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Forsmark site investigation
Water depth soundings in shallow bays in Forsmark

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Abstract

A high quality digital elevation model is required for many types of modelling, such as shoreline shifts, water exchange or geohydrology. The elevation model needs to have positive values over land, negative values over the sea, and water surface levels for lakes. For the Forsmark site, good level data are available for land /Wiklund, 2002/ and for deeper sea areas /Elhammer and Sandkvist, 2004/, but the data for shallow areas of the sea are not equally good. The available depth soundings of the Öregrundsgrepen /Elhammer and Sandkvist, 2004/ were not performed in shallower areas since the equipment used was designed for deeper waters.

The purpose of this investigation was to complement existing level measurements in shallow sea bays so that level data from the entire Forsmark regional model area will be of approximately the same spatial resolution.

Portable equipment with digital eco sounder, DGPS, and a field computer with GIS software were installed in a shallow-draught boat. The boat was driven along parallel transects and the water depth and position was measured every second and stored on the field computer.

In addition to stored position and water depth, the time of the measurements and the quality of the DGPS signals were recorded to make it possible to adjust depth values to the RHB70 system and delete low quality position measurements using water level data from Forsmark. All shallow sea bays from Asphällsfjärden to Kallrigafjärden were sounded. The total number of high quality depth values is approximately 84,000.

Sammanfattning

För flera typer av modelleringar, t ex strandlinjeförskjutning, vattenutbyte eller geohydrologi, krävs en digital höjdmodell med hög kvalitet. Höjdmodellen skall ha positiva värden över land, negativa värden över hav och vattenytenivå för sjöar. För platsundersökningen i Forsmark finns bra nivåuppgifter för land /Wiklund, 2002/ och för djupare delar av havet /Elhammer och Sandkvist, 2004/ men sämre kvalitet på data från grunda delar av havet. Den djuplodning av Öregrundsgrepen som är genomförd /Elhammer och Sandkvist, 2004/ kunde inte inkludera grundare områden då utrustningen är avsedd för djupare vatten.

Syftet med föreliggande undersökning är att komplettera befintliga nivåmätningar i grunda havsvikar så att nivådata från hela undersökningsområdet får ungefär samma rumsliga upplösning.

En portabel utrustning med digitalt ekolod, DGPS och en fältdator med GIS-program monterades i liten grundgående båt. Båten kördes sakta längs parallella transekter och vattendjupet och positionen mättes varje sekund och lagrades i fältdatorn.

Förutom position och vattendjup lagras information om vid vilken tidpunkt mätningen är gjord samt kvaliteten på DGPS-signalerna, varför det var möjligt att med hjälp av vattenståndsdata från Forsmark justera djupvärdena till RHB70-systemet, samt radera punkter mätta med dålig kvalitet på positionsmätningarna. Samtliga grunda havsvikar från Asphällsfjärden till Kallrigafjärden lodades. Totala antalet punktdjup med hög kvalitet uppgår till cirka 84 000.

Contents

1 Introduction

This document reports the data gained from depth soundings in shallow bays, one of several activities performed in the site investigation at Forsmark. The work was carried out in accordance with activity plan SKB PF 400-03-61 and the method description "A method for determination of morphometry, sediment distribution, and habitat diversity of lake basins and its application to three lakes in Uppland" /Brydsten et al, 2004/. Table 1-1 lists controlling documents for performing this work. The activity plan is an SKB's internal controlling document.

The depth soundings in shallow bays were carried out during two periods, August 18–22, 2003, and September 30 – October 5, 2003. Data are, together with depth soundings from deeper parts of the sea /Elhammer and Sandqvist, 2004/ and an existing digital elevation model covering the land areas /Wiklund, 2002/, used as input for interpolation of a digital elevation model (DEM). The areas where water depth soundings were performed is in shown in Figure 1-1.

Table 1-1. Controlling documents for the performance of the activity.

