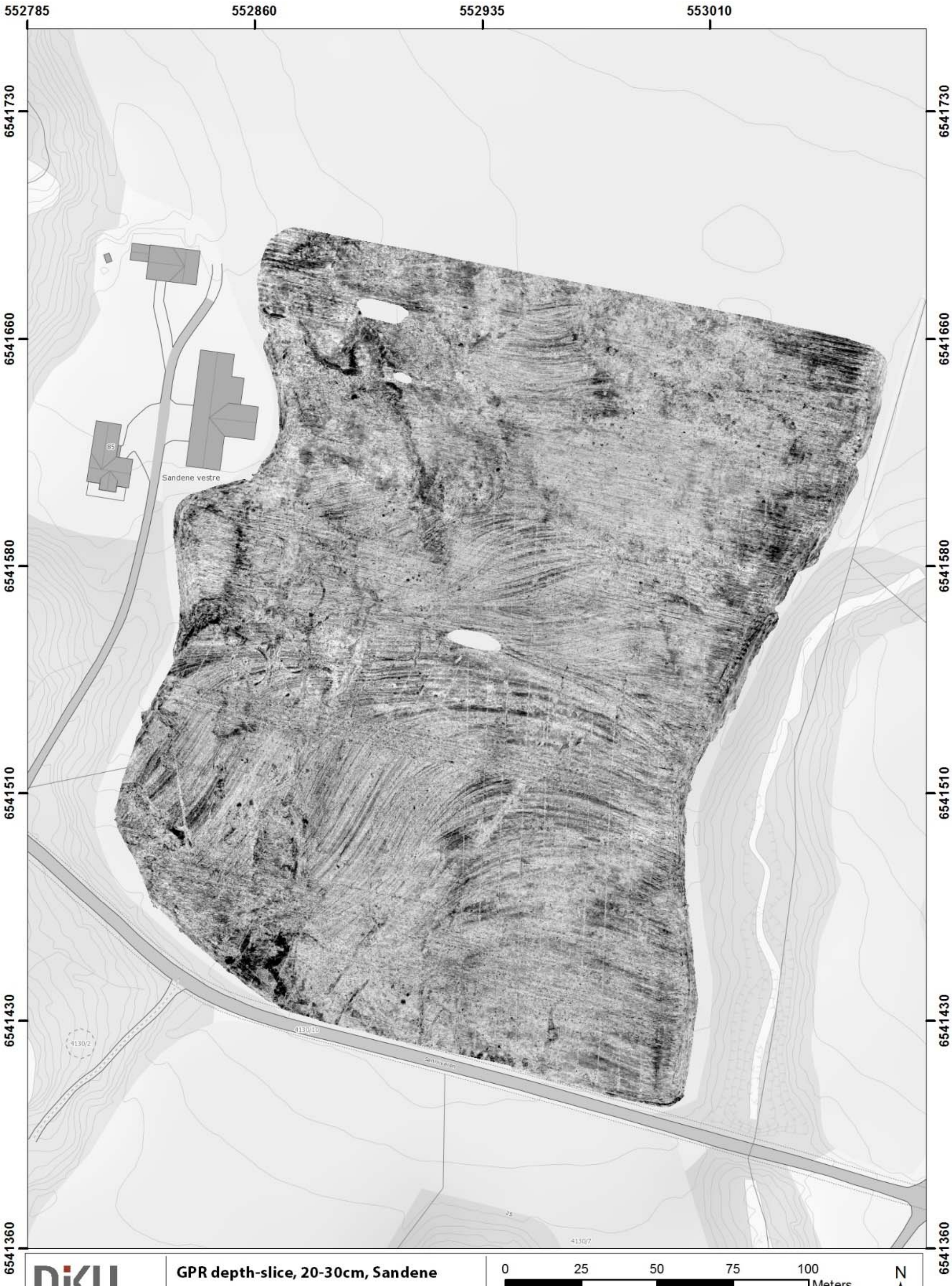

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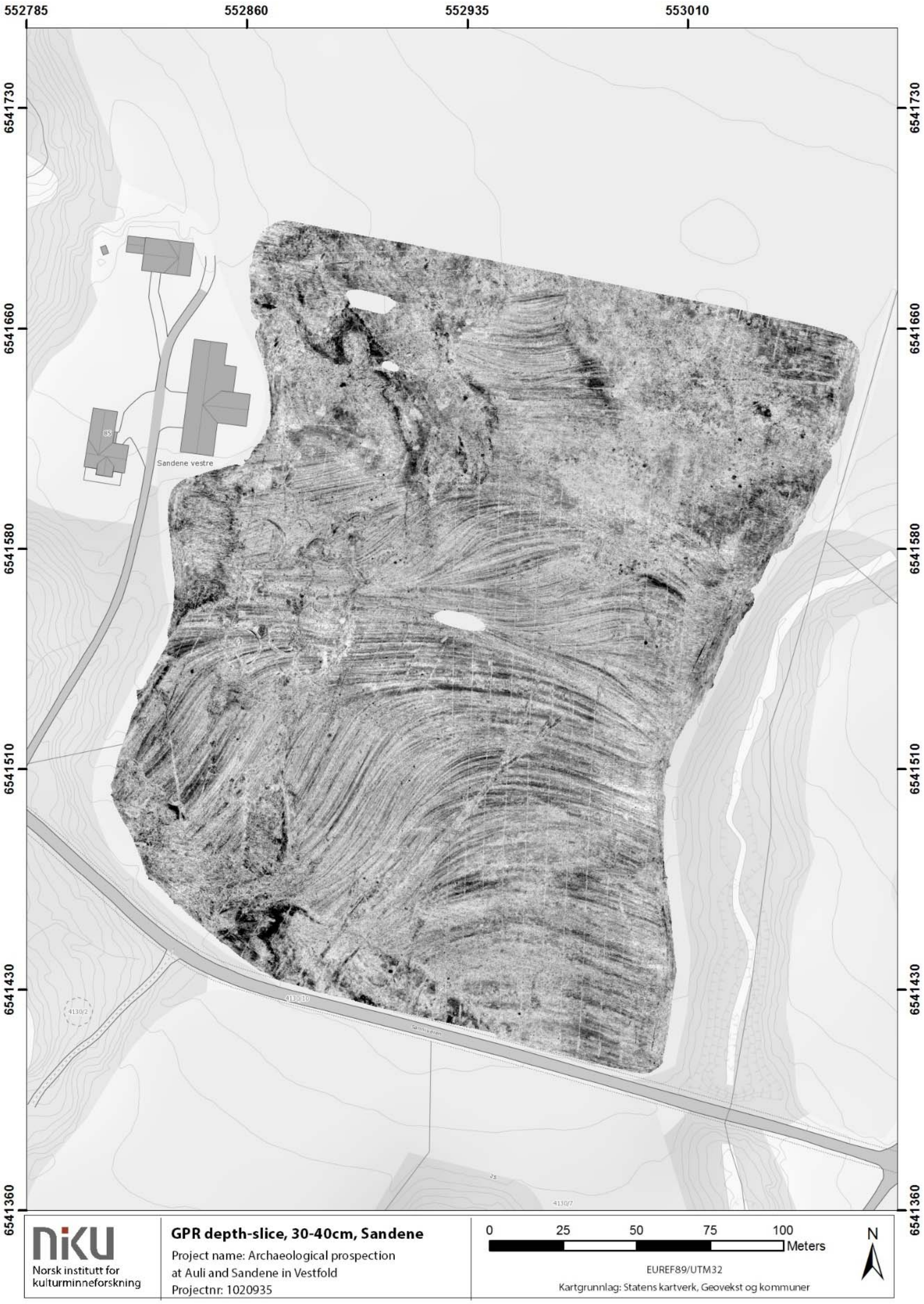
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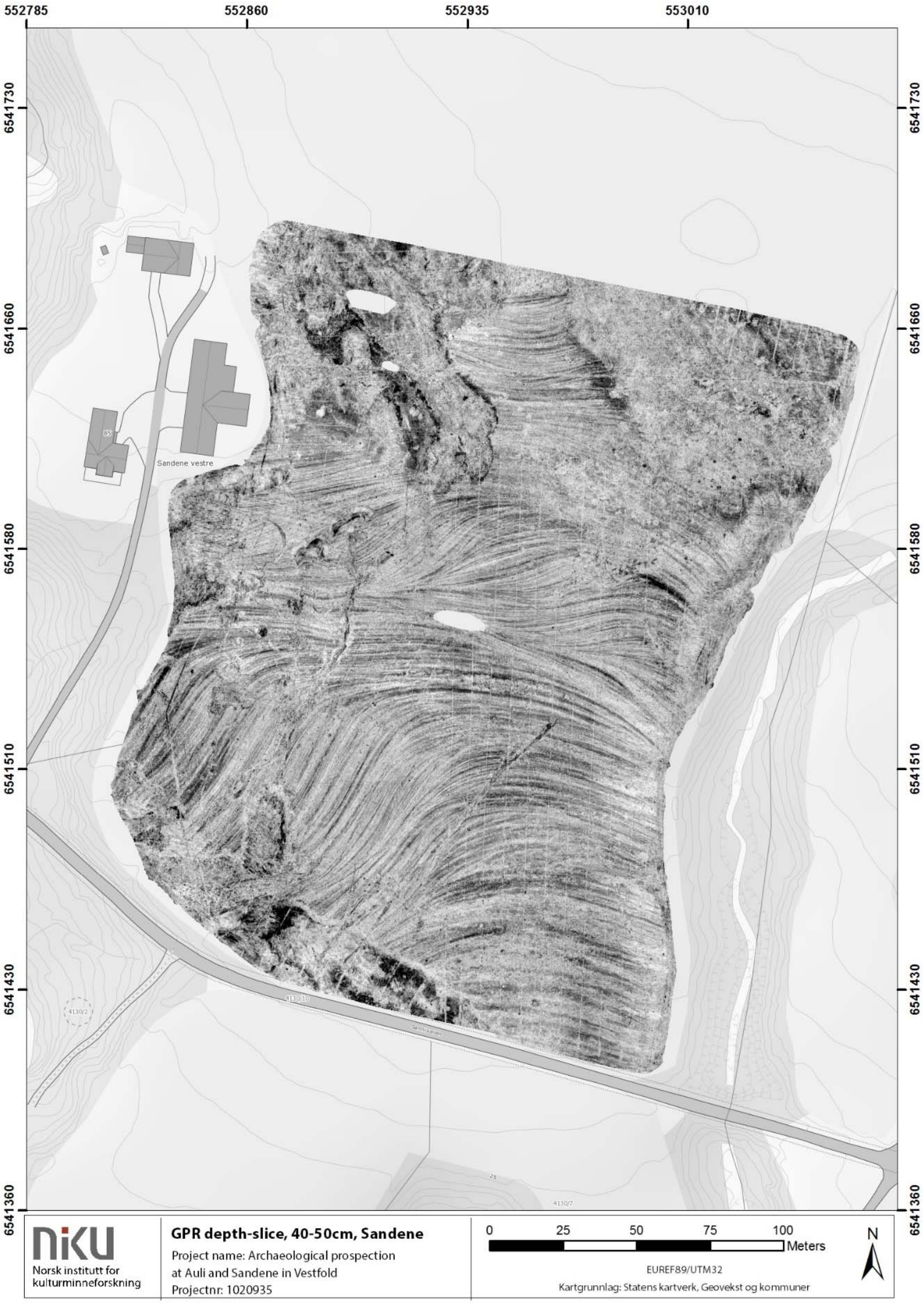
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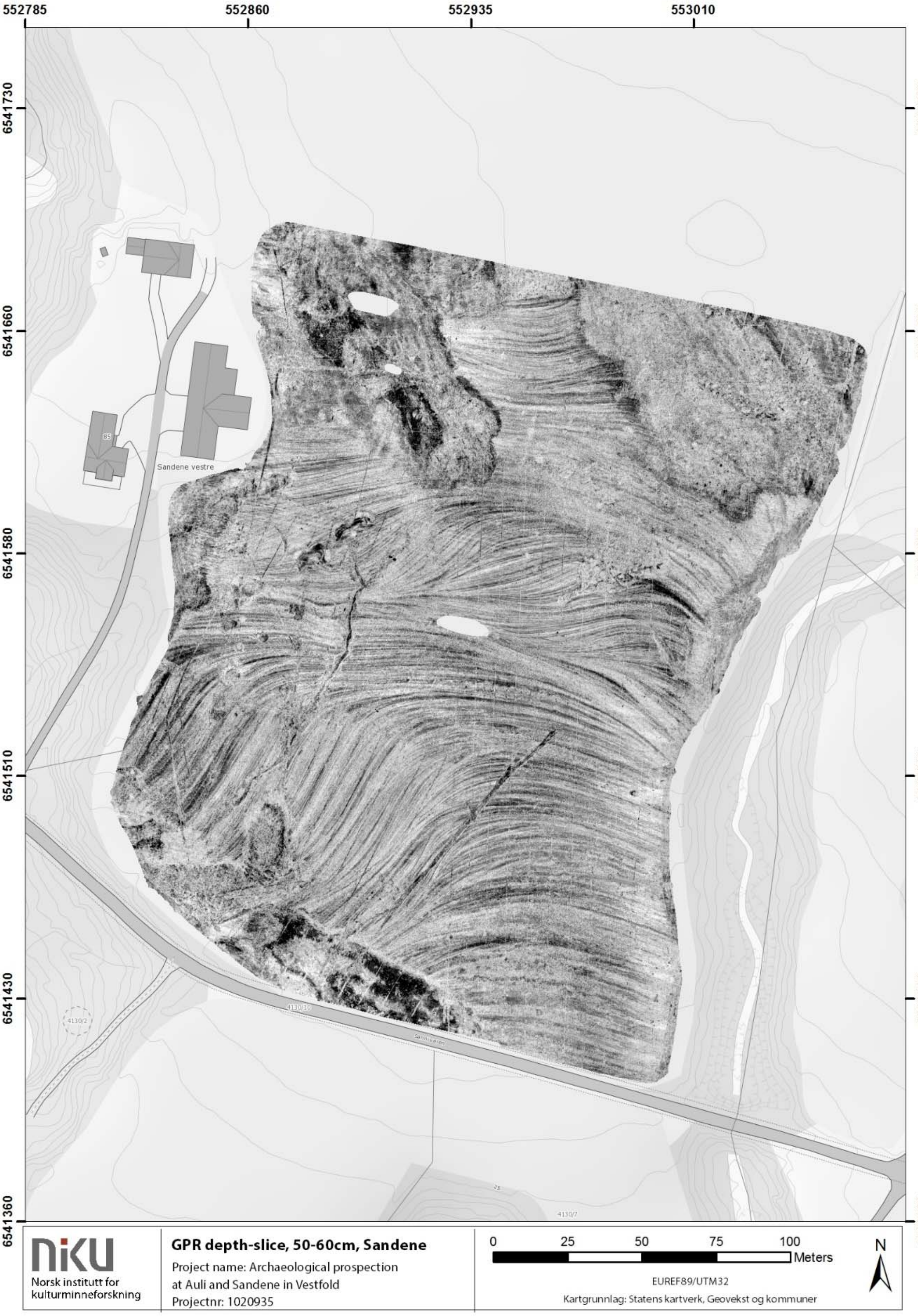
