Integrating Geological Resources in Areal Planning: a Case Study of the Bømoen Plus Village Project

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Fluvial and glaciofluvial deposits are common in Norwegian valleys and hold the country's most important sand and gravel resources. These deposits are relatively large in volume and are often suitable for aggregate excavation and for groundwater extraction. Increased understanding of the spatial distribution of sediments (and bedrock) and groundwater within an area can give a foundation for use of local resources as part of sustainable development. Bømoen Plus Village is a holistic and comprehensive research project focused on the development of a new village, consisting of residential and industrial areas. The aim is to achieve self-sufficiency in energy, water, and aggregates using the local geological resources. The study site, Bømoen (~2 km²) and Bjørkemoen (~1 km²) in Voss, Western Norway, is a glaciofluvial deposit divided by the river Raundalselvi.

A key aspect for the project is resource mapping and development of the area based on geological understanding. The initial phase of the investigation involved a comprehensive study of the area's geology and hydrogeology. This included Quaternary mapping, GPR subsurface profiling (145 profiles using antennas of varying frequencies), and Odex drilling (15 wells with 90mm and 115mm casings, along with information from 37 previously drilled wells in the area). Groundwater wells were installed in all boreholes. Quaternary mapping revealed predominantly glaciofluvial deposits across the area, with fluvial deposits near Raundalselvi. The investigations reveal a high content of boulders in the top layer, deposited during high-energy flows. Some areas displayed horizontal layers typical of layered sand and gravel in a Sandur, while others exhibited more homogeneous sandy sediments. In some areas these were divided by an erosional surface possibly representing river flow paths carving into the Sandur deposits. Odex drilling showed sand and gravel layers down to 25-35m. Fine sand and silt were typically found below the sand and gravel, with till observed above bedrock in some boreholes. Based on the collected data and interpretations, a 3D model was constructed to represent different geological units, assessing their quantities and distribution. These units encompassed till, marine sediments, deltaic foresets, and glacial outwash deposits, aligning with the common stratigraphic sequence found in valley deposits partially submerged below the marine limit.

The availability of sand and gravel plays a pivotal role in sustainable development by facilitating the extraction of significant groundwater volumes. Meanwhile, the dry sand and gravel content of the geological deposit holds immense importance for aggregate materials. The modelled total volume of sand and gravel within the project area is ~55 mill m^3. The average groundwater level is 9,5 m below the terrain, thus leaving 37 mill m^3 dry sand and gravel and 18 mill m^3 saturated sand and gravel resources. The current water abstraction rate for the municipality's reserve water supply in Bømoen stands at 90 l/s, suggesting that the extraction potential for the remainder of Bømoen exceeds this rate due to its larger size and similar geology. Surrounding catchment area connected to Bømoen by valleys and major rivers is more than 500 km², while the average precipitation is ~1330 mm/yr. Groundwater temperature measurements in Bømoen show an average of 6ºC, with higher fluctuations observed near the river Raundalselvi. Given water's specific heat capacity of 1,17 kWh/(m^3 ºC), a lowering of the water temperature by 4ºC through a heat exchanger, coupled with an abstraction rate of 10 l/s per well, yields an effect of 167 kW/well. A seasonally regulated usage of the groundwater through an Aquifer Thermal Energy Storage (ATES) system is planned, possibly coupled with excess heat. Since the hydraulic gradients are high, careful investigations are necessary for optimal localisation of the production and the injection wells.

Bømoen Plus Village will benefit from a coordinated utilization of sand and gravel resources as excellent foundation for buildings, a source for excavated aggregates and as aquifers for extraction of groundwater for drinking water, and for heating and cooling of the buildings.