CHAPTER THREE

A PROPOSED GROUNDWATER MONITORING NETWORK FOR THE BOWMANVILLE, SOPER AND WILMOT CREEKS DRAINAGE BASIN

By

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3.1 LOCATION

The Bowmanville, Soper and Wilmot Creeks drainage basin is located in southern Ontario on the north side of Lake Ontario between longitudes 78^0 35' and 78^0 51' W and latitudes 43^0 53' and 44^0 04' N in the Regional Municipality of Durham.

The basin has an area of about 270 km^2, a length of about 18 km in a northwest-southeast direction, and a width which varies between 6 and 14 km in an east-west direction. Land surface elevations vary from 74 m (a.s.l.) at Lake Ontario to about 375 m (a.s.l.) in the extreme northeastern part of the basin. The three main drainage systems in the basin are the Bowmanville, Soper and Wilmot Creeks, all of which flow southeasterly towards Lake Ontario. In addition, there are four small unnamed creeks with drainage areas ranging from about 1 to 4 km^2 which empty directly into Lake Ontario.

The Bowmanville Creek rises in the Oak Ridges Moraine at an elevation of about 305 m (a.s.l.) and flows southeast for a distance of about 22 km to its outlet into Lake Ontario at Port Darlington. The creek drains an area of 86.5 km^2 and has a total fall of about 228 m with an average gradient of about 9 meters per kilometer.

The Soper Creek rises in the Oak Ridges Moraine at an elevation of about 290 m (a.s.l.). It flows south to its confluence with the Bowmanville Creek about 0.8 km north of Port Darlington at an elevation of about 75 m. The creek drains an area of about 78 km^2. It has a length of about 20.2 km, a total fall of about 204 m, and an average gradient of about 10 meters per kilometer.

The Wilmot Creek rises in the Oak Ridges Moraine at an elevation of about 331 m (a.s.l.) and flows south to its outlet into Lake Ontario. The creek drains an area of about 88.8 km^2. It has a length of about 21.2 km, a total fall of about 225 m, and an average gradient of about 12 meters per kilometer (Singer 1981).

<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.

3.2 LAND USE

Most of the Bowmanville, Soper and Wilmot Creeks basin is in agriculture. The basin also contains quarries, woodlands, and recreational areas. The main urban centers within the basin are Bowmanville, Newcastle, and Orono. Other smaller urban areas include Hampton, Enniskillen, Haydon, and Leskard.

3.3 GROUNDWATER USE

Groundwater is a major source of water supply within the basin and it is used for rural domestic supply, livestock watering, municipal supply, and irrigation purposes. The total number of water wells within the basin on file with the Ministry of the Environment is 1,696. Of these, 180 are bedrock wells (10.6%), 1,437 are overburden wells (85%), and the remaining wells are of unknown type.

Three communities within the basin have municipal water-supply systems. These communities are Bowmanville, Newcastle and Orono. The Tyrone springs are used as a water supply source for the Town of Bowmanville. These springs satisfy approximately half of the water requirements of the town with the other half being obtained from Lake Ontario. Newcastle and Orono, on the other hand, utilize groundwater supplies exclusively.

3.4 PHYSIOGRAPHY

The physiography of the Bowmanville, Soper and Wilmot Creeks basin is a direct result of the deposition and erosion processes during glacial and post-glacial times. The three major physiographic units in the basin, the Lake Iroquois Plain, the Till Plain, and the Oak Ridges Moraine, were described by Gravenor (1957) and Chapman and Putnam.

After the retreat of the last glacier, the present lake Ontario basin was occupied by a glacial lake, Lake Iroquois which reached higher levels than Lake Ontario. The abandoned Lake Iroquois shoreline lies from 6 to 10 km north of the present-day shoreline of Lake Ontario and tilts upwards to the east within the area. Sand and gravel bars and beach terraces are well displayed at the surface along the abandoned shoreline.