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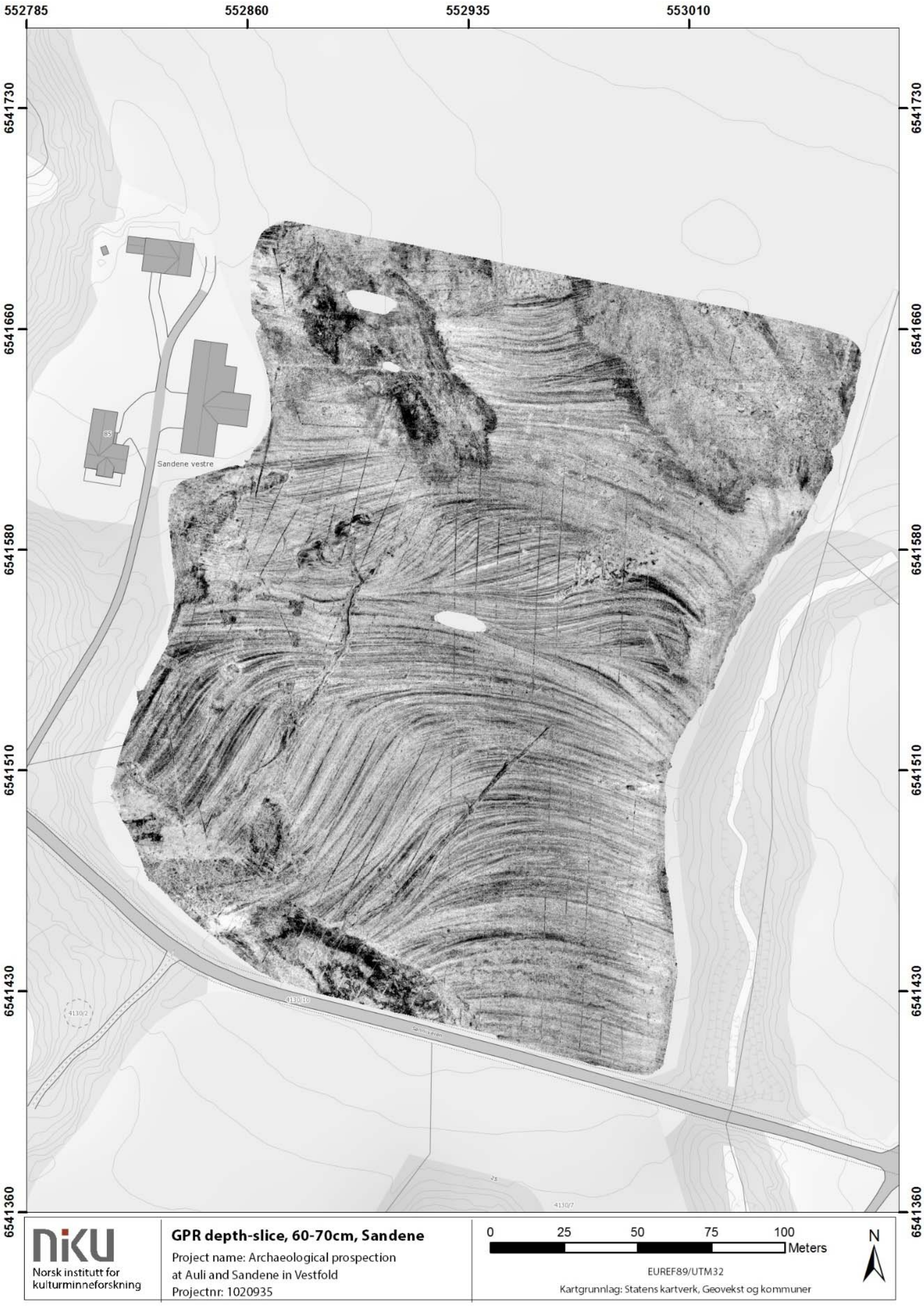
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6541580
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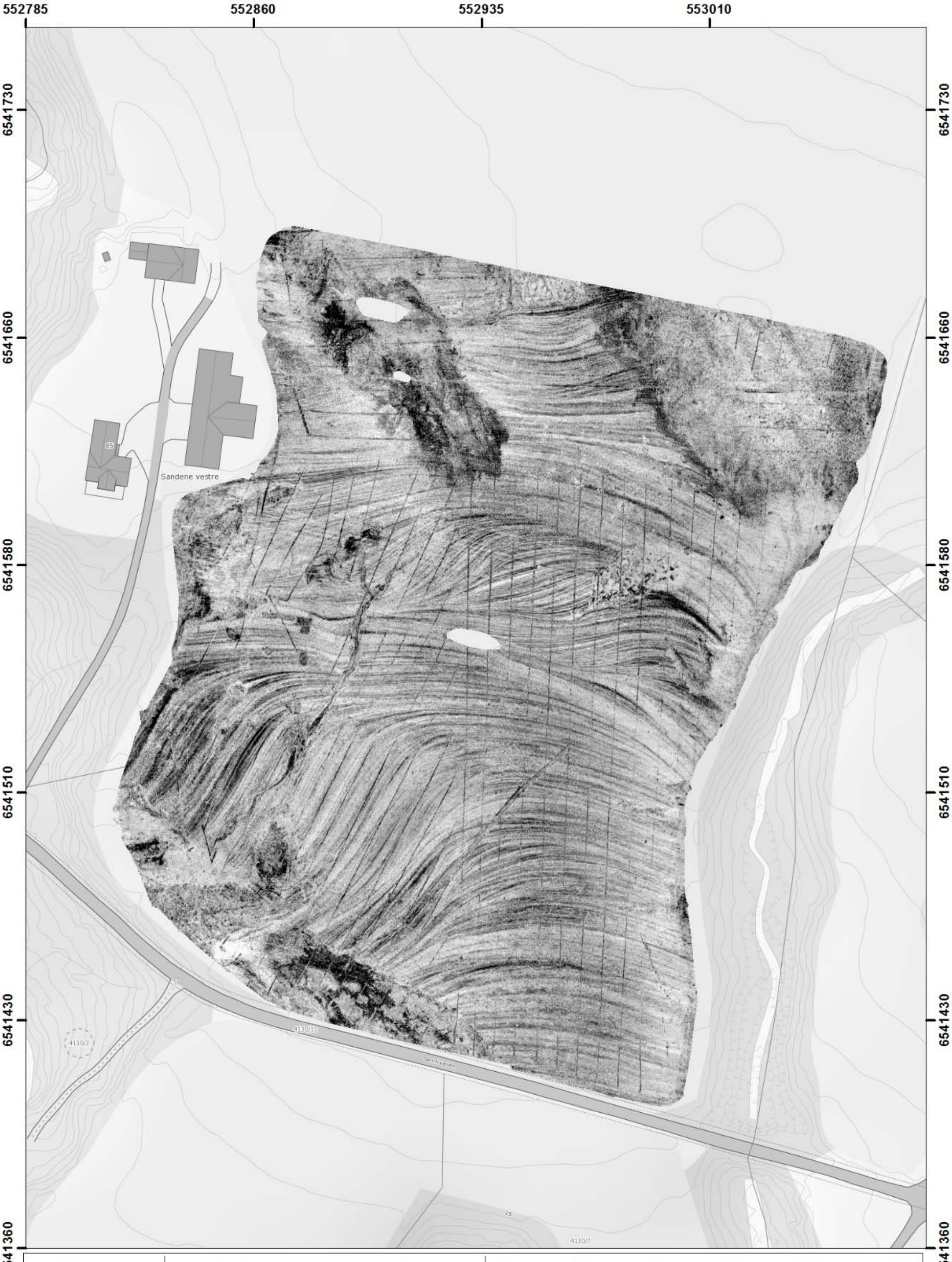
6541360
Sandene vestre
GPR depth-slice, 60-70cm, Sandene
Project name: Archaeological prospection
at Auli and Sandene in Vestfold
Projectnr: 1020935
Norsk institutt for
kulturminneforskning
0
25
50
75
100
Meters
EUREF89/UTM32
Kartgrunnlag: Statens kartverk, Geovekst og kommuner
N



