CHAPTER 8

A PROPOSED GROUNDWATER MONITORING NETWORK FOR THE SEVERN SOUND DRAINAGE AREA

By

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8.1 LOCATION

Severn Sound (to be referred to as the Sound in this chapter) is a group of bays in southeast Georgian Bay. The Sound is located in southern Ontario between longitude 79^0 $54^{'}$ and 79^0 $24^{'}$ W and latitude 49^0 $31^{'}$ and 49^0 $74^{'}$ N. The Sound has a total drainage area of about 1095 Km^2, a maximum length of about 43 km in a northwest-southeast direction and a maximum width of about 46 Km in a northeast-southwest direction. It is bounded on the north by Severn River basin and Georgian Bay, on the east by Lake Simcoe and Lake Couchiching basins, on the south by the Nottawasaga River basin, and on the west by Georgian Bay as well as by a narrow strip of land that drains into Georgian Bay.

The topography of the Sound is a direct result of the deposition and erosion processes during glacial and post-glacial times. Land surface elevations vary from 177 m above mean sea level (a.s.l.) along the shores of Georgian Bay to 412 m (a.s.l.) in a small area located within the Bass Lake moraine along the southern topographic divide.

The Sound contains six small watersheds draining from the south and a miscellaneous area draining land along the north shore of the Sound. The watersheds are those of the North, Coldwater, Sturgeon and Wye Rivers and the Hog and Copeland Creeks. Due to their small gradients within the flat-floored valleys, the streams have cut shallow channels and their flow at times is very sluggish. These small gradients explain the swampy character of many areas within the valleys.

The North River rises in a hilly plateau to the north of Bass Lake and empties into Matchedash Bay. It has three major tributaries: the Purbrook, Bear and Silver Creeks. The Coldwater River originates near Coulson and flows from south to north before it enters into Matchedash Bay. The Sturgeon River originates in a hilly plateau near Hillsdale and flows in a northerly direction before it empties into Sturgeon Bay. The Hog Creek originates in Medonte Township, flows in a northerly direction through Tay Township, and empties into Hog Bay in Severn Sound. The Wye River originates to the north of the Cook's Hill area in Flos Township and flows from south to north to its outlet into Georgian Bay. The Copeland Creek originates from Lalligan Lake in Tiny Township and flows in a northwesterly direction to its outlet into Penetang Harbour.

Most of the area lies in Simcoe County whereas a small area in the north is within Georgian Bay Township (Baxter Ward) in the District Municipality of Muskoka. As of 1995 a major restructuring of the County of Simcoe municipalities took place. The original thirteen local municipalities represented within the Sound were restructured to form seven municipalities. The old and new municipalities are as follows:

OLD MUNICIPAL STRUCTURE	**NEW MUNICIPAL STRUCTURE**
SIMCOE COUNTY:	
Tiny Township	Tiny Township
Flos Township Village of Elmvale	Springwater Township
Town of Penetanguishene Town of Midland	Town of Penetanguishene Town of Midland
Village of Port McNicoll Village of Victoria Harbour Township of Tay	Township of Tay
Township of Medonte Township of Oro	Township of Oro-Medonte
Township of Matchedash Township of Orillia Village of Coldwater	Township of Severn

As many groundwater studies and well records were filed under the old municipal names, they are used throughout the text of this chapter.

<u>NOTE</u>: A Key Map was included as part of the figures for this chapter. Those who wish to make a hard copy of the chapter can also make a transparency of the Key Map and use it for orientation purposes with the other figures.

8.2 LAND USE

The Sound includes the following types of land use:

- woodlots (includes reforested and pastured woodlots),
- intensive agriculture (corn, mixed, grain, and hay systems),
- non-intensive agriculture (pasture and grazing systems),

- row crops (corn and beans),
- specialty crops (field vegetables, market gardens, berries, tobacco, nurseries, and sod farms),
- non-agricultural lands (idle lands, extractions pits, and dumps),
- urban areas (includes recreational lands), and
- organic soils (marshes, bugs, and swamps).

8.3 GROUNDWATER USE

The number of water wells within the Sound has increased steadily from about 200 wells in 1965 to 3,211 wells in 1995. Of these, 1,103 (34. 3%) are bedrock wells, 1,958 (61.0%) are overburden wells and the remaining 150 (4.7%) are of unknown type. Most of the wells (85%) are being used for domestic water supply. The remaining wells are being used for livestock watering, municipal, commercial, industrial, irrigation, cooling, and mixed use purposes.

The following groundwater concerns have been identified within the Sound:

- concerns related to potential groundwater contamination from road de-icing, gasoline service stations, septic systems, closed and open landfill sites, dry cleaning operations, and decommissioning of industrial sites;
- concerns related to mining of groundwater by high capacity water takings (municipal supplies, industrial supplies, golf courses, irrigation, and bottled water);
- concerns related to quantity interference with shallow aquifers by high capacity water takings;
- concerns related to the protection of groundwater recharge areas, wetlands, and susceptible areas to contamination; and
- concerns related to the ownership of groundwater.

8.4 PHYSIOGRAPHY

Chapman and Putnam (1984) identified three physiographic regions in the Sound namely, the Georgian Bay Fringe, the Simcoe Lowlands and the Simcoe Uplands. The Georgian Bay Fringe physiographic region area forms a broad belt bordering Georgian Bay and occupying large parts of Muskoka and Parry Sound. The region occupies an almost continuous strip across the north-eastern parts of the Sound and extends further north along the shorelines of Georgian Bay from Matchedash Bay to Beausoleil Island. A major part of the region was covered by glacial Lake Algonquin and it is characterized by low relief, shallow soil, and bare rock knobs and ridges.

The Simcoe Lowlands physiographic region extends from Georgian Bay to Lake Simcoe.

The surface elevation of this within the Sound ranges from 177 to 250 m (a.s.l.). The region consists mainly of flat-floored valleys, which were flooded by glacial Lake Algonquin. On both sides of the valleys, shore cliffs, beaches and terraces, left during the various stages of glacial Lake Algonquin, can be traced for long distances. The floors of the valleys are covered by glaciofluvial, glaciolacustrine and recent deposits of mud, peat, and muck. In addition, large outcrops of Ordovician limestone are found within the North River watershed and are considered part of the Simcoe Lowlands physiographic region. These strata are generally flat-lying, with a low dip of about 5 meters per kilometre to the southwest (Deane 1950).

The Simcoe Uplands physiographic region consists of a series of broad, rolling till plains separated by steep-sided, flat-floored valleys. The surface elevations within this region range from 250 to 412 m (a.s.l.). Most of the till plains are encircled by numerous shorelines, indicating that they were islands in glacial Lake Algonquin. The till plains occur throughout the central parts of the Sound as well as in the Penetang Peninsula where they were probably submerged in glacial Lake Algonquin.

The Bass Lake Kame Moraine is also considered a part of the Simcoe Uplands physiographic region. The moraine, which consists mainly of sand and gravel with minor amounts of clay or boulders, is located along the south-eastern boundaries of the drainage area and is characterized by rolling, kettle and knob topography.

8.5 BEDROCK TOPOGRAPHY AND GEOLOGY

The topography of the bedrock within the Sound was determined based on the surficial distribution of Precambrian and Palaeozoic rocks and the records of 1,079 water wells and exploration boreholes. Figures Se-1 shows the bedrock elevations within the Sound area. The figure indicates that the bedrock elevations range from over 250 m to less than 120 m (a.s.l.). Highest elevations are found in the northeastern parts of the Sound area where the Palaeozoic rocks are either at or very close to the surface. They are also found within three dome-like structures located immediately north of Bass Lake. The lowest bedrock elevations are found in the southwestern part of the Sound area.

Figure Se-1 also indicates that the Sound contained two major drainage systems before the Quaternary Period. The two systems were separated by a series of dome-like structures that extended in an east-westerly direction immediately to the north of Bass Lake and then continued in a north-westerly direction to Sturgeon Bay. Surface water to the south and south-west of the bedrock ridge drained towards an extensive bedrock valley known as the Laurentian Channel, which extended from Georgian Bay towards Cook Bay on Lake Simcoe and further to Lake Ontario (Singer et al. 1997).

The bedrock in the Sound consists of Palaeozoic sedimentary rocks of Middle and Upper Ordovician age resting on a Precambrian basement (Figure Se-2). Young Quaternary deposits cover most of the Palaeozoic rocks. The Precambrian rocks are mostly obscured by a cover of Palaeozoic and Quaternary deposits. However, these rocks occur at the surface or very close to the surface within a narrow strip that extends along the northern borders of the Sound from Maple Valley in the east to Matchedash Bay in the west, and along the eastern shores of Georgian Bay northward to Honey Harbour and Beausoleil Island.

The Precambrian rocks within the Sound consist mainly of tonalite, granodiorite, monzonite, granite, syenite, gneiss, anorthosite and gabbro. According to Easton (1992), these rocks are part of the Central Gneiss Belt of the Grenville Province which is the youngest part of the Canadian Shield.

A succession of Palaeozoic sedimentary rocks of Middle Ordovician age overlies the Precambrian rocks over most of the Sound. Limestones outcrop at the surface at several locations in Medonte, Orillia and Tay Townships and form a narrow, limestone plain that extends along the southern rim of the Canadian Shield to Port McNicoll on Georgian Bay.

The Palaeozoic rocks belong to the Basal and Simcoe Groups of the Middle Ordovician age. Four formations of Middle Ordovician age have been identified within the Sound area. These formations include the Shadow Lake Formation of the Basal Group and the Gull River, Bobcaygeon, and Verulam Formations of the Simcoe Group (Johnson et al.1992).

The Shadow Lake Formation is the oldest of the Palaeozoic formations within the Sound area. Its contact with the overlying Gull River Formation is commonly gradational and is placed at the first significant carbonate bed (Liberty, 1969). The formation unconformably overlies the Precambrian basement and occurs at surface as a thin, narrow band to the east of Maple Valley and to the north of Carlyon in Orillia Township as well as at Waubaushene in Tay Township. Due to its relative thinnest, the Shadow Lake Formation and overlying Gull River Formation are commonly portrayed as a single unit (Figure Se-2).

The Shadow Lake Formation consists of shale, sandstone, limestone and conglomerate. Its thickness differs from place to place. In Tay, western Matchedash, and Medonte areas, the formation ranges in thickness from 0.0 to 12 m (Derry et al. 1989).

The Gull River Formation is the oldest unit of the Simcoe Group and it conformably overlies the rocks of the Shadow Lake Formation throughout the Simcoe County area. The unit represents deposition within a supratidal to intertidal, flat environment with coarser-grained beds representing storm deposition.

Armstrong and Anastas (1992) tentatively subdivided the Gull River Formation into two informal members, the lower and upper, which approximately correspond to the lower and middle members of Liberty (1969). Within the Sound, the lower member of the Gull River Formation consists of argillous, fine-grained, dolomitic limestones and dolostones; fine-grained, fossiliferous limestones; medium-grained limestones; and micritic to very fine-grained, sparsely to very fossiliferous limestones. The upper member of the Gull River Formation consists of micritic to very fine-grained, sparsely fossiliferous limestone. This upper member is completely exposed in the Medonte and Uhthoff quarries (Armstrong and Rheaume 1993).

The Bobcaygeon Formation overlies the Gull River Formation and it is generally more fossiliferous. The fauna, grain size and sedimentary features of the formation suggest a shallow, subtidal, depositional environment. Liberty (1969) subdivided the Bobcaygeon Formation into three members, lower, middle and upper. The lower member of the Bobcaygeon Formation consists of 6 to 8 m of grey-brown, very-fine- to coarse-grained, moderately fossiliferous limestones. The middle member consists of about 6 m of light to medium brown, fine- to coarse- grained, moderately fossiliferous limestones, which are interbedded with grey-green, calcareous shales. The upper member consists of approximately 10 m of light grey-brown to blue-grey, fine- to coarse-grained, fossiliferous, limestones (Armstrong and Rheaume 1993).

Conformably overlying the Bobcaygeon Formation are the interbedded limestones and shales of the lower member of the Verulam Formation. This unit occurs in a very small area to the southwest of Allenwood in Flos Township where it is covered by a thick mantle of Quaternary deposits. Its distribution in this area has been established from well records (Liberty 1969).

8.6 OVERBURDEN THICKNESS AND GEOLOGY

Most of the bedrock within the Sound area is obscured by a mantle of unconsolidated overburden sediments which were deposited during the Late Wisconsinan Stage of the Quaternary Period. These deposits occur mainly in the Simcoe Uplands and Simcoe Lowlands physiographic regions.

Figure Se-3 shows the spatial distribution of overburden thickness within the Sound area. The figure is based on data obtained from geologic logs of deep boreholes and the records of 1,536 wells. These wells either penetrate the bedrock or are deep overburden wells.To obtain additional accuracy, the surface elevations of those areas where the bedrock outcrops at the surface were also used in the compilation of the figure.