Large deltas were formed at the mouths of the Bowmanville, Soper and Wilmot Creeks as they emptied their waters into Lake Iroquois or a lower level post-glacial lake, creating a belt up to 3 km in width to the south of the abandoned shoreline. For the most part, this belt is composed of fine gravel and sand. Farther south, the offshore deposits of Lake Iroquois consist mainly of silt and clay. In the eastern, central and northwestern parts of the Iroquois Plain, till is exposed locally at the surface. In addition, two small drumlins which are located to the northeast of the Town of Bowmanville interrupt the plain.

The Till Plain is the second major physiographic region within the basin and extends over most of its central parts. Chapman and Putnam (1984) considered this plain as a part of the South Slope physiographic region which extends from the Niagara Escarpment to the Trent River and covers about 2,433 km^2. In doing so, Chapman and Putnam related this plain to the Lake Ontario Lobe. The topography of the Till Plain varies from regularly gentle to fairly steep slopes, yet presents a noticeable contrast to the irregular features of the Oak Ridges Moraine to the north and the flatter rolling surface of the Iroquois Plain to the south.

The Oak Ridges Moraine forms the northern part of the basin and is considered as one of the most significant physiographic regions in southern Ontario, extending from the Niagara Escarpment to the Trent River. The topography of the moraine is characterized by hilly, irregular surfaces, and it is marked by knolls, hummocks and closed depressions. Its elevation ranges between 275 and 375 m (a.s.l.) with the highest points being at the extreme northeastern parts of the basin (Singer 1981).

3.5 BEDROCK TOPOGRAPHY AND GEOLOGY

The bedrock in the Bowmanville, Soper and Wilmot Creeks basin is completely obscured by the overburden and its elevation ranges from approximately 60 to 71 m (a.s.l.) along the Lake Ontario shoreline to over 150 m (a.s.l.) in the Oak Ridges Moraine (Figure Bo-1). Based on the MOE water well records, it appears that the Oak Ridges Moraine is underlain by a bedrock ridge which may have acted as a pre-glacial drainage divide, although the lack of data precludes any detailed interpretation. Three bedrock valleys can be seen in the lower parts of the basin and appear to coincide roughly with the existing valleys of the Bowmanville, Soper and Wilmot Creeks.

A very small area in the southeastern corner of the basin is underlain by the Lindsay Formation of the Simcoe Group which is of Upper Ordovician age. A large part of the basin, however, is underlain by the younger Blue Mountain Formation (formerly the Whitby Formation) of Middle Ordovician age (Thurston et al.1992).

The Lindsay Formation is a grey to greenish-gray, fine- to coarse-grained limestone. The formation contains argillaceous beds, shale partings and abundant nodules. The contact with the younger Blue Mountain Formation is reported to be an unconformity. The Blue Mountain Formation consists of highly calcareous brownish or black shales with some limestone beds (Figure Bo-2).

3.6 OVERBURDEN THICKNESS AND GEOLOGY

In general, the overburden within the Bowmanville, Soper and Wilmot Creek basin thickens from less than 6 m along the Lake Ontario shoreline to about 215 m along the Oak Ridges Moraine in the north (Figure Bo-3). The overburden consists of glacial, glaciofluvial, and glaciolacustrine deposits of Pleistocene age with minor amounts of alluvial, beach, muck and swamp deposits of Recent age (Figure Bo-4).

The glacial deposits within the basin are mainly in the form of ground moraine and associated drumlins (Singer 1974; Funk 1977). The ground moraine is composed of sandy till and can be found mainly between the abandoned Lake Iroquois shoreline in the south and the base of the Oak Ridges Moraine to the north. Within these limits, the ground moraine constitutes a part of the South Slope physiographic region. A second and smaller area of a ground moraine extends to the south of the abandoned Lake Iroquois shoreline and constitutes a part of the Lake Iroquois Plain physiographic region.

A few well-formed, oval-shaped drumlins, composed of sandy till with abundant stones, are scattered within the basin. Both the ground moraine and the drumlins are believed to have been laid down by the Lake Ontario Lobe.