niku
Norsk institutt for kulturminneforskning

GPR depth-slice, 70-80cm, Sandene

Project name: Archaeological prospection at Auli and Sandene in Vestfold

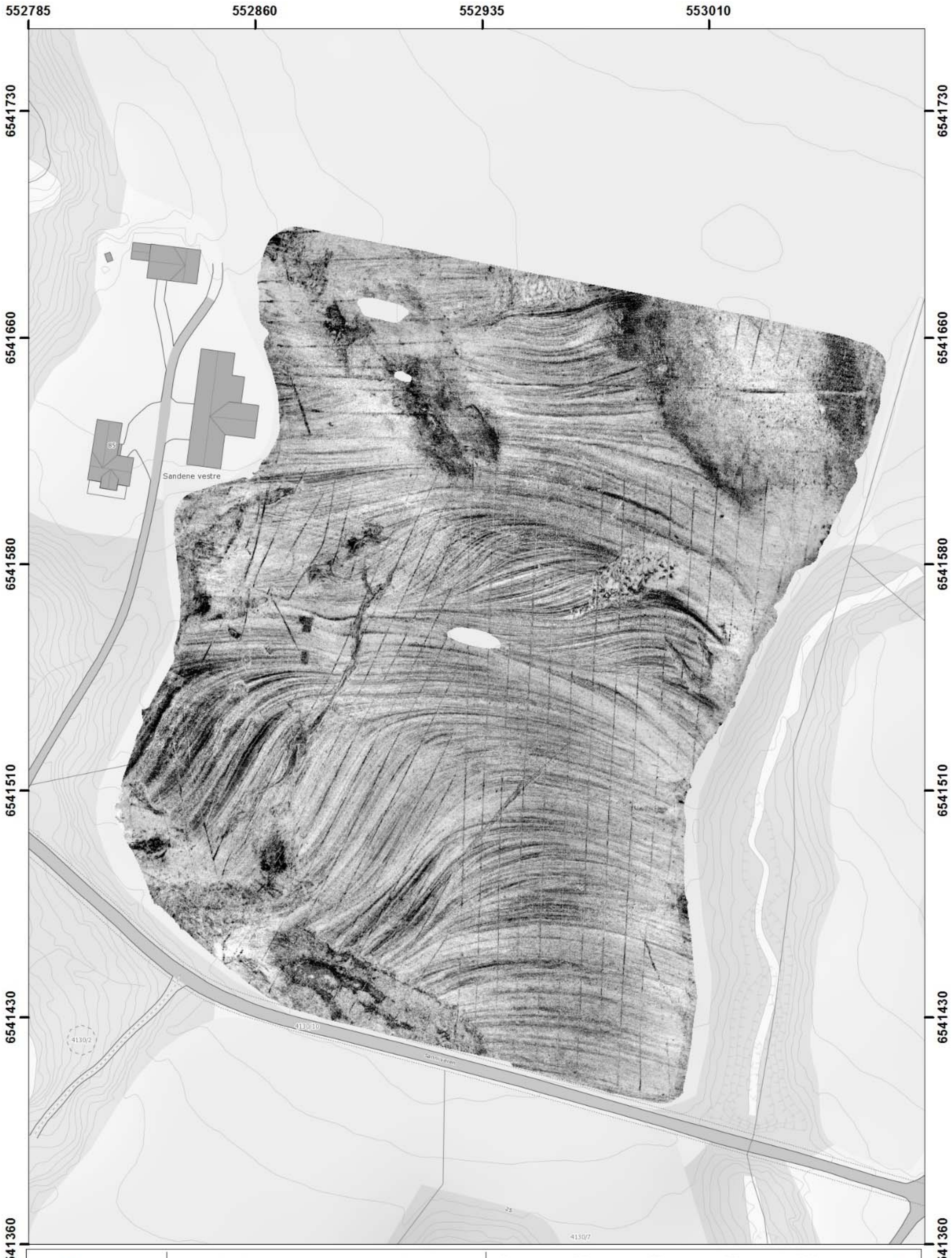
Projectnr: 1020935

0 25 50 75 100 Meters

N

EUREF89/UTM32

Kartgrunnlag: Statens kartverk, Geovekst og kommuner



GPR depth-slice, 80-90cm, Sandene

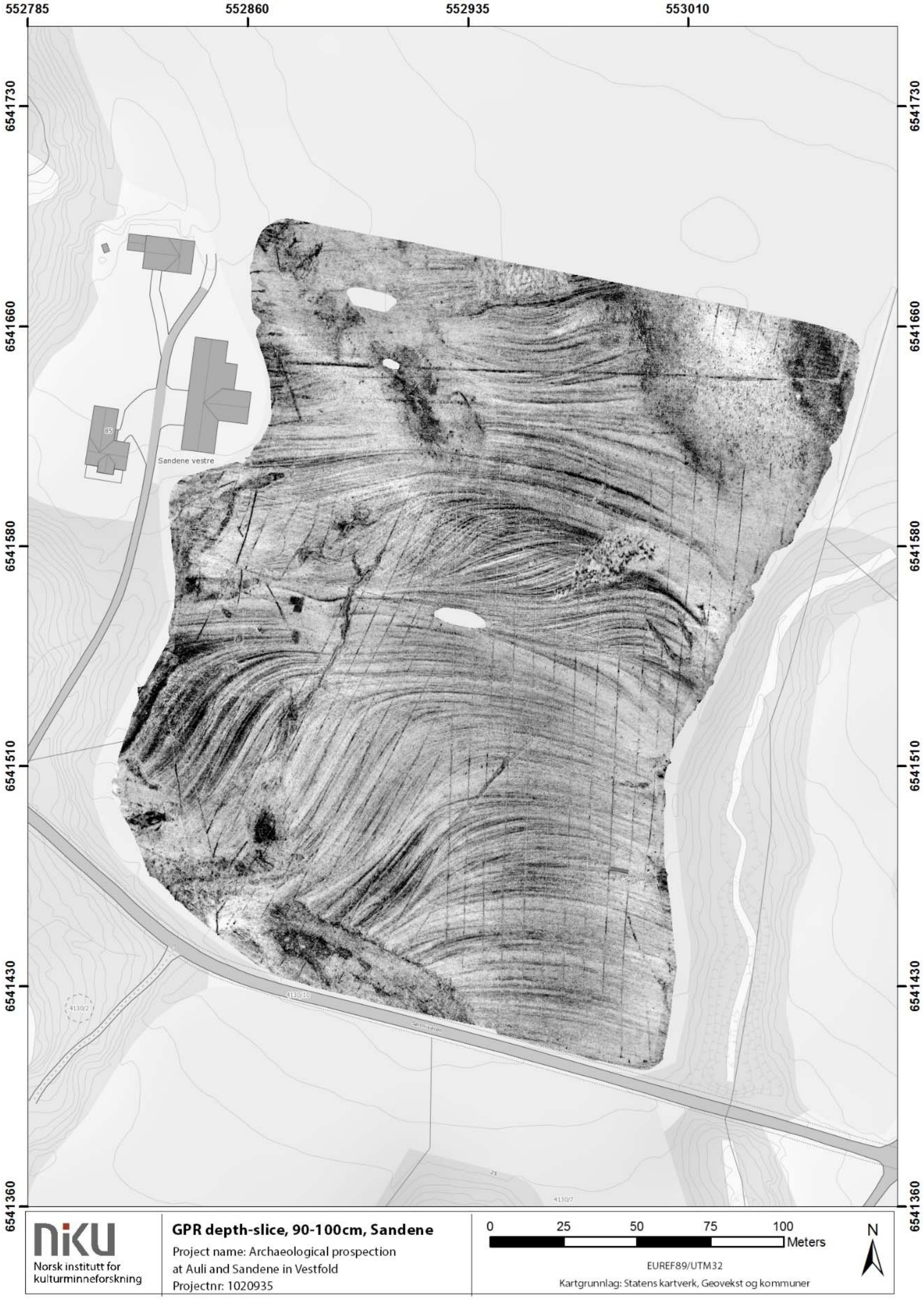
Project name: Archaeological prospection at Auli and Sandene in Vestfold