As expected, the thickness of the overburden in areas where the Precambrian and Palaeozoic rocks are at or close to the surface is small and ranges from 0 to less than 20 m. The thickness of the overburden increases gradually along a front extending in an easterly-northwesterly direction. This front extends from areas located to the north of Bass Lake in the east to areas located west of Midland in the northwest.

The maximum thickness of the overburden (120 to over 140 m) is found along an axis that extends from the southern boundaries of the Sound through Orr Lake until it reaches the western boundary. To the southwest of this axis, the overburden thickness starts to decrease to a range of 80 -120 m. Other thick overburden deposits are found within the area of the Bass Lake Kame Moraine. The maximum thickness of the overburden in this area ranges from 80 to 100 m along an axis that extends in a north-southerly direction to the west of Bass Lake.

The overburden deposits within the Sound consist of glacial, glaciofluvial, glaciolacustrine, and recent deposits. The following sections provide brief descriptions of these deposits.

8. 6.1 Glacial Deposits

Most of the glacial deposits within the Sound have a sandy silt to a silty matrix and are commonly rich in clasts. These tills were mapped by Barnett et al.(1991) as "Map Unit 19" on the OGS Map 2556. Other tills, which have a fine-grained, clast poor, predominantly silty clay to silt matrices, outcrop at the surface in a few small locals. These tills were mapped by Barnett (1991) as "Map Unit 21" on the OGS Map 2556.

The tills within the Sound consist of broad rolling plains; ground moraine, and drumlins. The till plains, which formed islands within proglacial Lake Algonquin, are surrounded by abandoned beaches. A thin layer of ground moraine covers the bedrock in parts of the northeastern and northern parts of the Sound. The greater part of the drumlin-field areas, the swales between the drumlins, and the gently rolling hills that are not definite enough to be called drumlins are also classified as ground moraine.

Most of the drumlins within the Sound occur along its eastern boundaries in Orillia Township. A few drumlins occur also in the areas between Sturgeon Bay and Hog Bay, and between Hog Bay and Midland Bay in Tay Township. The drumlins are composed mainly of a till with some stratified sand and gravel on the top, ends, or sides. The orientation of the long axes of the drumlins is northeast to southwest, which reflects most probably the orientation of the ice movement during the last readvance of the glacier (Figure Se-4).

Available data indicate that additional tills occur under the surface within the Sound. Barnett (1991), in a preliminary report on the stratigraphic drilling of Quaternary sediments in Barrie area, Simcoe County, described the geologic logs of 5 deep boreholes drilled in Medonte and Oro Townships. Three of these boreholes (OGS - 90 - 5, OGS - 90 -7 and OGS - 90 -14) reached the bedrock and provide complete profiles of the Quaternary section. Till-like, diamicton materials, separated by thick sequences of gravel, sand, silt and clay, were found at different depths in all the boreholes. The exact number of buried tills within the Sound, however, is not known.

8.6.2 Glaciofluvial Deposits

One of the most important ice-contact deposits within the Sound area is the Bass Lake Kame Moraine, which can be found at or near the surface south of Bass Lake. The moraine, which occupies the southern half of the Sound area and continues beyond its boundaries, is approximately 25 km long with a maximum width of 8 km. The surface elevation of the moraine ranges from about 275 to 412 m (a.s.l.). It is characterized by a hummocky topography with extensive kettles and knolls, tunnel channels, small dunes, and steep ice-contact slopes along its northern boundaries. The material of the moraine is mainly sand and gravel with only minor amounts of clay or boulders, and is water sorted to varying degrees.

Other ice-contact deposits are found to the north of Warminster and south of Fair Valley in the Coldwater River watershed, at various locations within the Sturgeon River watershed, and around Midland Park Lake. These deposits consist of fine to coarse-grained sand, gravelly sand and gravel with minor amounts of silt, clay, and flow till.

A small outwash deposit of well-sorted, fine to coarse-grained sand with minor gravel, silt and clay is found in the headwaters of the Coldwater River adjacent to the Bass Lake Kame Moraine. Other outwash deposits consisting mainly of medium to coarse sand with some boulders occur to the south and north of Orr Lake around earlier "Algonquin Islands", and also west of Midland Park Lake. The Coldwater River, the Hog Creek, and Wye River have cut channels through these outwash deposits.

The origin of the outwash deposits is fluvial or deltaic. As the glacier melted, streams loaded with sediment flowed away and deposited their load of sand and gravel in valleys or in deltas. Compared to the ice-contact deposits, the outwash deposits are generally more uniform. Their texture varies from silt to fine sand to coarse gravel, and their bedding is generally horizontal.

The flat to undulating topography of the outwash deposits has been modified by subsequent actions of Lake Algonquin waters producing boulder strips and some depressions on the surface. According to Burwasser and Boyd (1974), much of the outwash sand between the "Algonquin Islands" in the Orr Lake sheet has been reworked so completely that it is mapped as lacustrine sand. On the edges of the "Islands" and below the Algonquin bluff is a deposit, mapped as winnowed outwash, of medium to fine sand. These sands contain numerous boulders, some exceeding 2 metres in their longest dimension.

8.6.3 Glaciolacustrine Deposits

Extensive deposits of glaciolacustrine origin occur at the surface within the study area. They consist of very fine to medium-grained sand with silt and minor clay. These horizontally bedded deposits are found mainly in the headwaters of the North and Coldwater Rivers, over most of the valley of the Sturgeon River, around Orr Lake, and along the western boundaries of the study area.

The thickness of the glaciolacustrine deposits is highly variable. Within the Precambrian, rock-knob lowlands in the northern parts of the Sound, the deposits are generally thin, but can vary greatly within short distances. In areas, where the Palaeozoic rocks are close to the surface, the deposits are thin and uniform. In other areas, where deep boreholes were drilled in Medonte and Orillia Townships, the total thickness of the glaciolacustrine deposits is over 60 m.

The glaciolacustrine deposits within the Sound include abandoned beaches, sand plains, and clay plains. Abandoned beaches consisting of gravel and sand deposits are found around the "Algonquin Islands" within the Sound. At many places within the Sound, the abandoned beaches are poorly developed, but in many other places, however, one, two or three levels of well-developed beaches can be traced for long distances. These cascading beaches can be found particularly around Orr Lake, along both sides of the valleys of the Hog Creek and Wye River, and to the southwest of Midland Park Lake.

Clay flats of glaciolacustrine origin are most common in the depressions within the Sound, and are found in the middle sections of the North, Coldwater and Sturgeon Rivers and the Hog Creek. These glaciolacustrine clays also cover a large area extending from the south of Wye Marsh to the headwaters of the Wye River. In addition clay deposits that are varved with silt are found in the low central part of the Orr Lake area along the Wye River.

The thickness of the clay deposits vary from place to place. The records of water wells drilled for the Village of Elmvale indicate that the clays in some locations extend to depths of over 38 m. The well records in the vicinity of the Village of Coldwater show that the clay deposits are 6 to 20 m thick. Fine-grained silts and clays, 23 m thick, were also reported in water wells to the south of the Silver Creek Mobile Home Park in Orillia Township.

8.6.3 Recent Deposits

Accumulations of organic matter of mud, peat, muck and marl are found in many low, inadequately drained parts of the study area. The largest such deposits are found in Tiny Marsh, which is located in the southwestern corner of the study area and covers a surface area of about 8 km^2 of open marsh land. Modern alluvium deposits of gravel, very fine to coarse-grained sand, silt and clay occur along stream channels within the study area. These deposits are probably composed of reworked glaciolacustrine sediments.

8.7 GROUNDWATER OCCURRENCE IN THE BEDROCK

Five hydrogeologic units were identified within the bedrock in the Sound (Singer et al. 1996). These units include the Precambrian rocks, and the Shadow Lake-Gull River, Bobcaygeon and Verulam Formations.

From a hydrogeologic point of view, only those Precambrian rocks that are at or close to the surface within the northern parts of the Sound are significant as a source of groundwater supplies. The remaining Precambrian rocks are buried under thick sequences of younger rocks of Palaeozoic and Quaternary ages and, therefore, cannot be tapped for groundwater.

In their study of the hydrogeology of the Sound, Singer et al.(1999) identified 202 wells completed within the Precambrian rocks with short-duration, pumping test data. These data were used to estimate the transmissivity distribution for the wells. Since the availability of fractures and fissures within the Precambrian rocks is depth dependent, two suitable samples that reflect the degree of penetration of these rocks were selected from the available data. The first sample consisted of 87 wells whose depths of penetration are less than 20 m, and the second sample consisted of 125 wells whose depths of penetration are more than 20 m.

The minimum and maximum transmissivity values determined for the first sample were estimated to range from 0.50 to 1,485 m^2/day, respectively, and the geometric mean was estimated to be 5.6 m^2/day. The minimum and maximum transmissivity values for the second sample were estimated to range from 0.06 to 1,552 m^2/day, respectively, and the geometric mean was estimated to be about 1 m^2/day.

Based on the estimated transmissivity values for the two samples, Singer et al.(1999) concluded that the upper 20 m of the Precambrian rocks within the Sound have higher water-yielding capabilities compared to deeper rocks. Further, the low values of the geometric means for the transmissivity distributions of both samples indicate that the Precambrian rocks have a poor water-yielding capability.

The Shadow Lake and Gull River Formations are at or close to the surface within a strip extending from the eastern boundaries of the Sound towards the southern shores of Georgian Bay through to the area's western boundaries. Since it is not possible to distinguish between the two formations in the records of water wells drilled in this strip, the formations were combined into one hydrogeologic unit. Singer et al.(1999) identified 429 wells within the unit with suitable, short-duration data on pumping tests. The data were divided into two samples. The first sample consisted of 301 wells which penetrate the unit for less than 20 m, and the second sample consisted of 128 wells which penetrate the unit for more than 20 m.

The minimum and maximum transmissivity values for the first sample were estimated to range from 0.1 to 3,175 m^2/day, respectively, and the geometric mean of the sample's transmissivity distribution was estimated to be about 12 m^2/day. The minimum and maximum transmissivity values for the second sample were estimated to range from 0.05 to1,455 m^2/day, respectively, and the geometric mean of the second sample's transmissivity distribution was estimated to be about 2 m^2/day. Singer et al.(1999) concluded that the probability of finding more water in the Shadow Lake-Gull River hydrogeologic unit is higher within its upper 20 m. Given the relatively small water-yielding capability of the unit, however, it is doubtful that it contains a well-developed system of interconnected solution cavities.

Rocks of the Bobcaygeon Formation overly the rocks of the Gull-River Formation and cover most of the southern parts of the Sound. These rocks are obscured, however, by thick deposits of Quaternary origin. Singer et al.(1999) identified 148 wells within the formation with suitable, short-duration data on pumping tests. The data were divided into two samples. The first sample consisted of 84 wells which penetrated less than 20 m of the unit, and the second sample consisted of 72 wells which penetrated more than 20 m of the unit.

The minimum and maximum transmissivity values for the first sample were estimated to range from 0.25 to 1,696 m^2/day, respectively, while the value of the geometric mean of the transmissivity distribution was estimated to be about 8 m^2/day. The minimum and maximum transmissivity values for the second sample were estimated to range from 0.08 to 703 m^2/day, respectively, while the value of the geometric mean of the second sample's transmissivity distribution was estimated to be about 5 m^2/day. Singer et al.(1999) concluded that the probability of finding more water in the formation is higher within its upper 20 m and that the water-yielding capability of the formation is fair.

The rocks of the Verulam Formation occur within a small locality at the southwestern corner of the Sound. These rocks are buried under thick sequences of Quaternary deposits and no water wells tap the formation. Therefore, from a hydrogeologic point of view, the Verulam Formation is of little significance as a source of groundwater within the study area.

8.8 GROUNDWATER OCCURRENCE IN THE OVERBURDEN

In general, the availability of groundwater in the overburden ranges from poor to good. Most wells in the overburden are used to meet domestic supplies and livestock watering requirements. Locally, overburden aquifers are the most productive sources of groundwater within the Sound and provide a number of urban areas with water supplies.

A large number of wells are completed in areas where till deposits outcrop at the surface within the Sound. Singer et al.(1999) identified a sample of 710 such wells that have short-term data related to pumping tests and estimated their transmissivity distribution. The minimum and maximum transmissivity values for the sample were estimated to range from 0.3 to15,784 m^2/day, respectively, and the geometric mean of the sample was estimated to be about 45 m^2/day.

Singer et al.(1999) also identified a sample of 117 wells with data related to short-term pumping tests. The wells are completed in areas where ice-contact deposits outcrop at the surface. The pumping test data were used to determine the transmissivity distribution for the sample. The minimum and maximum transmissivity values were estimated to range from 1 to 10,526 m^2/day, respectively, and the geometric mean was estimated to be 126 m^2/day.