The glaciofluvial deposits within the basin consist of the Oak Ridges Moraine, a few kames, and outwash plains. According to Gravenor (1957), the Oak Ridges Moraine was formed between two ice lobes, one is the Lake Ontario Lobe advancing from the southeast, and the other is the Northern Lobe, a predecessor to the Simcoe Lobe, advancing from the northeast. The area between the two lobes was filled with great volumes of sand and gravel up to 150 m in thickness. Gravenor (1957) reported a surprising lack of incorporated till in the moraine and concluded that the melting of the ice between the two ice lobes was rapid and the floods of water pouring out left much stratified material, but little till.

A small area to the southwest of the Village of Enniskillen was identified by Gravenor (1957) as kame. The kame area is composed of sand, gravel and minor amounts of till deposits and it was built, probably, in contact with the ice. Also, an area of outwash sediments of sand and gravel is found south of the Oak Ridges Moraine and immediately north of the abandoned Lake Iroquois shoreline, extending between the Wilmot Creek in the east and the Bowmanville Creek to the west. According to Gravenor (1957), these sediments represent materials deposited by streams that flowed into Lake Iroquois.

Glaciolacustrine sediments were deposited in Lake Iroquois along and to the south of the abandoned shoreline where sand and gravel bars and beach terraces are common. The thickness of these deposits range from 1 to 8 m. A sandy belt, up to 3 km in width, occurs south of the abandoned shoreline. In places, the thickness of the sand reaches 30 m. Further south, the offshore deposits of Lake Iroquois consist mainly of silt and clay up to 8 m in thickness.

In the eastern, central and northwestern parts of the Iroquois plain, till is exposed at the surface. The exposed till has a surface elevation equal to or lower than the silt and clay deposits of Lake Iroquois indicating that it was flooded by water. Gravenor (1957) believes that these low lying till surfaced areas represent locations where strong currents prevented the deposition of silt and clay.

Along most of the main stream valleys there are several terraces formed when the streams were flowing at higher levels. The terrace deposits are composed of mixtures of gravel, sand, silt and clay. Also, along most of the Lake Ontario shoreline there is a beach of gravel and sand between the base of the bluffs and the lake. In several localities, sand bars have been built across bays. The most important bays enclosed by these barriers are the harbor of Port Darlington on the Bowmanville Creek and the harbor of Newcastle on the Wilmot Creek.

The stratigraphic succession as exposed in the Lake Ontario bluffs within the Bowmanville, Soper Creeks basin was described by Singer (1974) who identified five units: Proglacial Lake Unit consisting mainly of clay, Upper Glacial Unit consisting of two till sheets separated by sand and silt, Middle Glacial Unit consisting of till, the Clarke Deposits Unit consisting of clay and sand, and a Lower Glacial Unit consisting of till.

The stratigraphic succession as revealed in wells drilled in the Oak Ridges area indicates the presence of at least five major units: an Upper Unit consisting of glacial and glaciofluvial deposits, a Middle Unit consisting of glaciolacustrine and glaciofluvial deposits, a Lower Unit consisting of glaciofluvial deposits, and a Basal Unit consisting of glacial deposits (Singer 1981).

3.7 GROUNDWATER OCCURRENCE IN THE BEDROCK

Groundwater occurs in fissures, joints and bedding planes of the bedrock formations. The development of the fracture system within the bedrock is relatively limited. Further, the widening of these fractures and the formation of solution cavities due to dissolution of the calcium carbonate in the limestone by chemically aggressive water appears to be of minor importance in the basin.

Over 180 wells are completed in the bedrock. Most of these wells are located within the Iroquois Plain physiographic unit where the thickness of the overburden is small. It would appear that groundwater supplies obtained from the bedrock come mainly from its upper part because most of the bedrock wells penetrate only the upper few meters of the bedrock. Four wells are reported to penetrate the bedrock from 21 to 24 m, one well to 72 m and another to 91 m. These deep wells are either dry or have a very low yield.