Projectnr: 1020935

Norsk institutt for kulturminneforskning

EUREF89/UTM32

Kartgrunnlag: Statens kartverk, Geovekst og kommuner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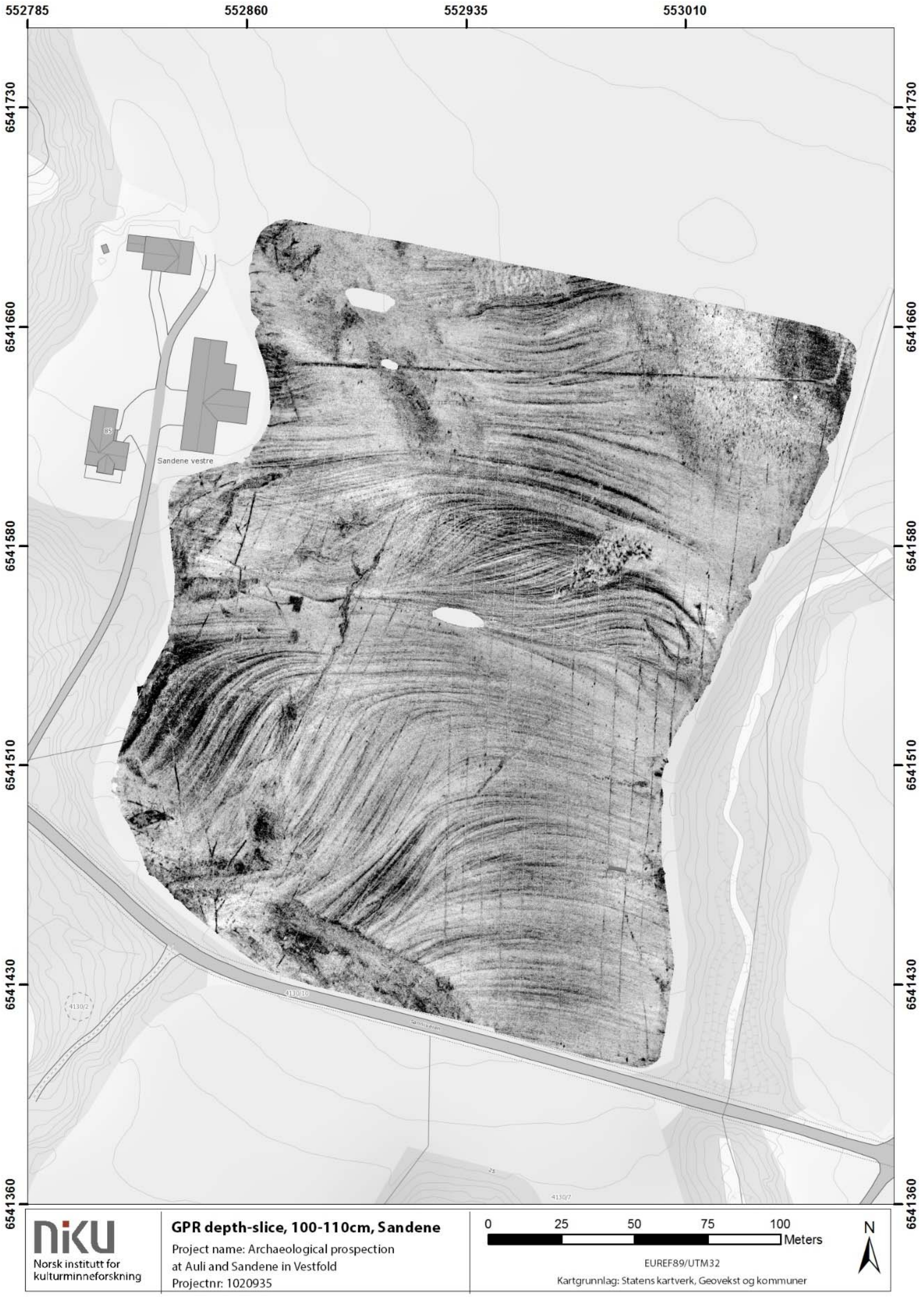
6541360
Sandene vestre
niku
Norsk institutt for kulturminneforskning
GPR depth-slice, 90-100cm, Sandene
Project name: Archaeological prospection at Auli and Sandene in Vestfold
Projectnr: 1020935
0
25
50
75
100
Meters
N
EUREF89/UTM32
Kartgrunnlag: Statens kartverk, Geovekst og kommuner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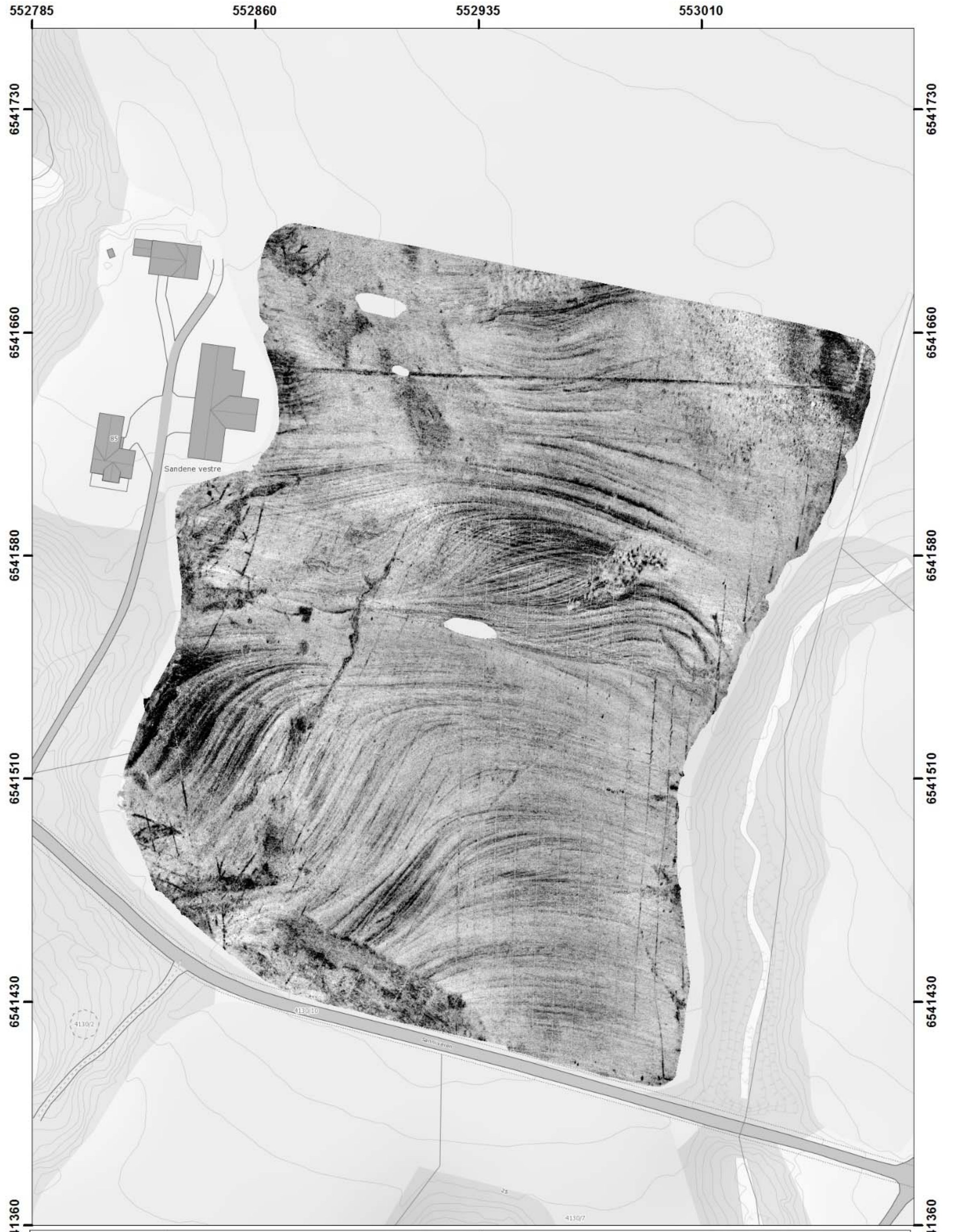
6541430
6541360
Sandene vestre
4130/10
4130/2
4130/7
niku
Norsk institutt for kulturminneforskning
GPR depth-slice, 100-110cm, Sandene
Project name: Archaeological prospection at Auli and Sandene in Vestfold
Projectnr: 1020935
0
25
50
75
100
Meters
N
EUREF89/UTM32
Kartgrunnlag: Statens kartverk, Geovekst og kommuner



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GPR depth-slice, 110-120cm, Sandene

Project name: Archaeological prospection at Auli and Sandene in Vestfold

Projectnr: 1020935

0 25 50 75 100 Meters

N

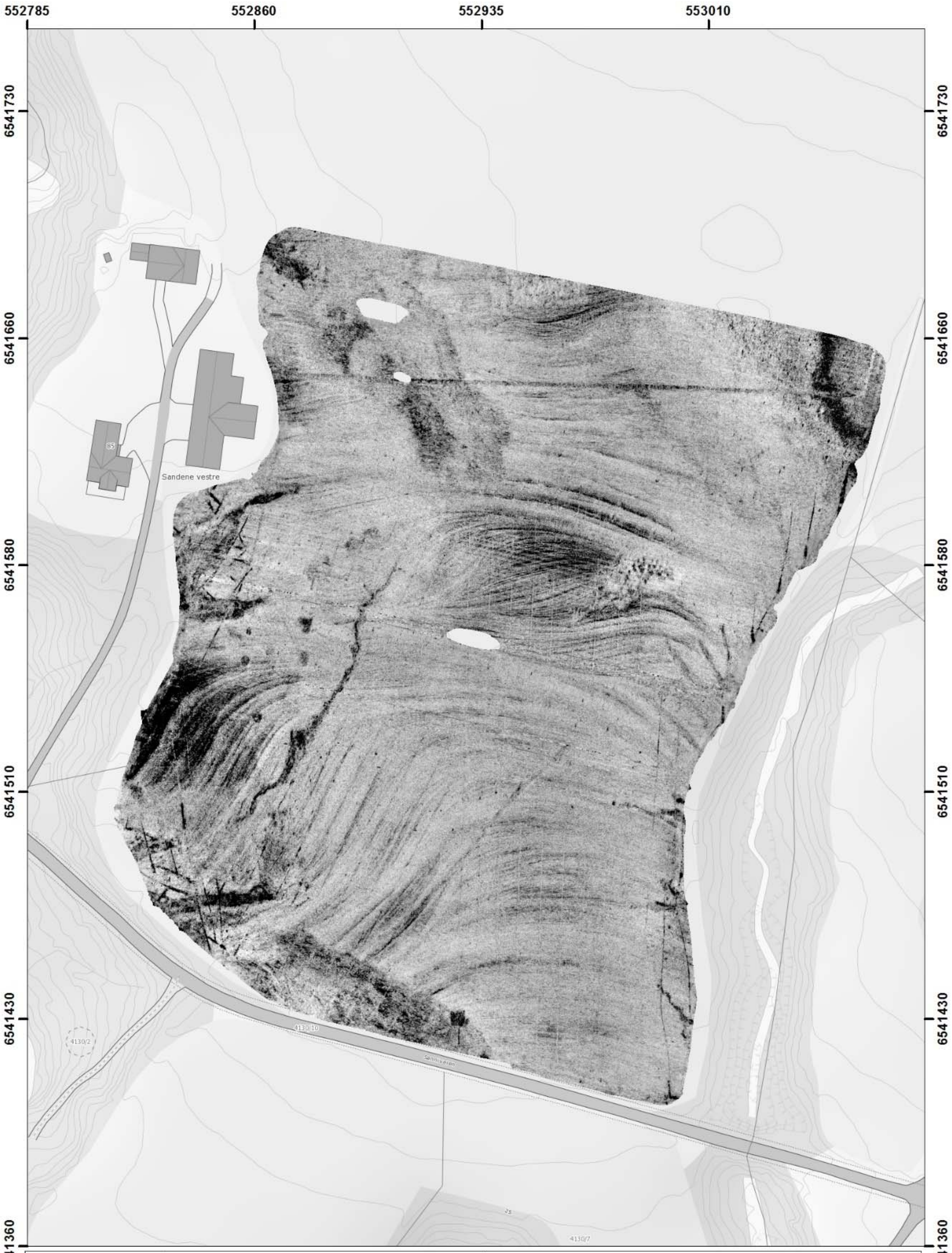
EUREF89/UTM32

Kartgrunnlag: Statens kartverk, Geovekst og kommuner

niku
Norsk institutt for kulturminneforskning

GPR depth-slice, 120-130cm, Sandene
Project name: Archaeological prospection at Auli and Sandene in Vestfold
Projectnr: 1020935