A sample of 124 wells completed in outwash deposits have suitable data related to short-term pumping tests. Singer et al.(1999) used these data to determine the transmissivity distribution for the sample. The sample's minimum and maximum transmissivity values were estimated to range from 0.2 to 1,937 m^2/day, respectively, and the geometric mean was estimated to be about 65 m^2/day.

A sample of 383 wells completed in glaciolacustrine sand and gravel deposits have suitable data related to short-term pumping tests. Singer et al.(1999) used these data to determine the transmissivity distribution for the sample has been identified. The sample's minimum and maximum transmissivity values were estimated to range from 0.3 to 34,800 m^2/day, respectively, and the sample's geometric mean was estimated to be about 75 m^2/day.

A sample of 154 wells completed in glaciolacustrine clays have suitable data related to short-term pumping tests. Singer et al.(1999) used these data to determine the transmissivity distribution for the sample. The minimum and maximum transmissivity values were estimated to range from 0.14 to 1,262 m^2/day, respectively, and the geometric mean was estimated to be about 67m^2/day.

Singer et al.(1999) concluded, based on the analyses of the transmissivity distributions for wells completed in various overburden deposits, that wells completed in areas where glaciofluvial ice-contact and outwash deposits outcrop at the surface have the highest water-yielding capabilities. Wells completed in areas where till or glaciolacustrine clays are at the surface are in general less productive. Having said that, it is possible to have highly productive wells completed where till or glaciolacustrine deposits occur at the surface. This is due to the fact that the overburden profile is highly variable both vertically and horizontally, and any overburden well may encounter sand or gravel deposits at some depth.

8.9 SUGGESTED BEDROCK MONITORING AREAS

Figure Se-13 shows the locations of bedrock wells with specific capacities of over 50 l/min/m and the boundaries of suggested areas for monitoring groundwater in the bedrock. The susceptibility of groundwater to contamination in these areas was determined based on information related to the thickness and type of overburden materials above the bedrock (Figure Se-14).

Areas where groundwater in the bedrock is highly susceptible to contamination are defined as those where the bedrock is either near or at the surface or is covered by highly permeable sand and/or gravel deposits. Areas where the bedrock is moderately susceptible to contamination are defined as those where the overburden above the bedrock contains clay or clay till deposits that are less than 3 m in thickness. Areas where the bedrock has low susceptibility to contamination are defined as those where the overburden contains clay or clay till deposits that are more than 3 m in thickness. The term variable susceptibility to contamination is used for areas where the susceptibility of groundwater to contamination ranges from low to high.

Based on the above definitions, four areas (A, B, C, and D) are proposed for groundwater monitoring within the bedrock. Groundwater susceptibility to contamination within areas (A and B) is high. Area (A) extends along the northeastern topographic divide from Matchedash Bay to Maple Valley and it is underlain mainly by Precambrian rocks. Area (B) extends from Matchedash Bay to the Town of Midland and is underlain by the rocks of the Gull River and Shadow Lake Formations.

Areas (C and D) are underlain by the rocks of the Bobcaygeon Formation and the susceptibility of groundwater to contamination within these two areas is variable. Area (C) extends from the eastern topographic divide to the Village of Coldwater and occupies mainly the middle parts of the North River watersheds. Area (D), on the other hand, extends from the western topographic divide through the northern parts of the Wye River and the Hog Creek watersheds.

8.10 SUGGESTED OVERBURDEN MONITORING AREAS

Figure Se-15 shows the location of overburden wells with specific capacities of over 50 l/min/m, and the boundaries of suggested areas for groundwater monitoring. Groundwater within the suggested areas has a high, low or variable susceptibility to contamination. The susceptibility of groundwater to contamination in these areas was determined based on information related to the thickness and type of overburden materials (Figure Se-16).

Areas where the shallow overburden aquifers are highly susceptible to contamination are defined as those where sand and/or gravel deposits are either near or at the surface. Areas where shallow overburden aquifers are moderately susceptible to contamination are defined as those where the sand and/or gravel deposits are covered by clay or clay till deposits that are less than 3 m in thickness. Areas where the overburden aquifers have low susceptibility to contamination are defined as those where the overburden contains clay or clay till deposits that are more than 3 m in thickness. The term variable susceptibility to contamination is used for areas where the susceptibility of groundwater to contamination ranges from low to high.

Based on the above definitions, six areas (E, F, G, H, I, J, and K) are proposed for groundwater monitoring in the overburden. In addition, groundwater monitoring in Area (K) is optional. Groundwater susceptibility to contamination within areas (E, F, and J) is mainly high, within areas (G, H, and I) is variable, and within area (K) is low.

Area (E) is located between the eastern topographic divide and Bass Lake and it is underlain mostly by till and glaciolacustrine sand and gravel. Area (F) is within the Bass Lake Kame Moraine and is underlain mainly by glaciofluvial sand and gravel. Area (G) is located between Hillsdale and the southern topographic divide and is underlain by till. Area (H) forms the topographic divide between the Coldwater and Sturgeon Rivers and is underlain by till. Area (I) is underlain by till and it forms the upper parts of the Hog Creek watershed. Area (J) extends along the western topographic divide and is underlain mainly by glaciofluvial and glaciolacustrine sand and gravel deposits. Area (K) is located in the Elmvale area within the upper parts of the Wye River and is underlain by clay deposits.

8.11 HISTORICAL MONITORING WELLS

Three historical monitoring wells, which tap groundwater in the overburden, have been identified in the basin. The locations of these wells are as follows:

Well No. 118	The well is 33.53 m deep and located in Simcoe County, Town of Midland.
Well No. 144	The well is 3.66 m deep and located in Simcoe County, Orillia Township, Concession 6, Lot 19.
Well No. 146	The well is 5.49 m deep and located in Simcoe County, Tay township, Concession 8, Lot 9.

Figure Se-17 shows the locations of the historical monitoring wells and Appendix I gives the geographic coordinates of these wells.

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FIGURES

Key Map - Se — A transparency to be used with other figures for orientation purposes.

Figure Se - 1 — Bedrock topography in the Severn Sound drainage area.

Figure Se - 2 — Bedrock geology in the Severn Sound drainage area.

Figure Se - 3 Overburden thickness in the Severn Sound drainage area.

Figure Se - 4 Overburden geology in the Severn Sound drainage area.

Figure Se - 5 Bedrock wells with specific capacities equal to or less than 5 l/min/m.

Figure Se - 6 Bedrock wells with specific capacities between 5 and 25 l/min/m.

Figure Se - 7 Bedrock wells with specific capacities between 25 and 50 l/min/m.

Figure Se - 8 Bedrock wells with specific capacities higher than 50 l/min/m.

Figure Se - 9 Overburden wells with specific capacities equal to or less than 5 l/min/m.

Figure Se -10 Overburden wells with specific capacities between 5 and 25 l/min/m.

Figure Se -11 Overburden wells with specific capacities between 25 and 50 l/min/m.

Figure Se -12 Overburden wells with specific capacities higher than 50 l/min/m.

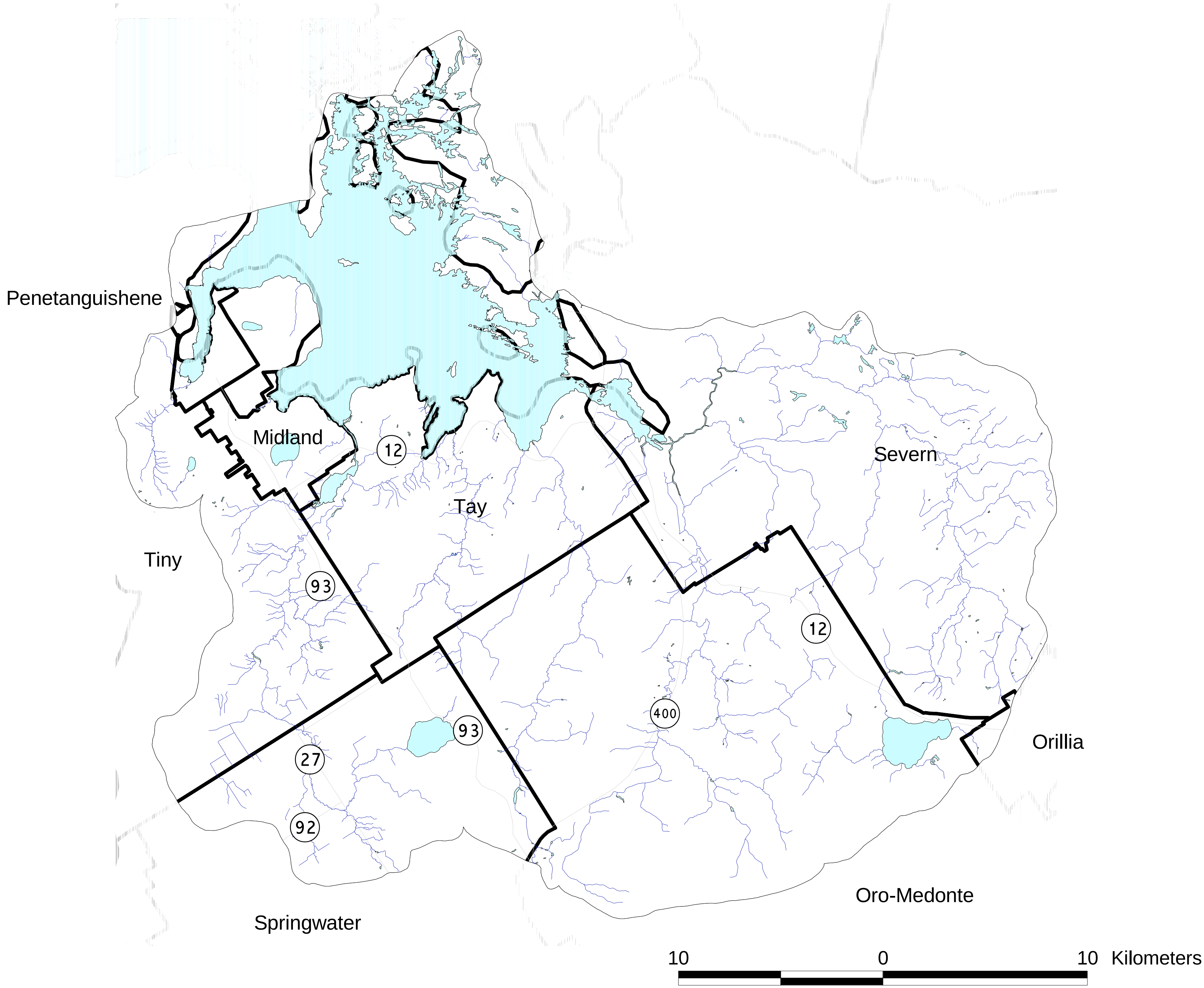
Figure Se -13 Suggested areas for monitoring groundwater in the bedrock.

Figure Se -14 Panel diagram showing the geologic logs of bedrock wells with specific capacities higher than 50 l/min/m.

Figure Se -15 Suggested areas for monitoring groundwater in the overburden.

Figure Se -16 Panel diagram showing the geologic logs of overburden wells with specific capacities higher than 50 l/min/m.

Figure Se - 17 Locations of historical monitoring wells in the Severn Sound drainage area.