In general, the majority of wells completed in the bedrock are suitable for supplying domestic requirements only. The production from these wells ranges from a few liters per day to a few liters per minute, with some of the wells being pumped dry under normal usage. Short-term pumping tests are available for 70 wells. Of these, 56 wells have specific capacities of less than 5 l/min/m (Figure Bo-5), eight wells have specific capacities between 5 and 25 l/min/m (Figure Bo-6), three well with specific capacities between 25 and 50 l/min/m (Figure Bo-7), and three wells with specific capacities higher than 50 l/min/l (Figure Bo-8).

The specific capacity data for the bedrock wells indicate that the bedrock in the Bowmanville, Soper and Wilmot Creeks basin has a low water-yielding capacity and is of limited importance as an aquifer. The overburden overlying the bedrock in the basin contains a number of units which are characterized by very low permeability. Four of these units, namely, the Basal Till, the Lower Till, the lower member of the Clarke Deposits Unit and the Middle Till are found at the bottom of the overburden section overlying the bedrock. As a result of this geological setting, Singer (1981) concluded that the net groundwater recharge to the bedrock in the basin is small. Also, the regional groundwater flow within the bedrock takes place mainly within its top few meters and the bulk of the groundwater recharge, transmission and discharge occur within the overburden.

3.8 GROUND WATER OCCURRENCE IN THE OVERBURDEN

In general, the groundwater availability in the overburden ranges from poor to good. Most wells are used for domestic supplies and livestock requirements. Locally, the overburden aquifers are the most productive sources of groundwater within the basin

Four tills were identified in the basin, the Basal Till, the Lower Till, the Middle Till and the Upper Till. All the tills are heterogeneous, unsorted mixtures of particles ranging in size from fine clay to boulders. Both the Lower and Middle tills, which overlie the Basal Till, are dense and contain an exceptionally high percentage of silt and clay that make them practically impermeable. This hydrogeologic characteristic of both tills hinders the leakage of water to underlying formations.

The Upper Till is the predominant surface deposit in the basin. This till, although sandy in texture, contains a high percentage of silt and clay. The result is that low permeability is an inherent characteristic of the till. Nevertheless, the till is not completely impermeable and it permits leakage of water to the sand and gravel deposits which may be present at depth. Wells constructed in the till often encounter silt and sand deposits. These deposits, which appear to be discontinuous, commonly yield adequate water supplies to meet domestic needs and livestock's requirements. If sand or gravel deposits are not encountered by the wells, their water yields are usually poor.

The sand and gravel deposits of glaciofluvial and glaciolacustrine origin constitute the most important overburden aquifers within the basin. In general, these aquifers are highly permeable and yield water more readily to wells and springs. Their importance, however, as sources for water supply, is a function of their areal extent, thickness and geologic setting.

Data collected from deep observation wells drilled in the Oak Ridges area indicate the presence of a capping of sand and gravel with minor amounts of silt and till deposits. The sand and gravel deposits are displayed at the surface throughout most of the Oak Ridges area and represent the most important overburden aquifer within the basin. The thickness of the aquifer ranges from a few meters up to100 m. It has a knob-and-kettle relief with virtual lack of surface drainage. Rain and snowmelt infiltrate readily through the sandy topsoil and either return back to the atmosphere via evapotranspiration or percolate down to recharge the groundwater whenever the soil moisture is above field capacity. This leaves little or no water for overland flow.

Because the Oak Ridges Aquifer is underlain by till deposits which have lower permeability, the bulk of groundwater moves laterally within the aquifer and issues along the base of the ridges as springs and seepage faces to become a part of the surface runoff cycle. A small portion of the water leaks through the overburden and reaches the bedrock to become part of the regional groundwater flow system. Hence, the Oak Ridges Aquifer acts as a major recharge zone, whereas its base acts as a major discharge zone.

Few wells were drilled in the Oak Ridges Aquifer within the basin. This makes an evaluation of the water yielding characteristics of the aquifer from water wells data a difficult task. A baseflow analysis of the streamflow at station W-1, which drains 10.8 km^2 of the aquifer, gives an average groundwater discharge of 10 $l/s/km^2$ (Singer 1981).