0 25 50 75 100 Meters
N
EUREF89/UTM32
Kartgrunnlag: Statens kartverk, Geovekst og kommuner



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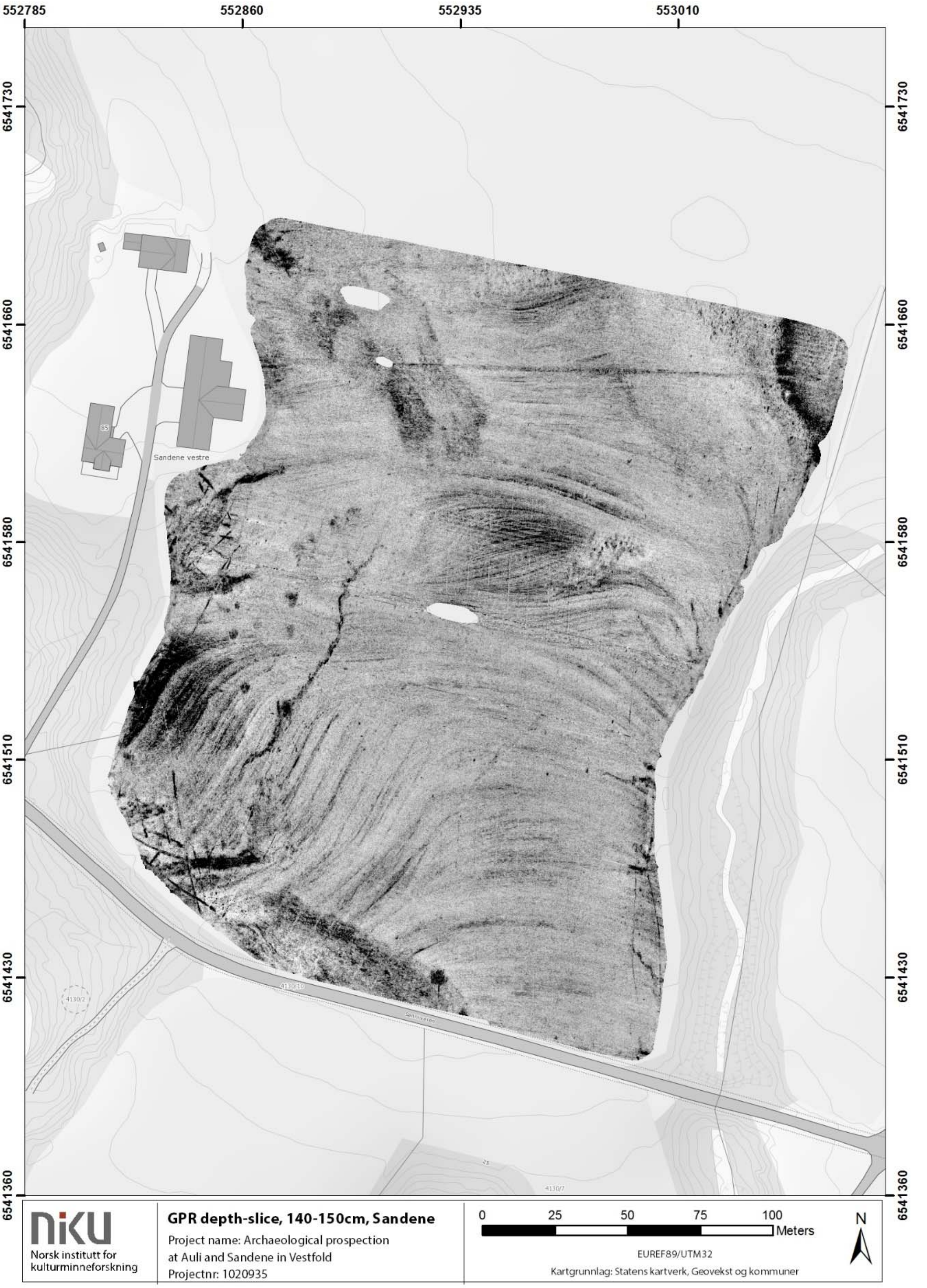
GPR depth-slice, 130-140cm, Sandene
Project name: Archaeological prospection at Auli and Sandene in Vestfold
Projectnr: 1020935