Key Map - Se A transparency to be used with other figures for orientation purposes

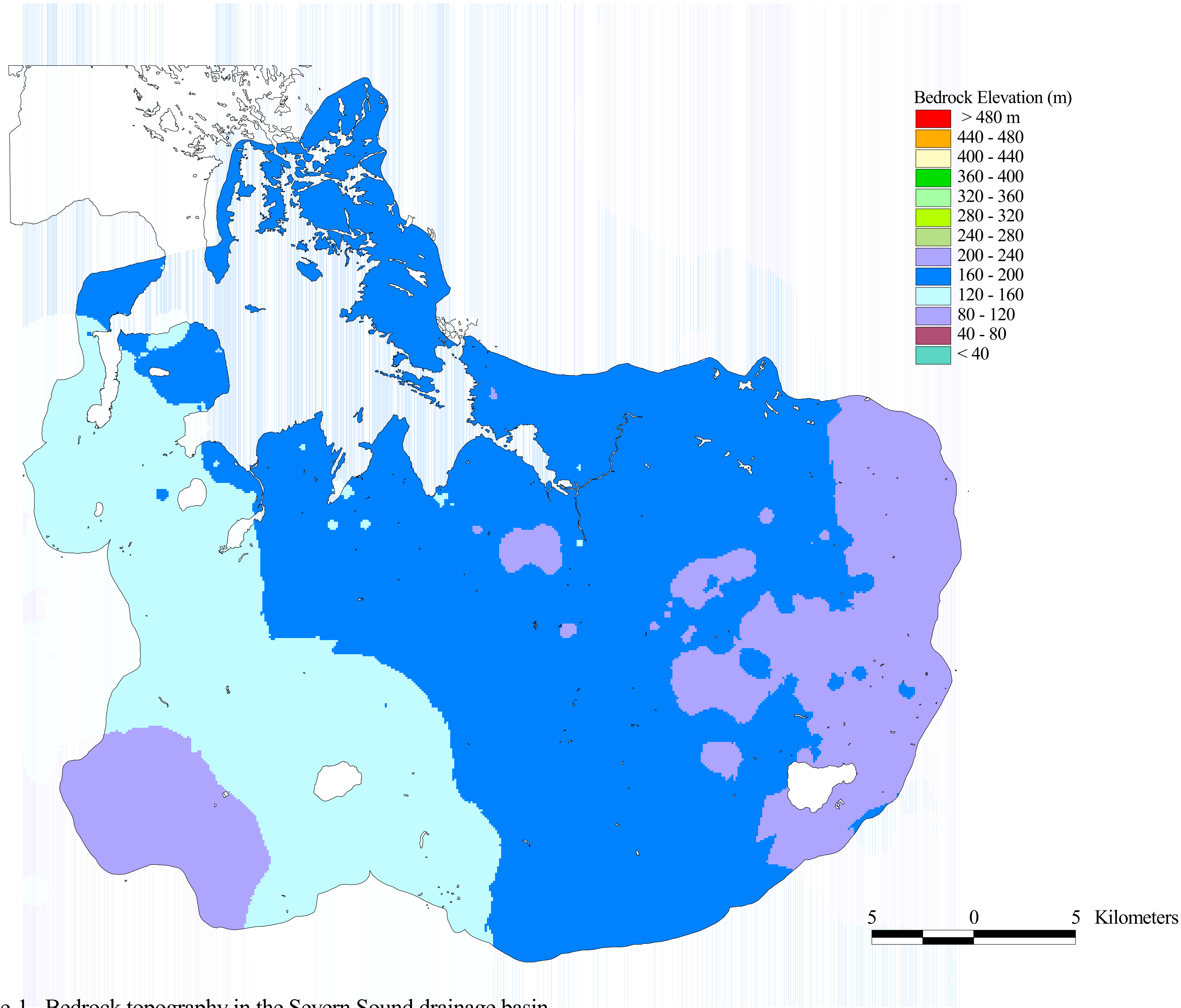


Figure Se-1. Bedrock topography in the Severn Sound drainage basin.

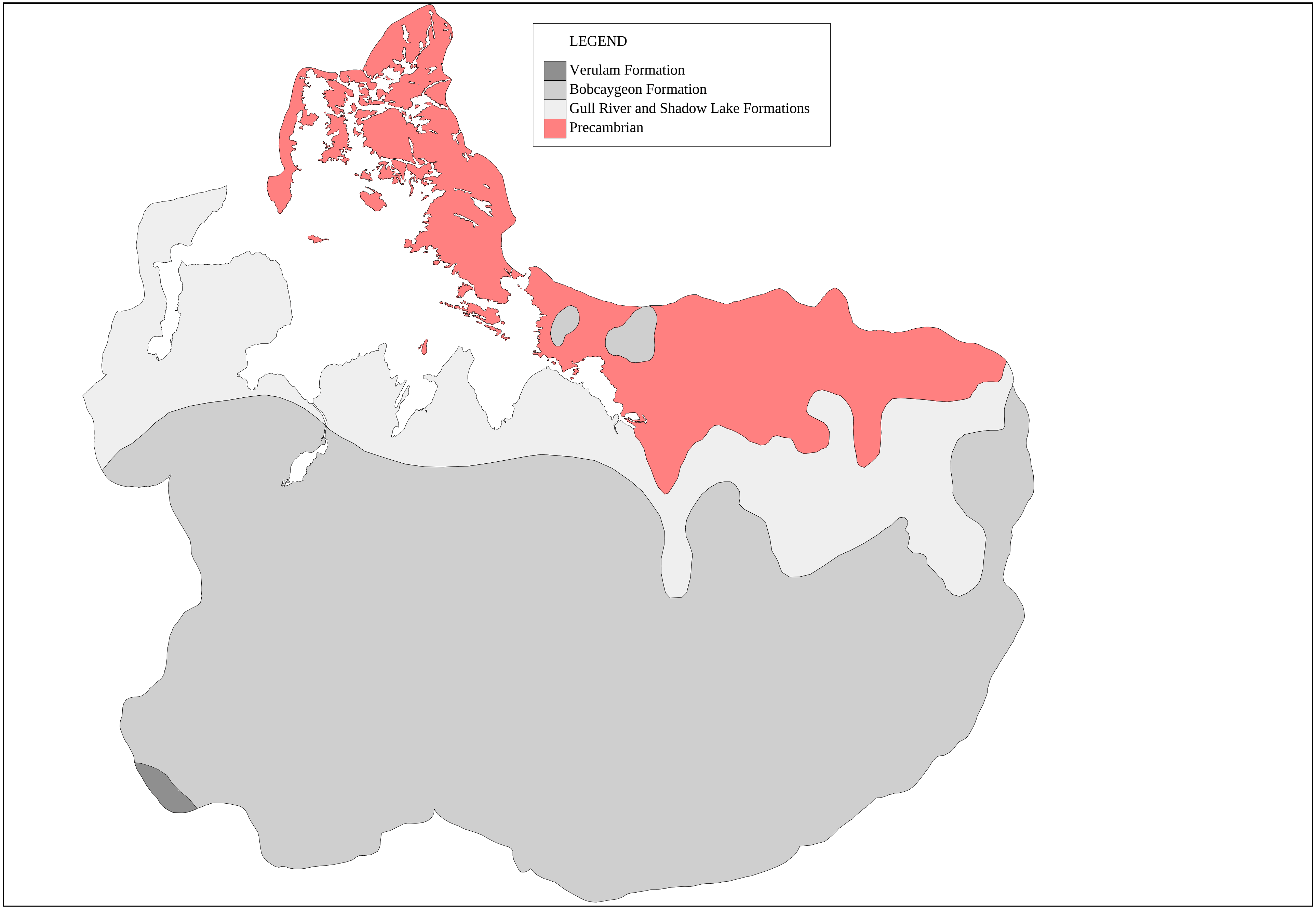


Figure Se-2. Bedrock geology in the Severn Sound drainage basin.

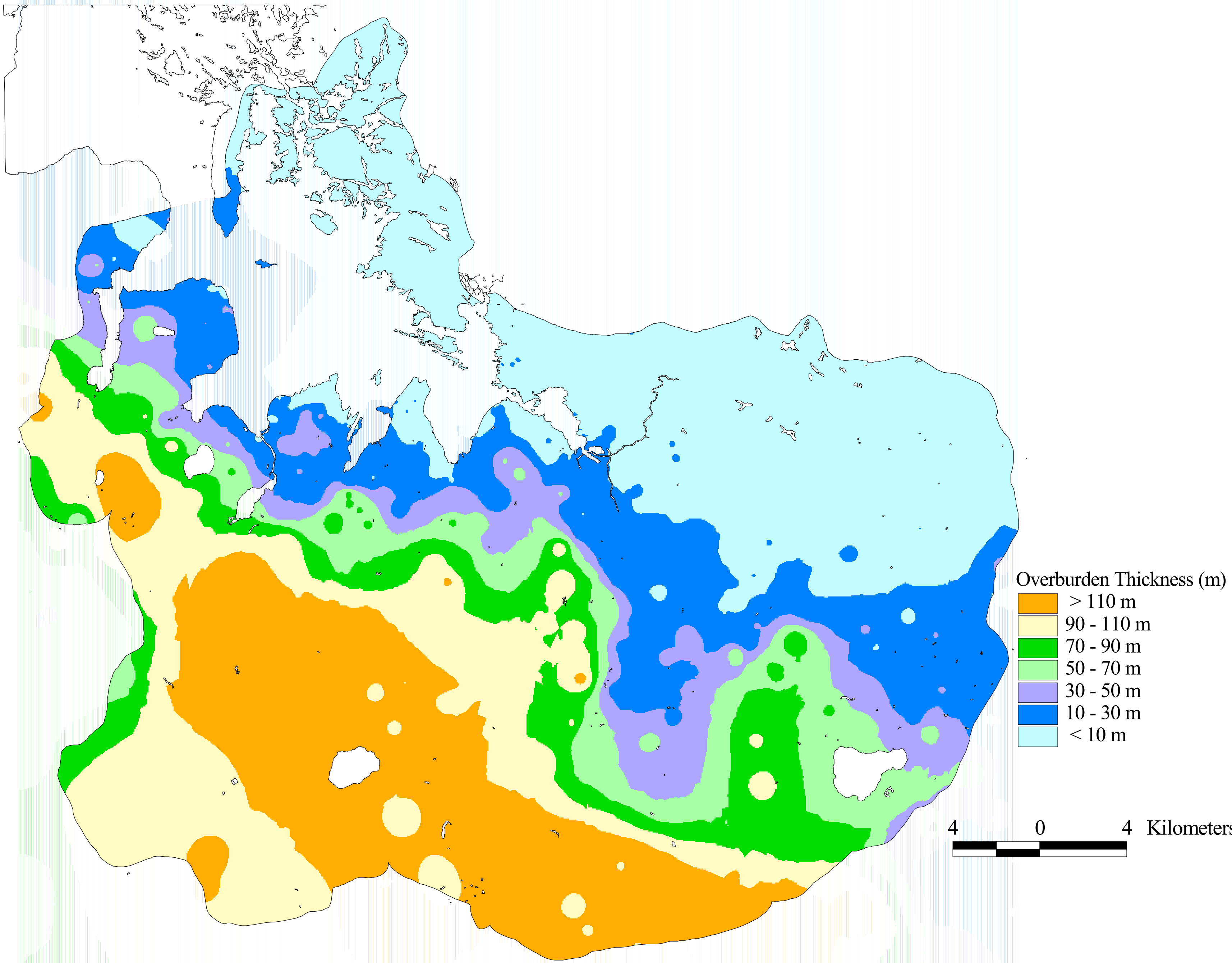


Figure Se-3. Overburden thickness in the Severn Sound drainage basin.

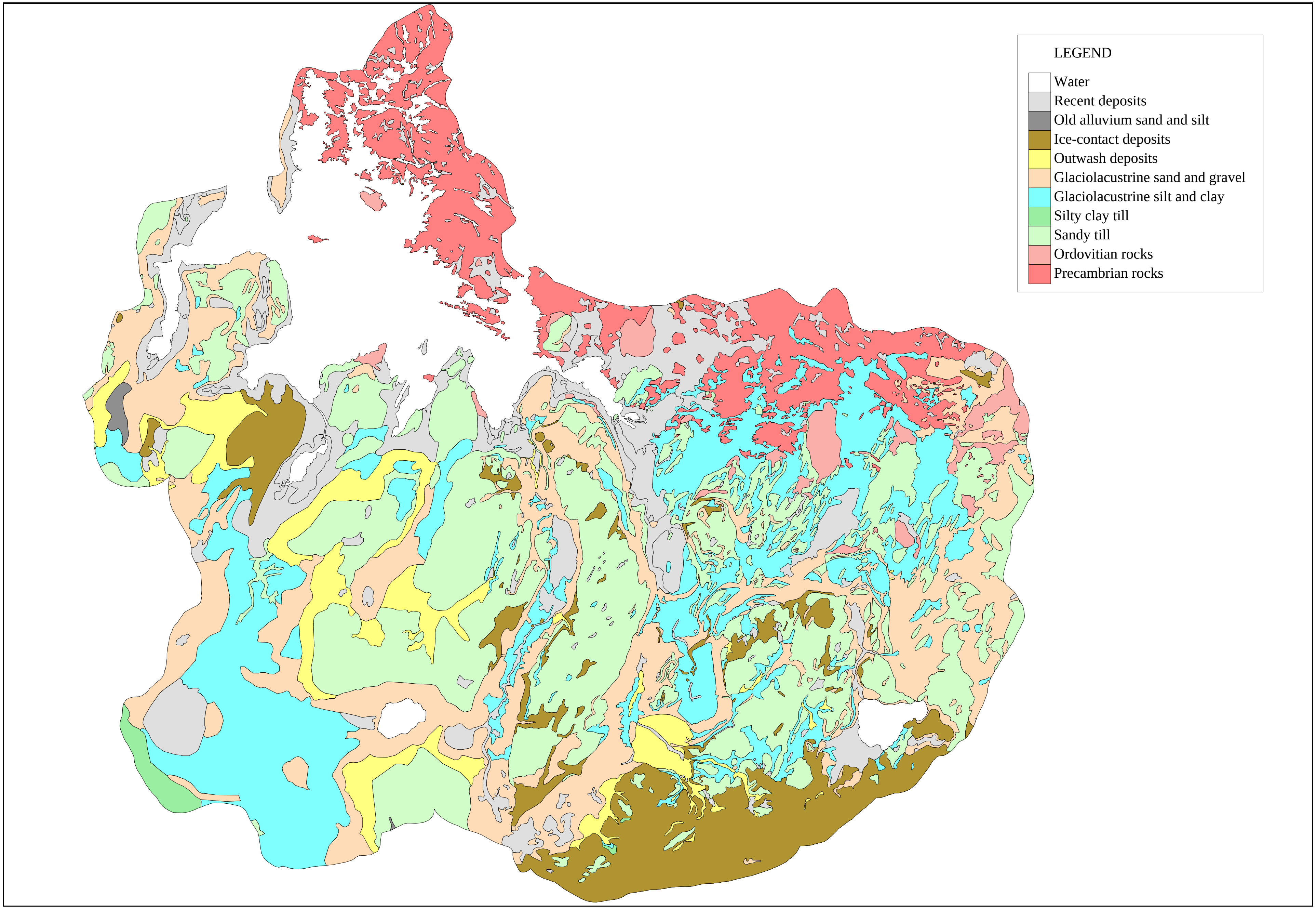


Figure Se-4. Overburden geology in the Severn Sound drainage basin.