An outwash plain that extends between Hampton on the west, Enniskillen and Tyrone to the north, Orono to the east, and the abandoned Lake Iroquois shoreline to the south represents the second most important aquifer in the basin. The Outwash Aquifer, which consists of sand and gravel, ranges in thickness from 2 to 24 m. It covers an area of about 20 km^2 and it is underlain by a sandy till. Its surface is intersected by the Bowmanville, Soper and Wilmot Creeks and their tributaries. Excess water from rain and snowmelt percolates to the aquifer and moves mainly laterally to the nearest streams to discharge as baseflow.

Sand and gravel bars and beach terraces,1 to 8 m thick, are well displayed at surface along the abandoned Lake Iroquois shoreline. Immediately to the south of these deposits there is a flat, deltaic belt up to 3 km in width, composed for the most part of fine-grained gravel and sand. Logs of wells drilled within this deltaic belt and particularly those located to the southwest of Gaud Corners on the Bowmanville Creek, approximately 1.6 km south of Stephens Gulch on the Soper Creek and immediately to the south of Orono on the Wilmot Creek, indicate the presence of sand beds that have a continuous thickness of over 30 m. The Lake Iroquois sand and gravel bars and the associated deltaic belt represent the third most important surficial aquifer in the basin.

Figure Bo-3 shows a number of bedrock valleys which are indicative of preglacial drainage. Logs of wells which penetrate the valleys, which are located to the east of the Town of Bowmanville and in the vicinity of the Village of Newcastle and to its north, indicate the presence of gravel-like deposits up to 6 m in thickness. The water-yielding characteristics of these deposits range from adequate to excellent depending on their thickness and they can provide enough water supply for domestic and farm needs. In addition, the water supply for the Village of Newcastle is believed to originate from these channel deposits.

Over 1,430 wells are completed in the overburden. Specific capacity data are available for 1,046 wells. Of these, 417 wells (39.8%) have specific capacities less than 5 l/min/m (Figure Bo-9), 489 wells (46.7) have specific capacities between 5 and 25 l/min/m (Figure Bo-10), 67 wells (6.4 %) have specific capacities between 25 and 50 l/min/m (Figure Bo-11), and 73 wells (6.9%) have specific capacities more than 50 l/min/m (Figure Bo-12).

Figure Bo-12 indicates that the wells with specific capacities higher than 50 l/min/m are located within the Oak Ridges Moraine, the till plain, the outwash plain, the deltaic sand plain, and the clay plain. All these wells tap sand and/or gravel deposits at various depths.

3.9 MONITORING GROUNDWATER IN THE BEDROCK

As indicated earlier, the analysis of specific capacity data for bedrock wells indicates that the bedrock (mainly the Blue Mountain Formation) is of limited importance as an aquifer in the Bowmanville, Soper and Wilmot Creeks basin. Only 10.6% of the wells in the basin are bedrock wells and the overwhelming majority of these wells have specific capacities less than 5 l/min/m. Given these facts, a large area extending from the Oak Ridges to Lake Ontario has been identified on Figure Bo-13 for optional monitoring of groundwater within the bedrock. The susceptibility of groundwater to contamination within this optional area is low (Figure Bo-14).

3.10 SUGGESTED OVERBURDEN MONITORING AREAS

Figure Bo-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 either a high, a variable, or a low susceptibility to contamination. The susceptibility of groundwater to contamination was determined based on information related to the thickness and type of overburden materials (Figure Bo-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 (A, B, C, D, E, and F) are proposed for groundwater monitoring in the overburden. Groundwater has low susceptibility to contamination in area (A), a variable susceptibility to contamination in areas (C), (D), and (E), and a high susceptibility to contamination in areas (B) and (F).

Area (A) is located within the lower part of the Wilmot Creek watershed between Newcastle and the main channel of the creek. The area is covered by glaciolacustrine clays of Lake Iroquois. Area (B) is located to the east of the main channel of the Wilmot Creek between Orono and the Stalker Creek. The area is covered with glaciolacustrine sand of Lake Iroquois. Area (C) is located just to north of area (B) and is underlain by glacial till. Area (D) covers the middle parts of the Bowmanville Creek watershed and is underlain by glaciofluvial outwash deposits. Area (E) extends from Enniskillen to Tyrone and covers parts of the watersheds of the Bowmanville and Soper Creeks. The area is underlain by glacial till. Area (F) constitute the upper portions of the Bowmanville, Soper and Wilmot Creeks basin and is part of the Oak Ridges Moraine.