Activity plan	Number	Version
Utveckling av sjö-, hav- och strandförskjutnings-applikationer I GIS	AP PF 400-03-61	1.0
Method description	**Report number**	**Authors**
A method for determination of morphometry, sediment distribution, and habitat diversity of lake basins and its application to three lakes in Uppland	SKB R-04-40	Brydsten L, Carlsson T, Brunberg A-K, Blomqvist P

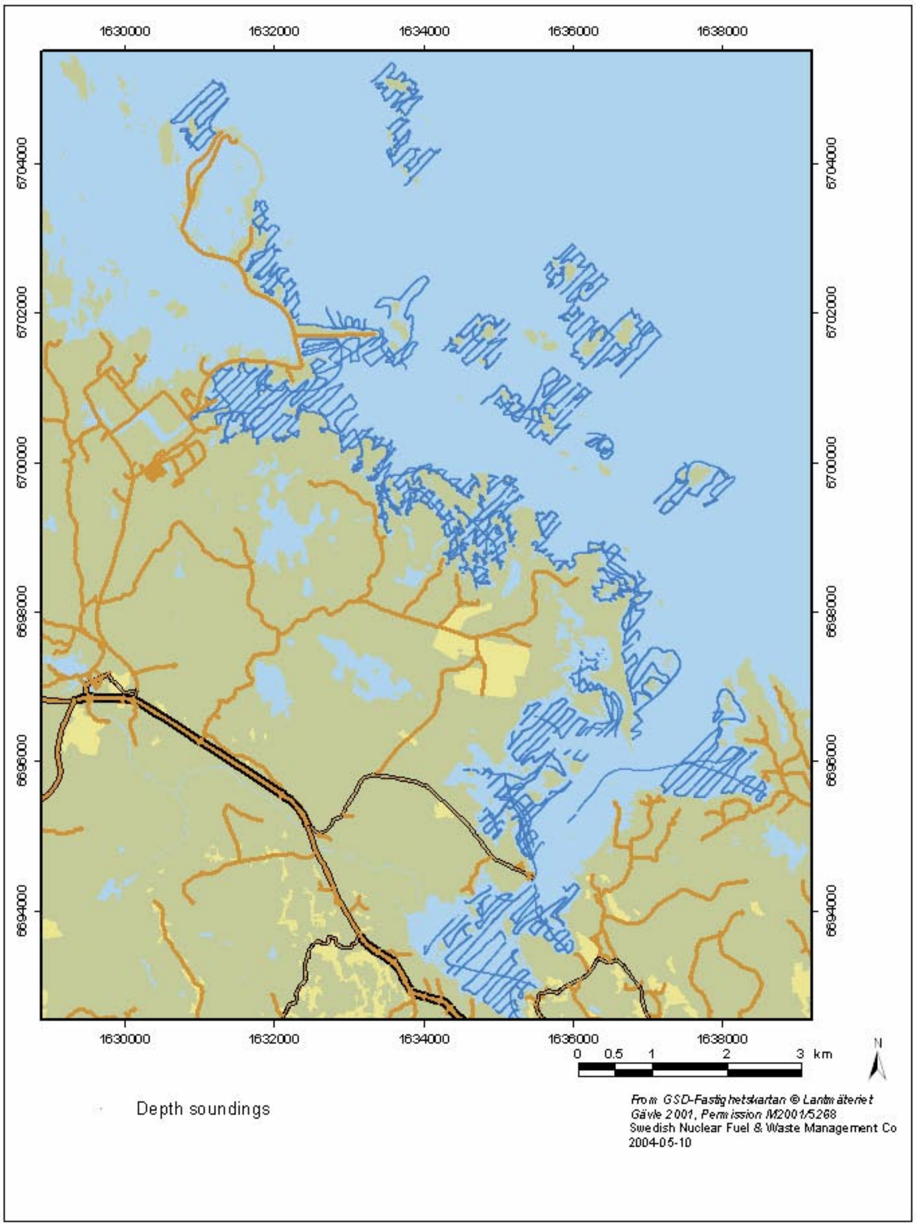

Figure 1-1. *General overview of the Forsmark site investigation area. The blue line indicates transects in shallow areas where water depth soundings were performed.*

Table 1-2. Data references.

Subactivity	Database	Identity number
Forsmark water depth sounding	SICADA GIS	Field Note no Forsmark 300

The depth soundings data in ESRI shape format (points) are delivered to SKB and stored in SICADA and GIS databases. The references to the files are listed in Table 1-2.