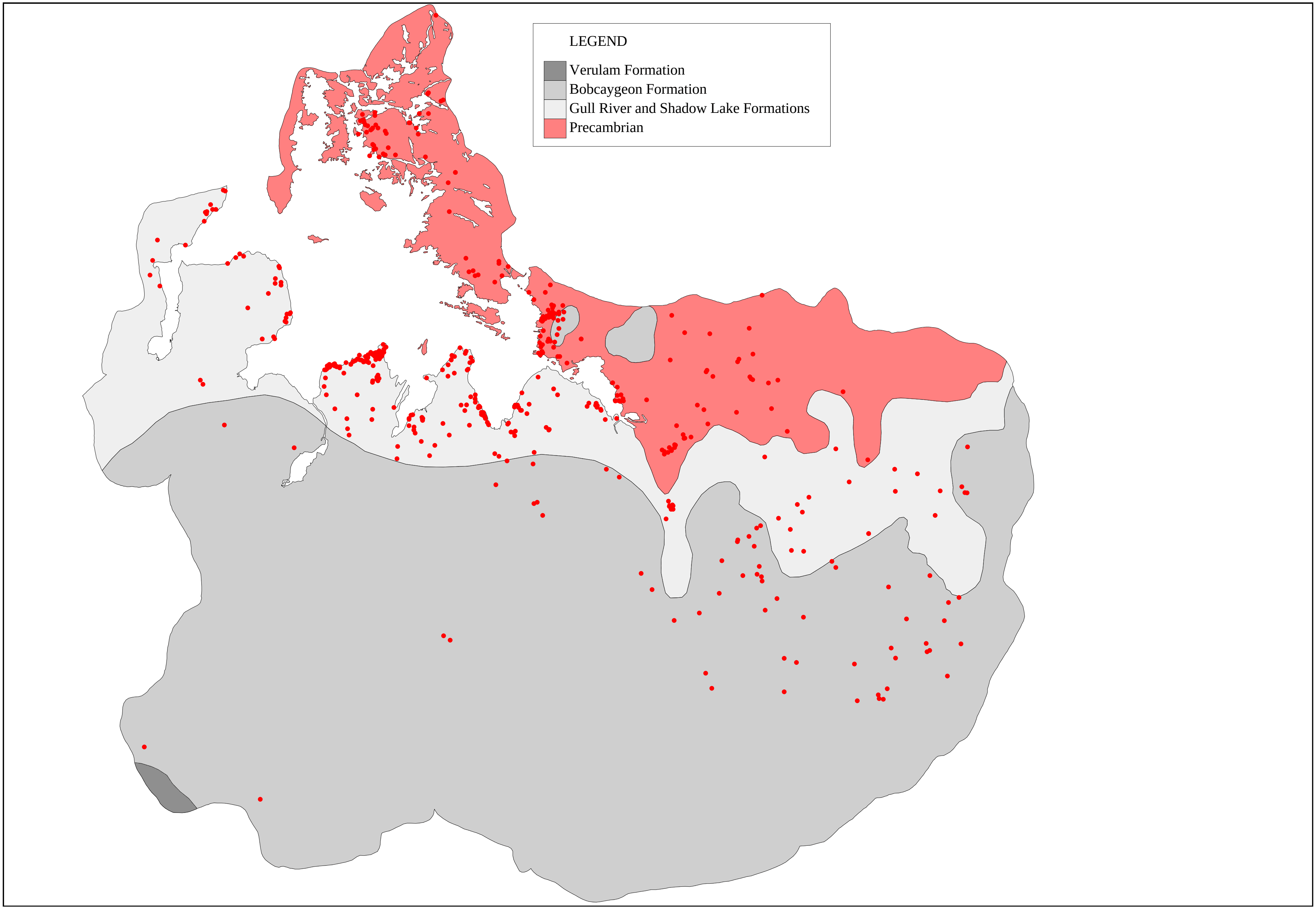


Figure Se-5. Bedrock wells with specific capacities equal to or less than 5 l/min/m.

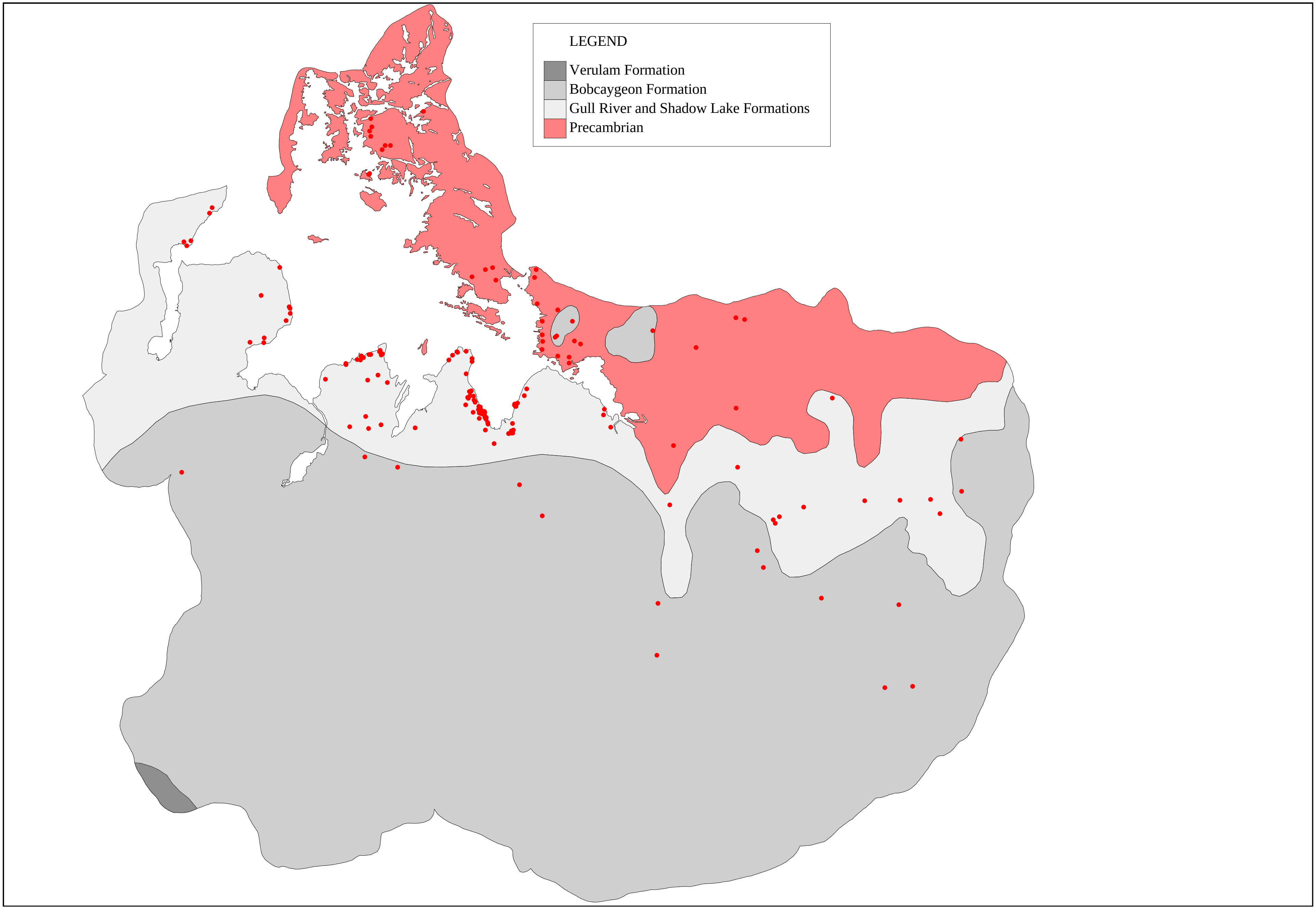


Figure Se-6. Bedrock wells with specific capacities between 5 and 25 l/min/m.

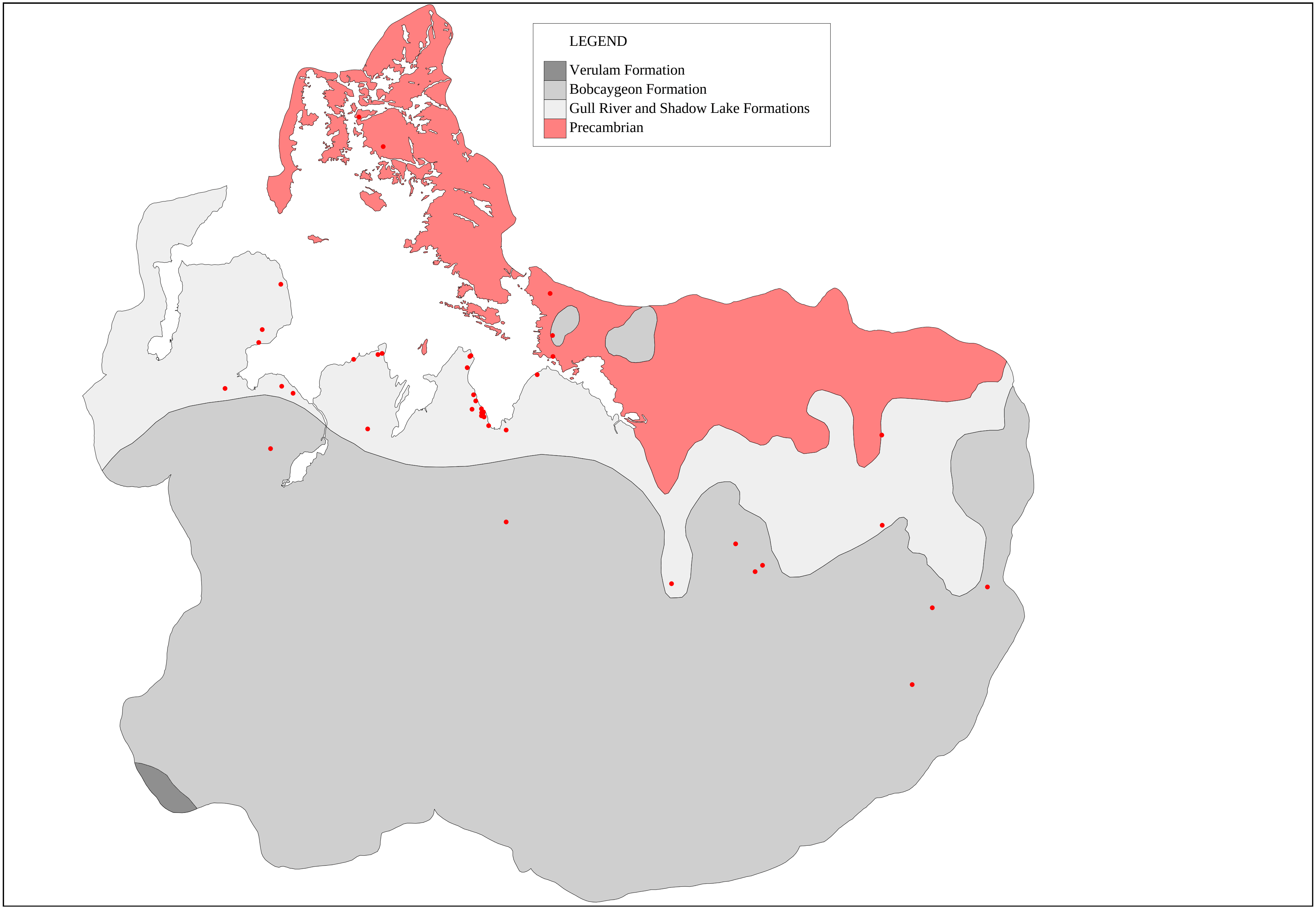


Figure Se-7. Bedrock wells with specific capacities between 25 and 50 l/min/m.