3.11 HISTORICAL MONITORING WELLS

Nineteen wells and piezometers ere used in the past for monitoring groundwater in the Bowmanville, Soper and Wilmot Creeks drainage basin. The locations of the wells and piezometers and their historical numbers are as follows:

Well No. 487	An overburden well that is 26.0 m deep and is located within the upper part of the Soper Creek watershed in Durham County, Newcastle Township, Concession 8, Lot 5. The well ends in fine grained sand and it is also known as well No. S - 1a.
Well No. 488	An overburden well which is located next to well No. 487. The well is 50.3 m deep, it ends in coarse grained gravel, and it is also known as well No. S -1b.
Piezometers 489, 490 and 492	The piezometers are within a bedrock well which is 48 m deep and ends in limestone. The well is located within the Soper Creek watershed in Durham County, Concession 4, Lot 6. The well is also known as well No. S - 4.

Well No. 492	An overburden well, known as well No. S -5, and is located next to well No. S - 4. The well ends in silty till and is 12.8 m deep.
Well No. 493	A bedrock well, 9.75 m deep, which is located to the northeast of Bowmanville in Durham County, Newcastle Township, Concession 2, Lot 7. The well ends in limestone and is also known as well No. S -5.
Well No. 494	An overburden well, 7.3 m deep, and ends in a sandy clay till. It is located next to well No. S - 6a and is also known as well No. S -6b.
Well No. 495	An overburden well, 16.75 m deep, and ends in fine sand. It is located in Durham County, Newcastle Township, Concession 5, Lot 35 and is also known as well No. S - 7.
Well No. W - 1	An overburden well, 45.73 m deep, and ends in a silty till. It is located within the Wilmot Creek watershed (Concession 8, Lot 31).
Well No. W - 2	A bedrock well, 154.57 m deep, and ends in limestone. It is located next to well No. W -1.
Well No. 498	A bedrock well, 65. 24 m deep, and ends in limestone. It is located northwest of Orono in Durham County, Newcastle Township, Concession 5, Lot 32.
Piezometers 499, 500, 501, and 507	The piezometers are located within two adjacent overburden wells known as well No. W - 5a (46.34 m deep) and well No. W -5b (14.33 m deep). The wells are located in Durham County, Newcastle Township, Concession 6, Lot 22.
Well No. 502	A bedrock well, 11 m deep, and ends in limestone. The well is located to the west of Newcastle in Durham County, Newcastle Township, Concession 2, Lot 32.
Piezometers 503, 504, 505 and 506	A bedrock well, 219.51 m deep, and ends in limestone. The well, which is known as well No. W - 8, is located near the northern topographic divide of the Wilmot Creek watershed in Durham County, Newcastle Township, Concession 10, Lot 28.
Well No. 508	An overburden well that ends in silty till. It is 63 m deep and is located in the northern part of the Bowmanville Creek watershed midway between Enniskillen and Burketon Station in Durham County, Newcastle Township, Concession 9, Lot 21. The well is also known as well No. B -1.
Well No. 509	An overburden that ends in silty till. It is 11.5 m deep and is located within the Bowmanville Creek watershed to the

southwest of Enniskillen in Durham County, Newcastle Township, Concession 7, Lot 21. The well is also known as well No. B -2.

Well N0. 526 — An overburden well, 131.1 m deep, and ends in clay. The well is also known as well No. W - 9 , and it is located next to well W - 8.

Piezometers 510 and 511 — The two piezometers are within a well that is located in the lower parts of the Bowmanville Creek watershed in Durham County, Newcastle Township, Concession 2, Lot 12 . The well, which ends in the bedrock, is 36 m deep and is also known as well No. B - 4.