0 25 50 75 100 Meters
N
EUREF89/UTM32
Kartgrunnlag: Statens kartverk, Geovekst og kommuner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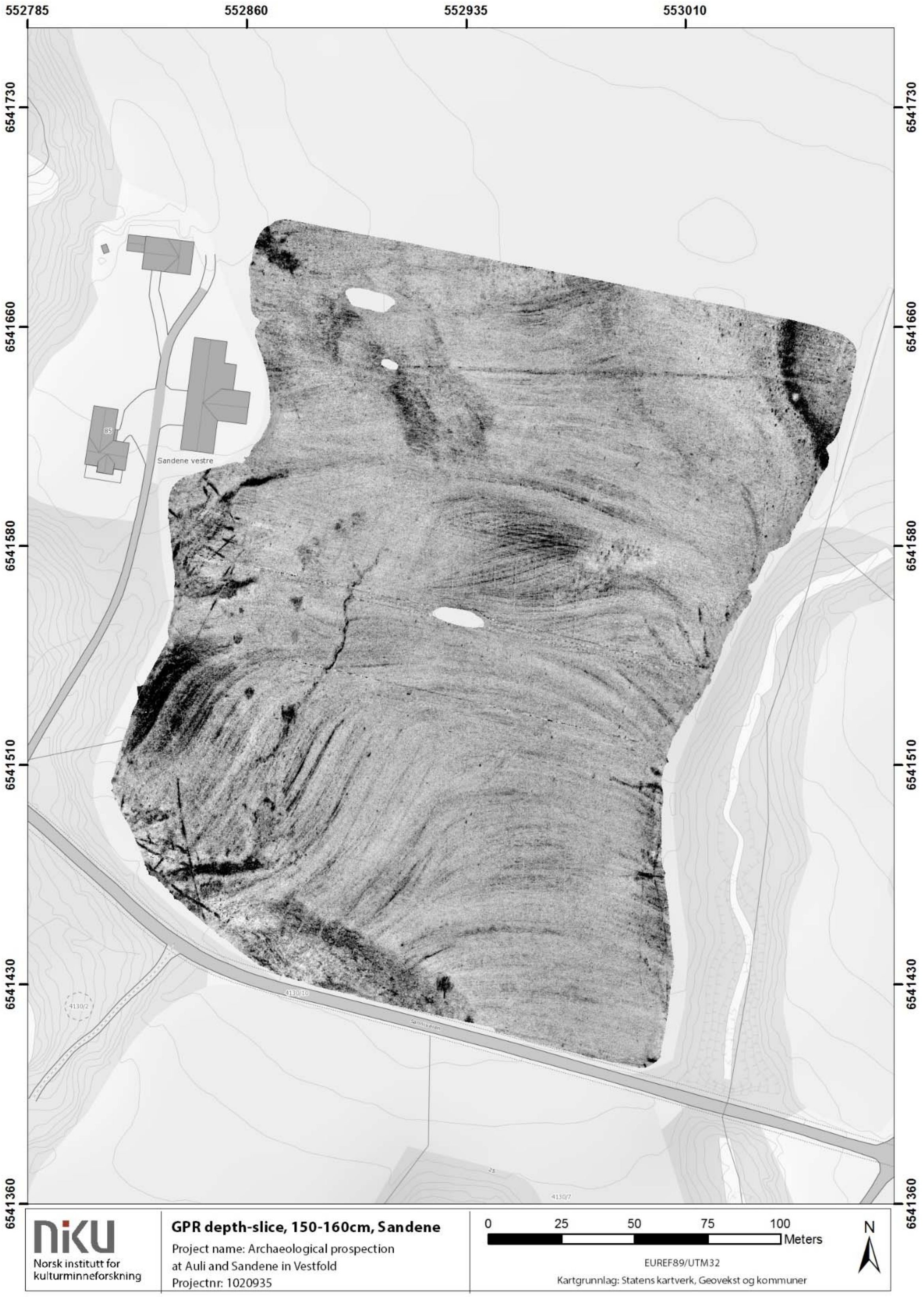
6541360
Sandene vestre
niku
Norsk institutt for kulturminneforskning
GPR depth-slice, 140-150cm, Sandene
Project name: Archaeological prospection
at Auli and Sandene in Vestfold
Projectnr: 1020935
0 25 50 75 100 Meters
N
EUREF89/UTM32
Kartgrunnlag: Statens kartverk, Geovekst og kommuner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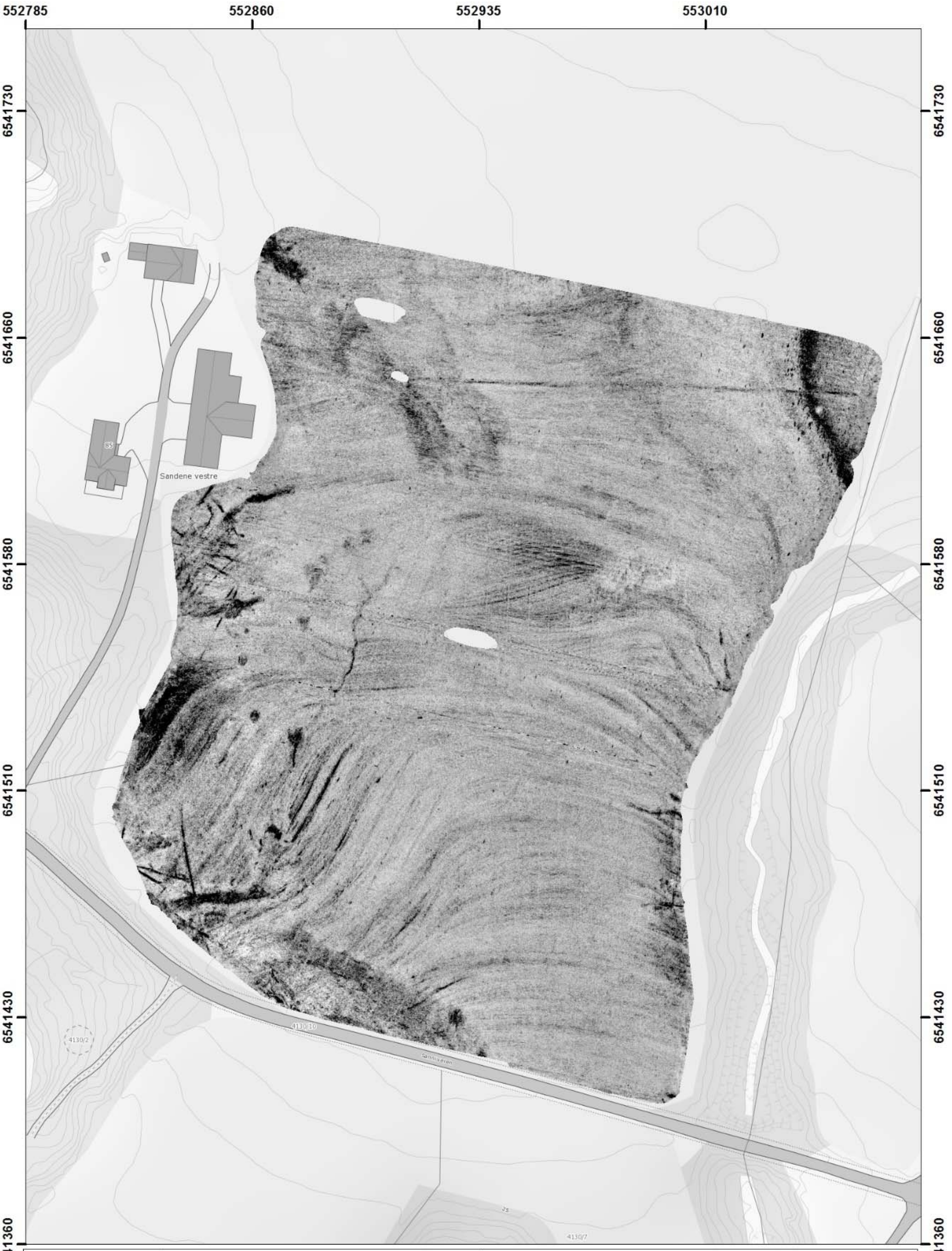
6541360
Sandene vestre
GPR depth-slice, 150-160cm, Sandene
Project name: Archaeological prospection
at Auli and Sandene in Vestfold
Projectnr: 1020935
Norsk institutt for
kulturminneforskning
0
25
50
75
100
Meters
N
EUREF89/UTM32
Kartgrunnlag: Statens kartverk, Geovekst og kommuner