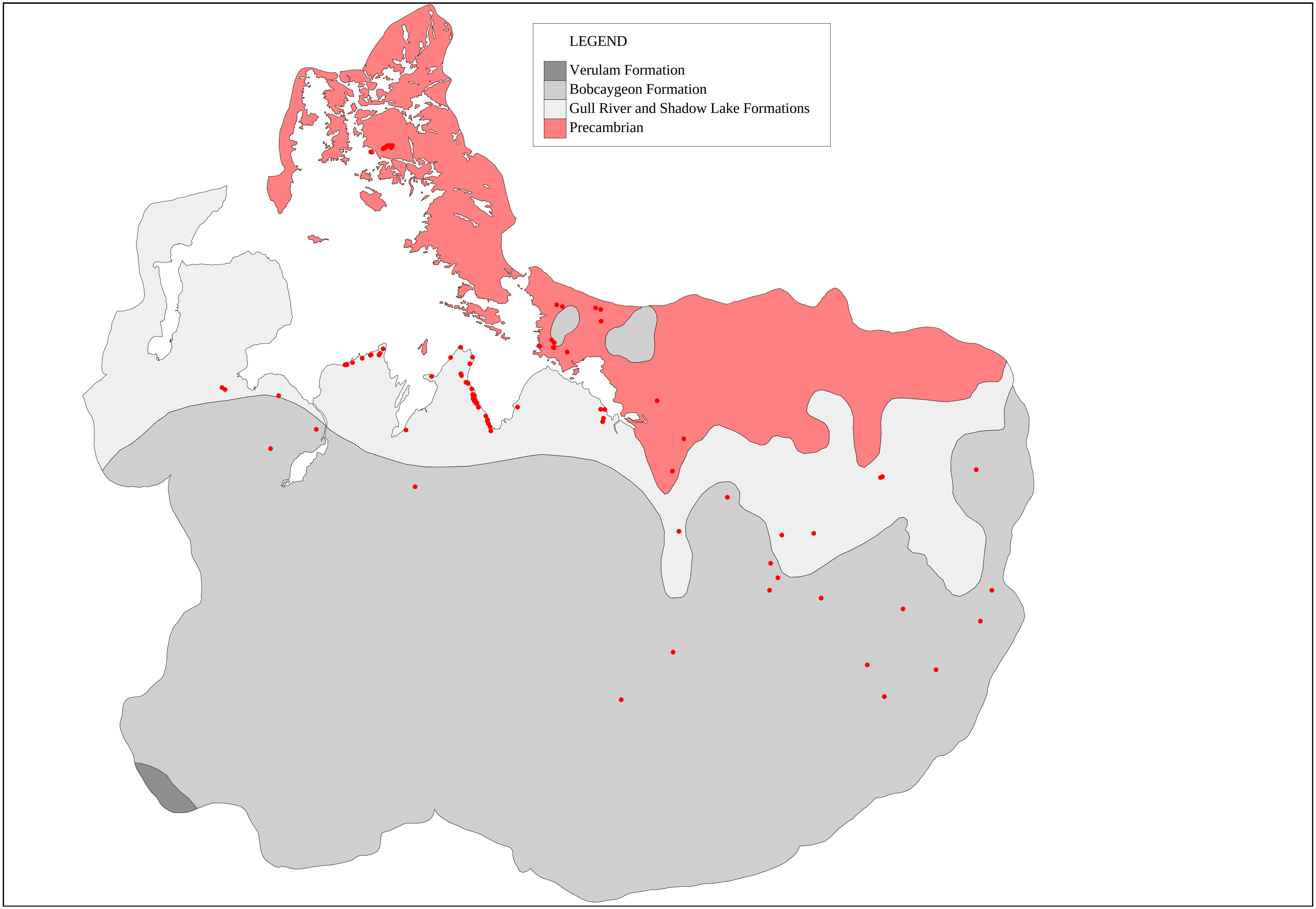


Figure Se-8. Bedrock wells with specific capacities higher than 50 l/min/m.

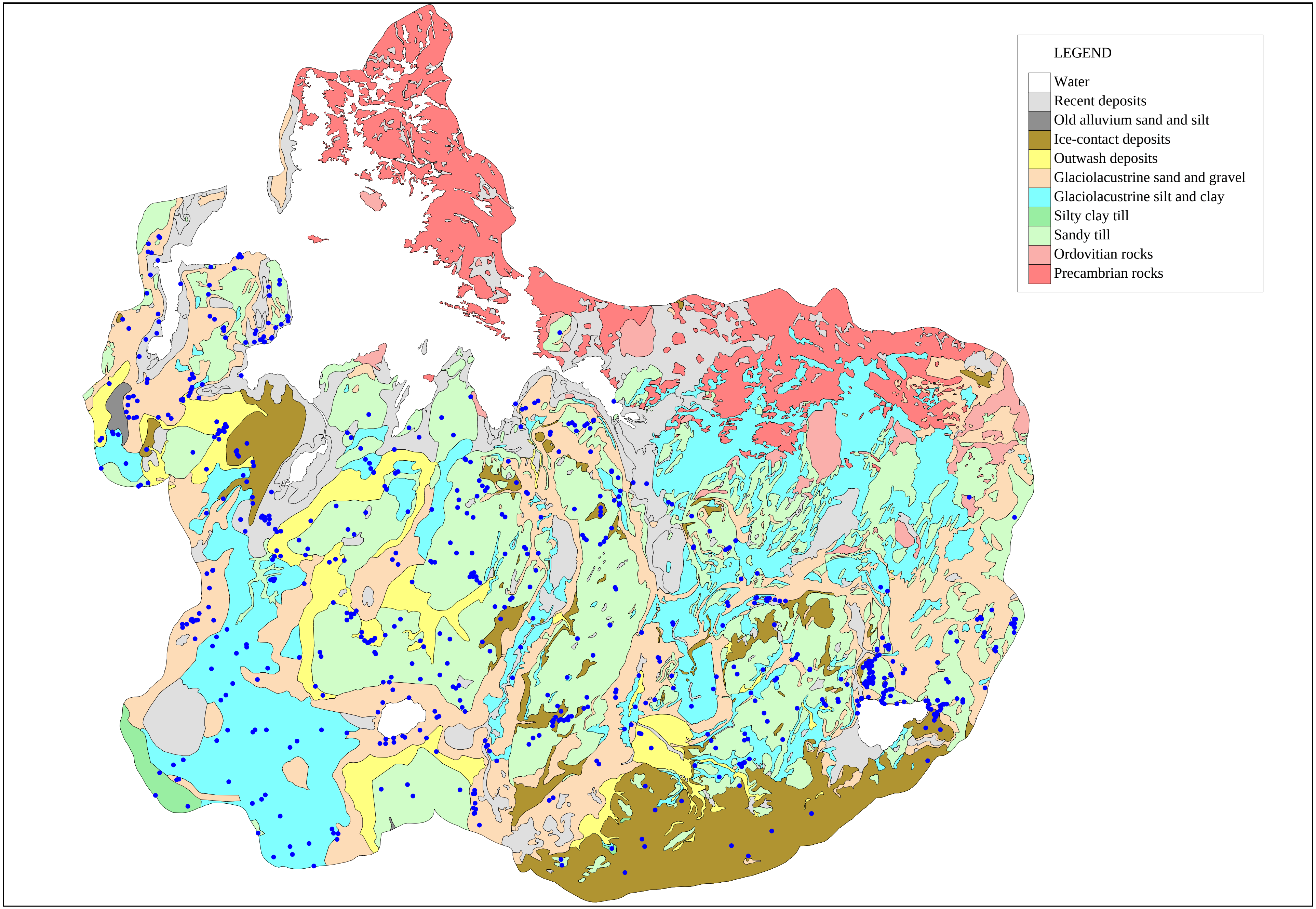


Figure Se-9. Overburden wells with specific capacities equal to or less than 5 l/min/m.

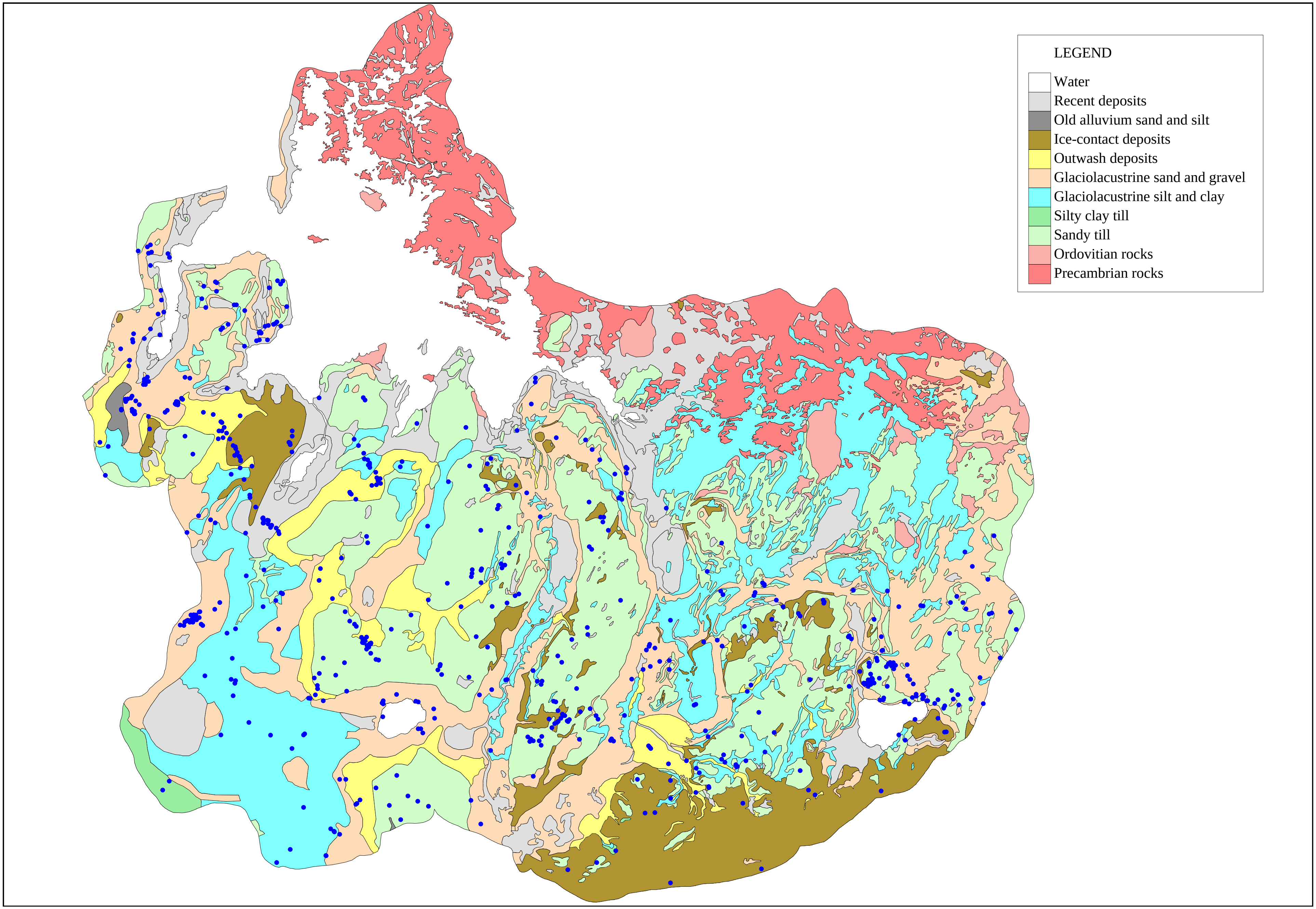


Figure Se-10. Overburden wells with specific capacities between 5 and 25 l/min/m.