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

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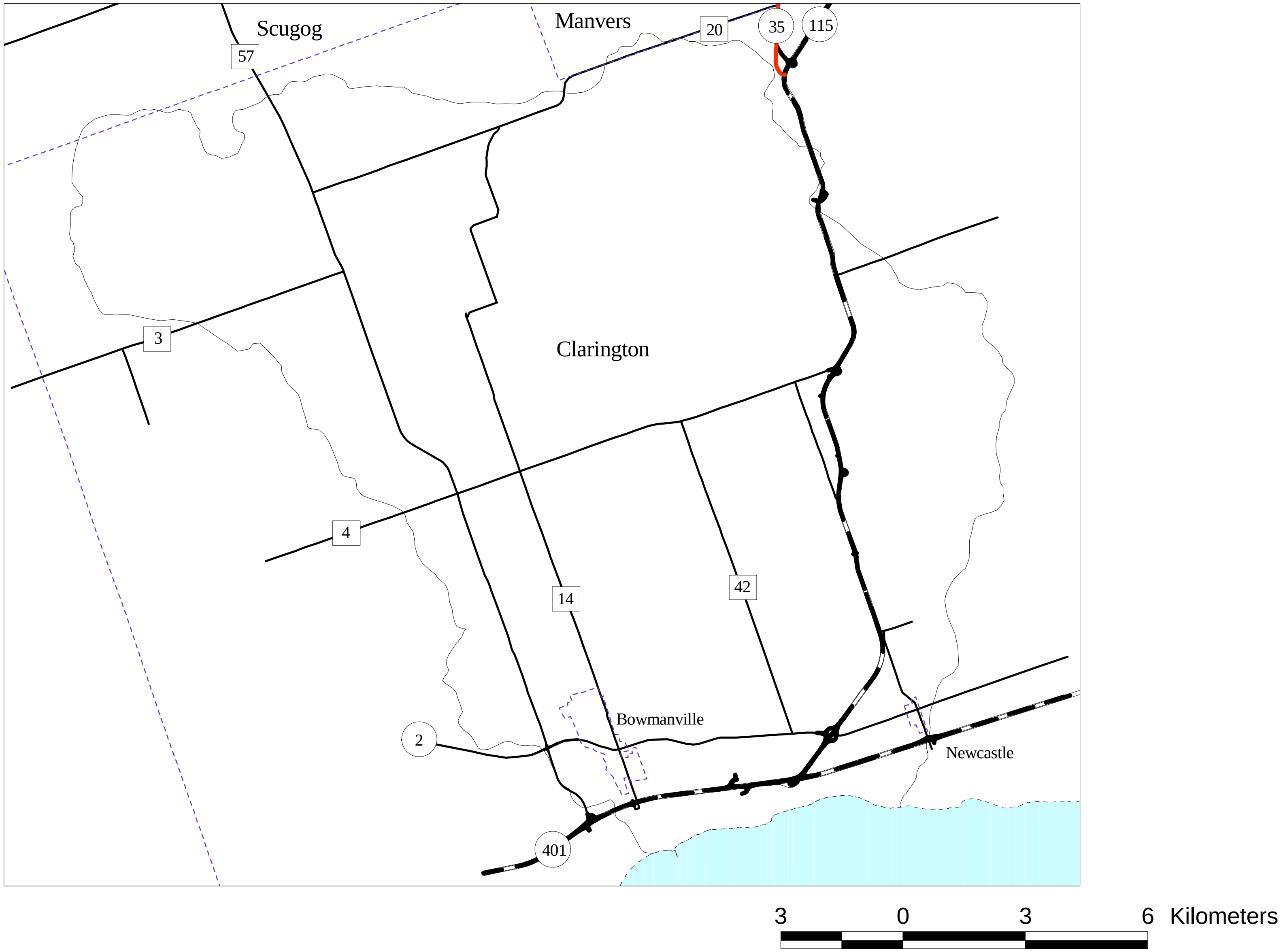
FIGURES

Figure Bo - 17 Locations of historical monitoring wells in the Bowmanville, Soper and Wilmot Creeks drainage basin.