Norsk institutt for kulturminneforskning

GPR depth-slice, 160-170cm, Sandene

Project name: Archaeological prospection at Auli and Sandene in Vestfold

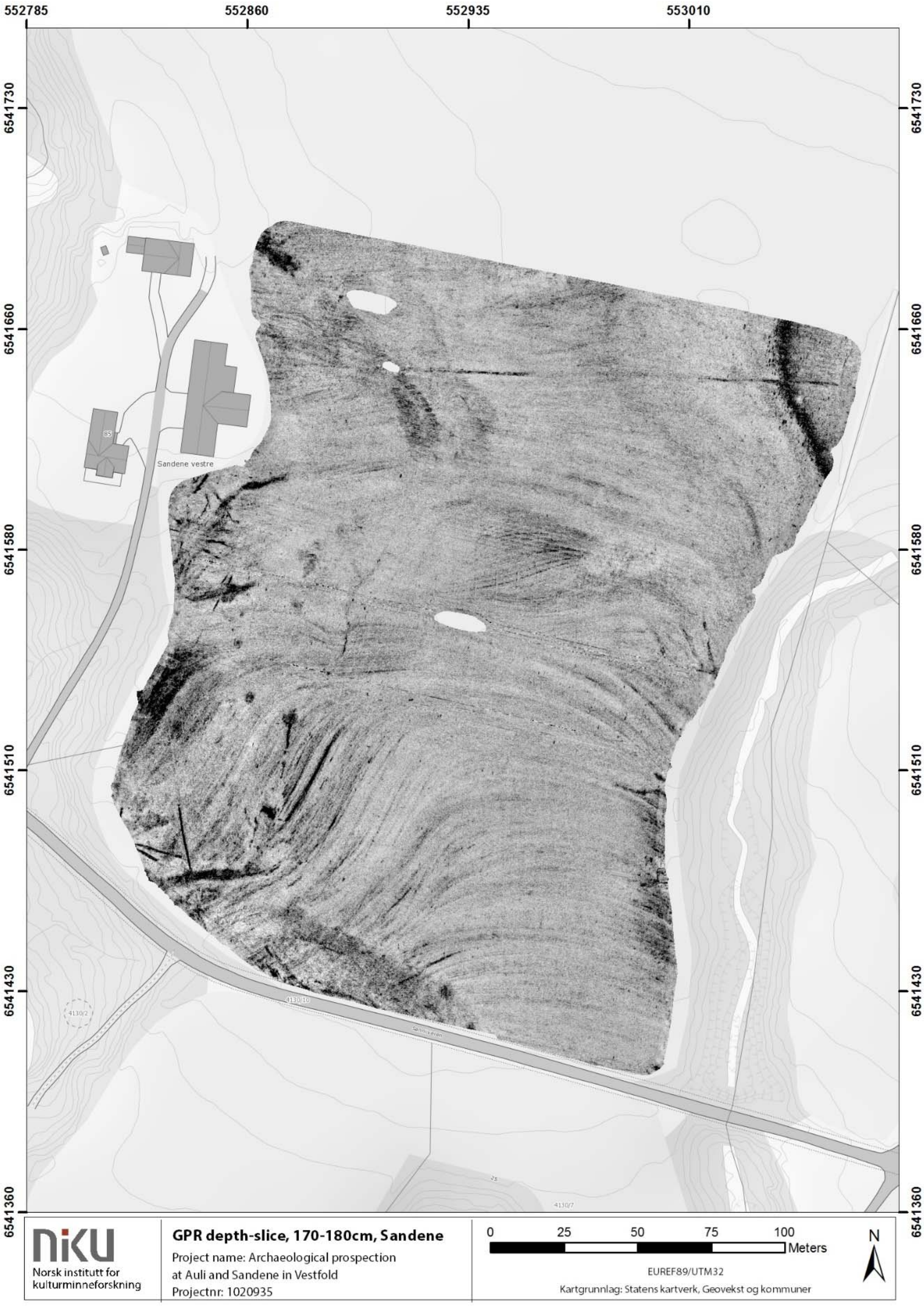
Projectnr: 1020935

0 25 50 75 100 Meters

EUREF89/UTM32

Kartgrunnlag: Statens kartverk, Geovekst og kommuner

N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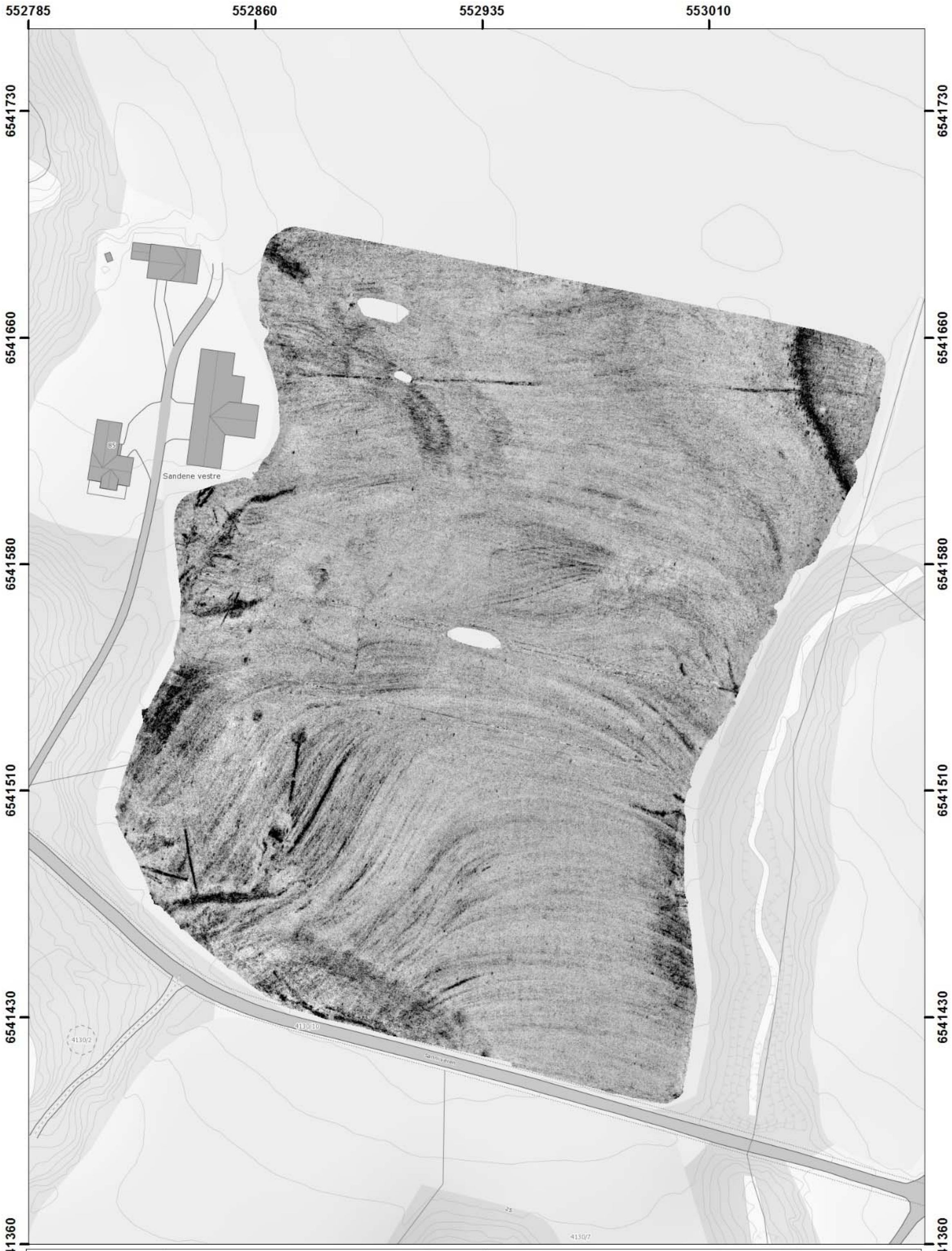
6541730
6541660
6541580
6541510
6541430
6541360
Sandene vestre
niku
Norsk institutt for kulturminneforskning
GPR depth-slice, 170-180cm, Sandene
Project name: Archaeological prospection at Auli and Sandene in Vestfold
Projectnr: 1020935
0 25 50 75 100 Meters
EUREF89/UTM32
Kartgrunnlag: Statens kartverk, Geovekst og kommuner
N



Norsk institutt for kulturminneforskning

GPR depth-slice, 180-190cm, Sandene

Project name: Archaeological prospection at Auli and Sandene in Vestfold

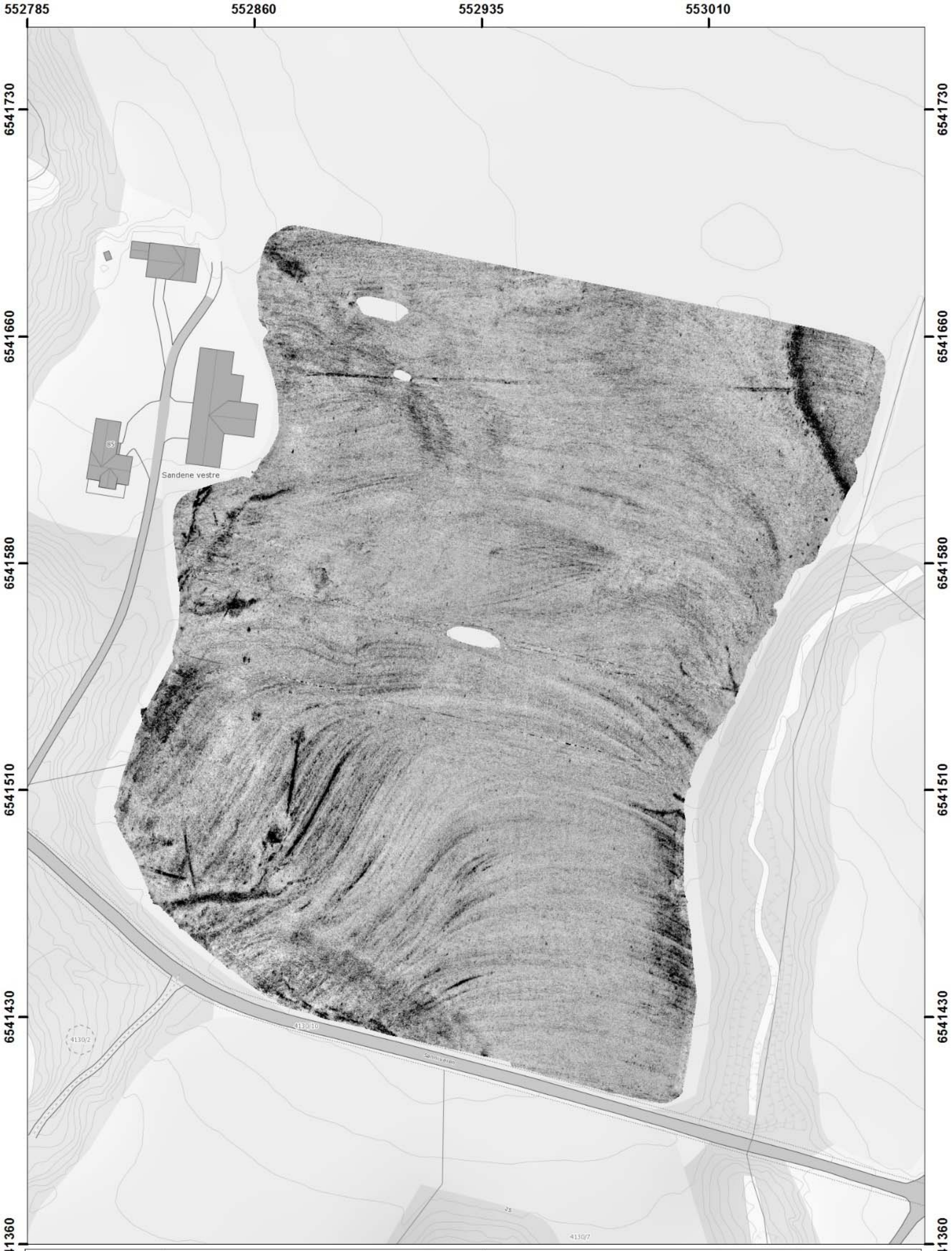
Projectnr: 1020935

0 25 50 75 100 Meters

N

EUREF89/UTM32

Kartgrunnlag: Statens kartverk, Geovekst og kommuner



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Norsk institutt for kulturminneforskning

GPR depth-slice, 190-200cm, Sandene

Project name: Archaeological prospection at Auli and Sandene in Vestfold

Projectnr: 1020935

0 25 50 75 100 Meters

N

EUREF89/UTM32

Kartgrunnlag: Statens kartverk, Geovekst og kommuner

Norsk institutt for kulturminneforskning er et uavhengig forsknings- og kompetansemiljø med kunnskap om norske og internasjonale kulturminner.

Instituttet driver forskning og oppdragsvirksomhet for offentlig forvaltning og private aktører på felter som by- og landskapsplanlegging, arkeologi, konservering og bygningsvern.

Våre ansatte er konservatorer, arkeologer, arkitekter, ingeniører, geografer, etnologer, samfunnsvitere, kunsthistorikere, forskere og rådgivere med spesiell kompetanse på kulturarv og kulturminner.

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