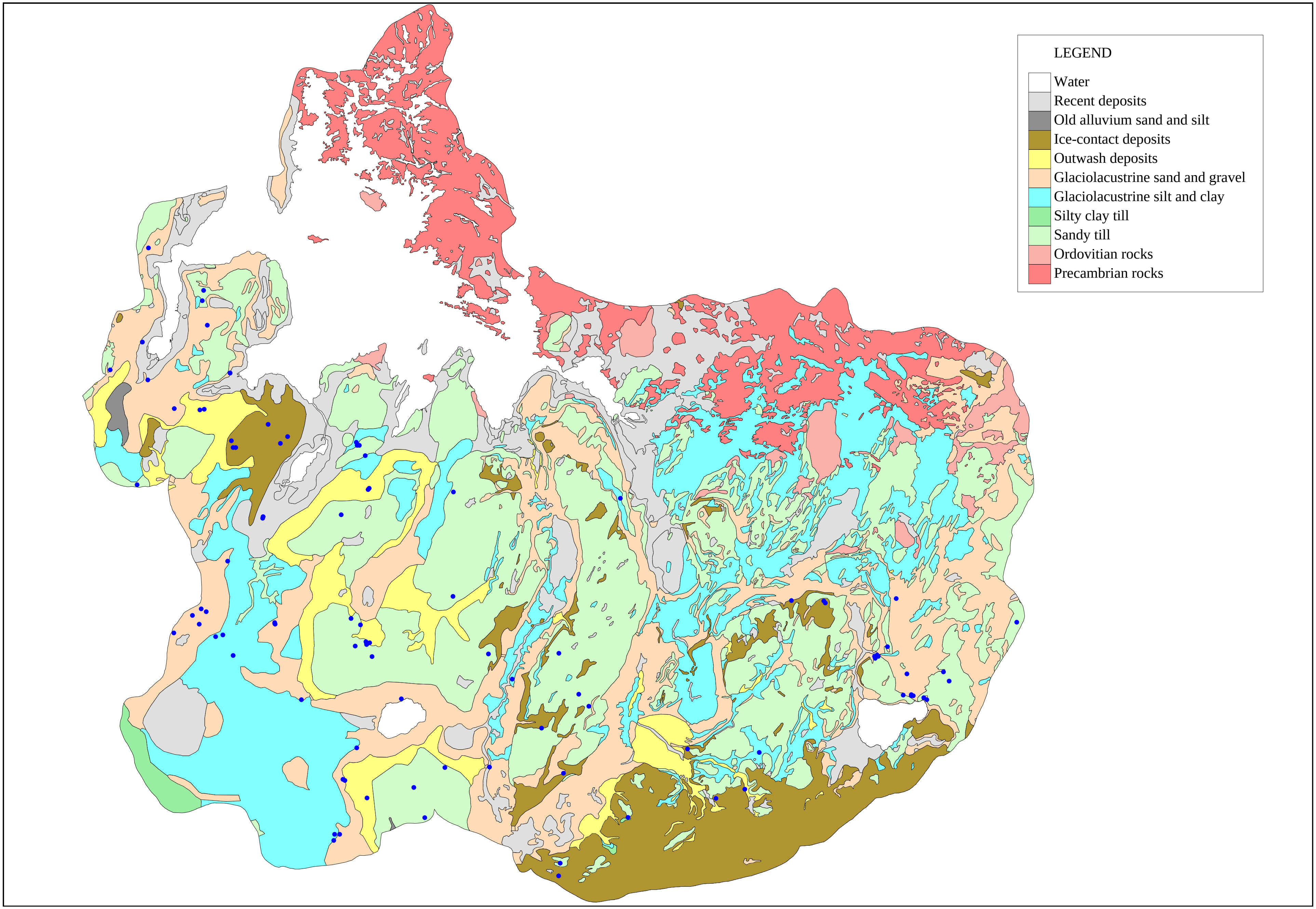


Figure Se-11. Overburden wells with specific capacities between 25 and 50 l/min/m.

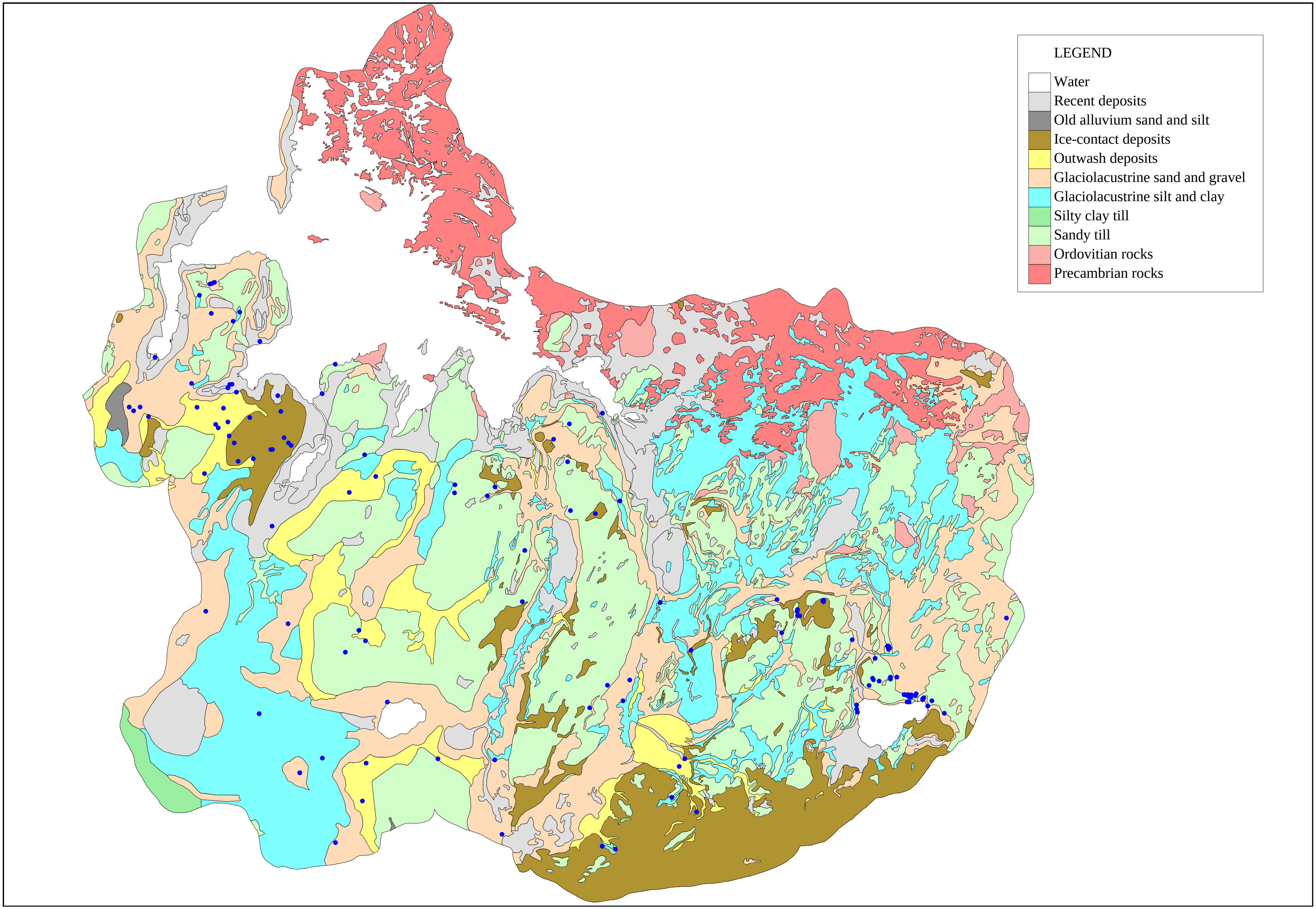


Figure Se-12. Overburden wells with specific capacities higher than 50 l/min/m.

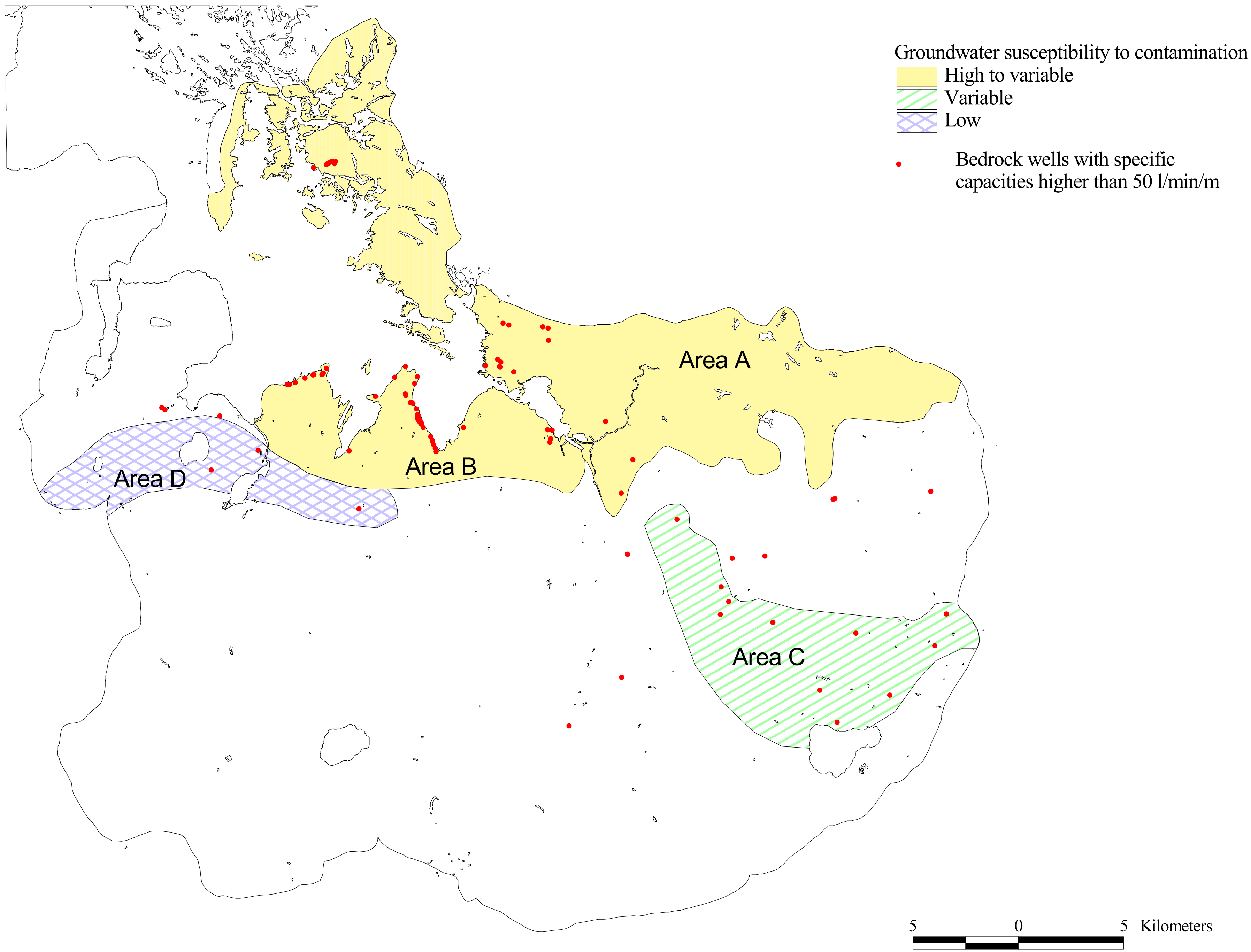


Figure Se-13. Suggested areas for monitoring groundwater in the bedrock.

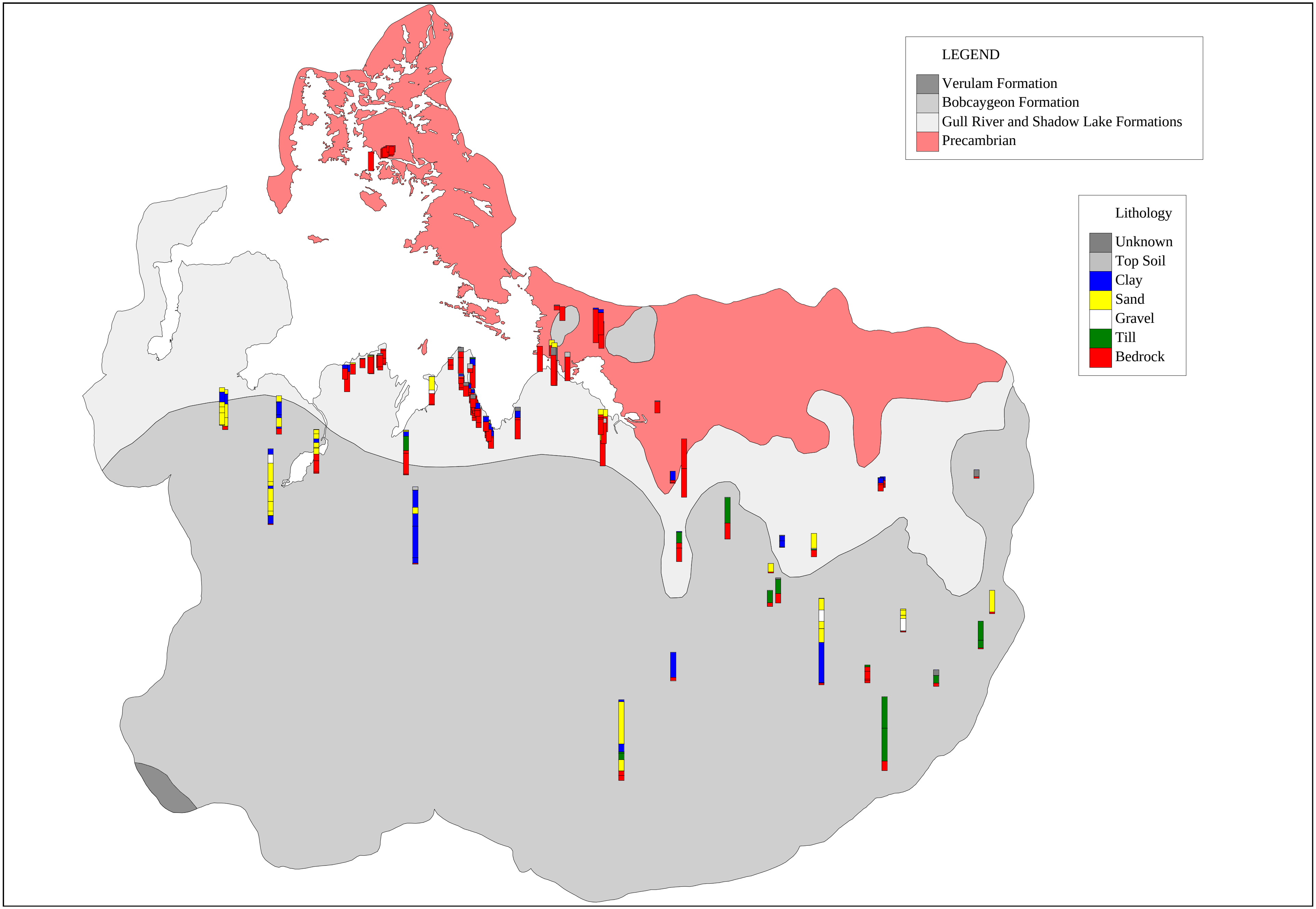


Figure Se-14. Panel diagram showing the geologic logs of bedrock wells with specific capacities higher than 50 l/min/m.