2 Method for mapping water depths

The field equipment used to map water depths was a digital echo sounder (Simrad EQ32 Mk 11) and a DGPS (Trimble Pro XR) connected to a field computer (Itronix GoBook) using ESRI ArcPad real time GIS software. For each update of the GPS position (each second), the X and Y coordinates were recorded from the GPS, together with the Z value (water depth) from the digital echo sounder. Approximately 2000 depth values per hour were recorded.

An orthophoto (1 meter resolution) was used as background imaging in the field computer. Each recorded depth point was displayed on top of the orthophoto. Thereby, it was possible to observe which parts of the area had already been mapped, and this was used as a navigational aid. The aim was to record water depths evenly over the target area, i.e. the distance between two points along a transect should not be more than half the distance between two adjacent transects. Since it was possible in the ArcPad program to choose the time interval between recorded water depths, this interval was used to set the travel time for half the distance between two adjacent transects. The update of the coordinates from the GPS was not fully synchronized with the signal from the echo sounder entailing that the maximum time difference between the signals could be half a second. With a boat speed of 1 knot, this will give an accuracy in the recorded coordinates of 0.5 m. The maximum speed of the boat was therefore limited to attain a targeted spatial accuracy.

A calculation example: assume that the maximum acceptable error in coordinates is 10 m. The DGPS accuracy, measured with a long time series of recordings at a fix point close to the shore, is 5 m. The maximum error due to boat speed will then be 5 m. With an acceptable error of 0.5 m per knot boat speed, the maximum boat speed will be 10 knots. Assuming that the distance between transects is chosen to 50 m, the time interval between depth recordings along a transect will be 5 seconds, if the distance between records along a transect is half of that between transects.

3 Execution

3.1 General

During the first field period, an approximately 6.5 m long boat with an outboard motor and pilot house was used. With this boat it was not possible to measure water depths shallower than approximately 0.7 m. During the second period, a smaller open boat with an outboard motor was used. Water depths down to approximately 0.5 m were measured with this boat. Accordingly, water depth measurements are lacking in areas between the shoreline and approximately 0.5–0.7 m depth.

The extension of the area with measured water depths is shown in Figure 1-1. The boat was driven in parallel transects with 25–100 m equidistance (see Figure 1-1). The shorter equidistance was used on bottoms with a high variance in topography. In total, approximately 84,000 depth values were recorded.

3.2 Data handling/post processing

Data captured with the ArcPad field GIS program was stored in ESRI shape format. One of the attributes in the table is PDOP (Position dilution of precision), a measure of the position quality. With the PDOP value, it was possible to exclude measurements with low position quality. However, this was only performed for a few measurements.

On some bottoms the recorded water depths were obviously wrong. Either the echo sounder returned a no value code or an extreme high water depth (100–300 m). These records were therefore easy to select and were deleted from the dataset. On these bottoms the soundings were made manually with a measure rope with a sinker.

The depth values were adjusted due to different water levels in the sea over time. Using sea level records from Forsmark with hourly accuracy, the water depth values were adjusted to zero sea level in the RHB70 height system.

3.3 Nonconformities

No nonconformities with respect to the activity plan or the method description occurred.

4 Results

The cleaned shape file (points) contains approximately 84,000 points with attributes for X and Y coordinates in RT90 2.5 gon W datum and water depth (Z) in RHB70 height system. The shape file is named Forsmark_depthsoundings and is stored in the primary databases (SICADA and GIS) and will be used, together with other elevation data, for construction of a new digital elevation model. The Field Note [FN] number for the shape-file is Forsmark 300.

5 References

Elhammer A, Sandkvist Å, 2004. "Detailed marine geological survey of the sea bottom outside Forsmark". SKB P-03-101, Svensk Kärnbränslehantering AB.

Wiklund S, 2002. "Digitala ortofoton och höjdmodeller. Redovisning av metodik för platsundersökningsområdena Oskarshamn och Forsmark samt förstudieområdet Tierp Norra". SKB P-02-02, Svensk Kärnbränslehantering AB.

Brydsten L, Carlsson T, Brunberg A-K, Blomqvist P, 2004. A method for determination of morphometry, sediment distribution, and habitat diversity of lake basins and its application to three lakes in Uppland. SKB R-04-40, Svensk Kärnbränslehantering AB.