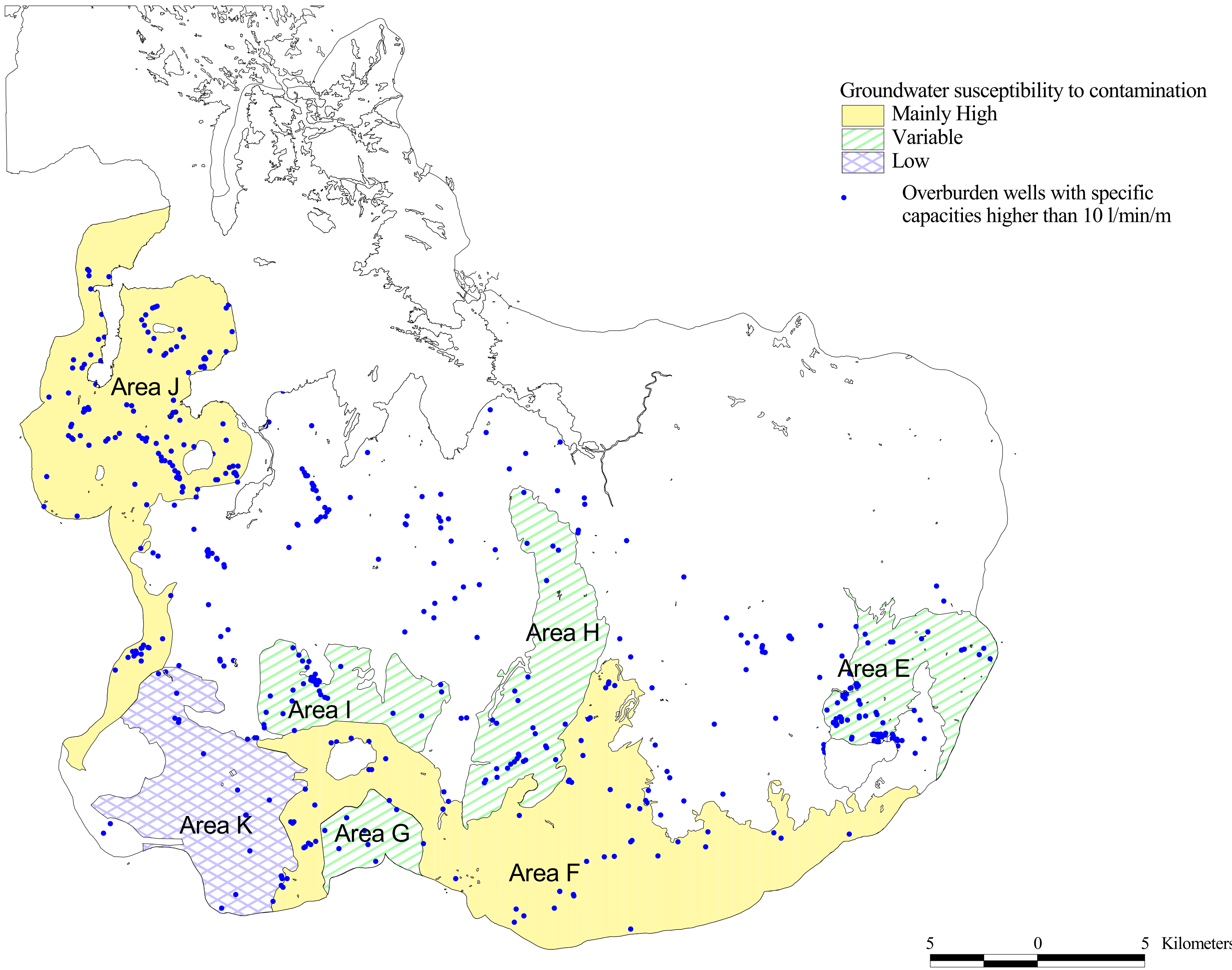


Figure Se-15. Suggested areas for monitoring groundwater in the overburden.

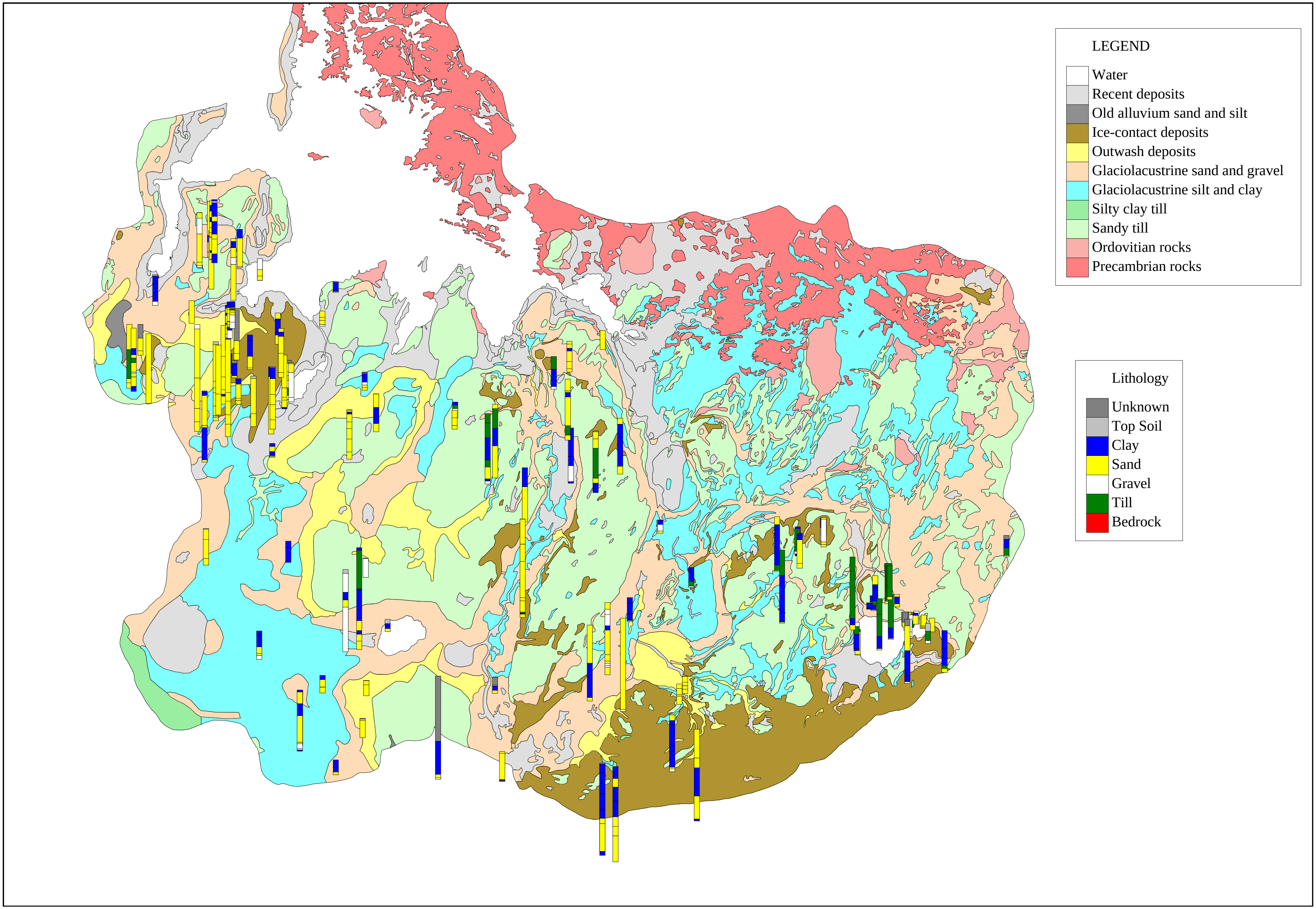


Figure Se-16. Panel diagram showing the geologic logs of overburden wells with specific capacities higher than 50 l/min/m.

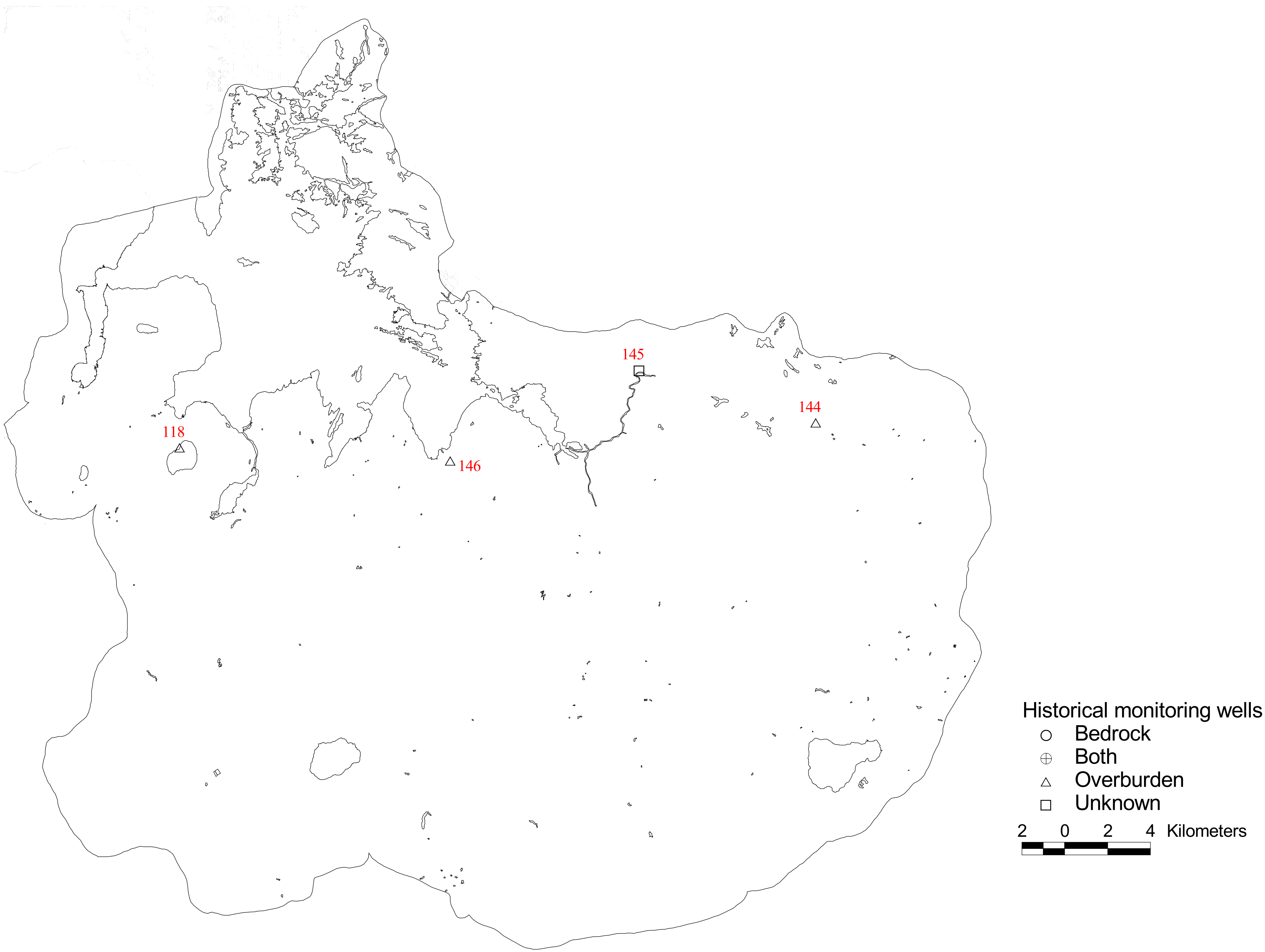


Figure Se-17. Locations of historical monitoring wells in the Severn Sound drainage area.