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

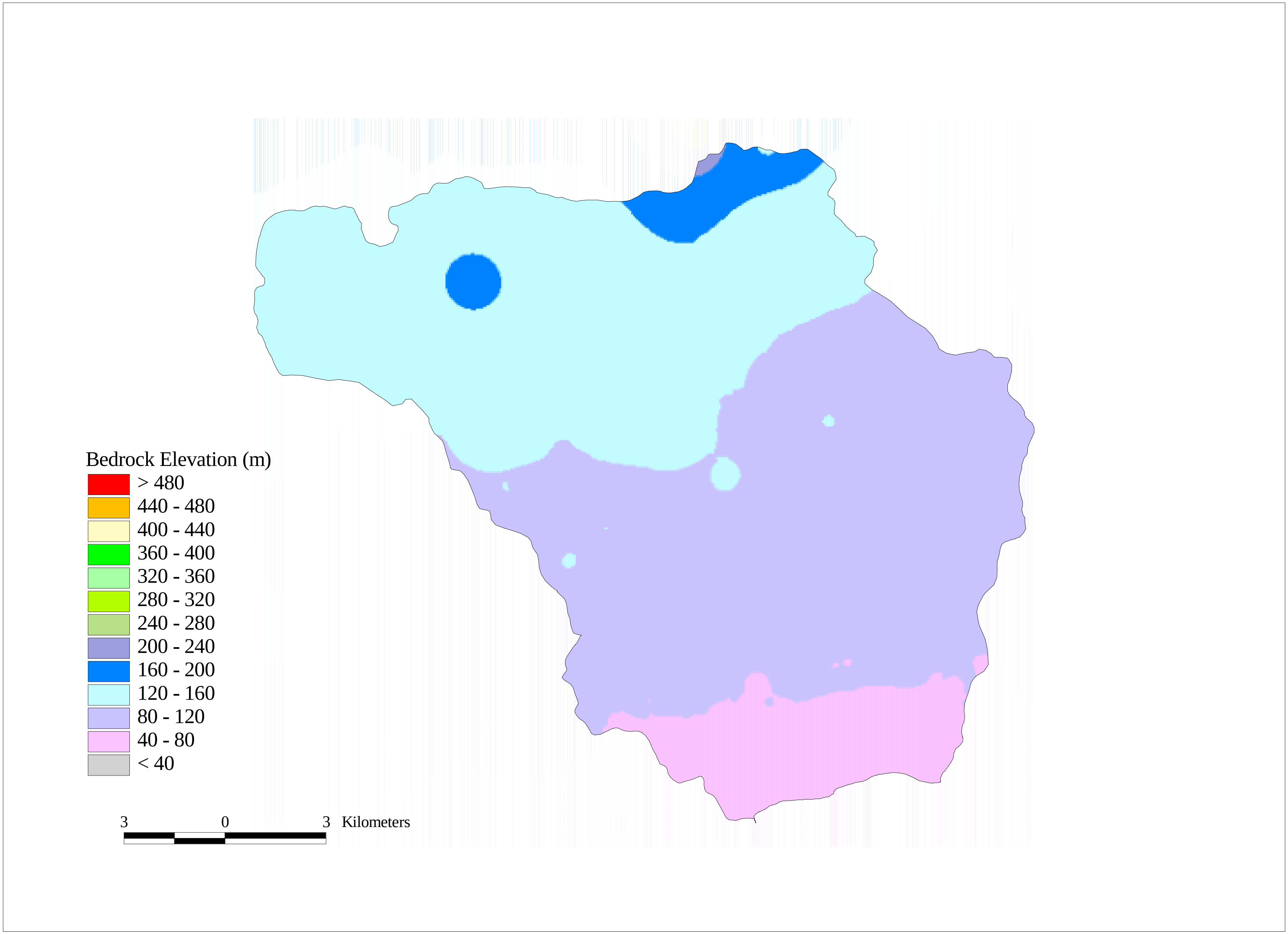


Figure Bo-1 Bedrock topography in the Bowmanville, Soper and Wilmot Creeks drainage basin.

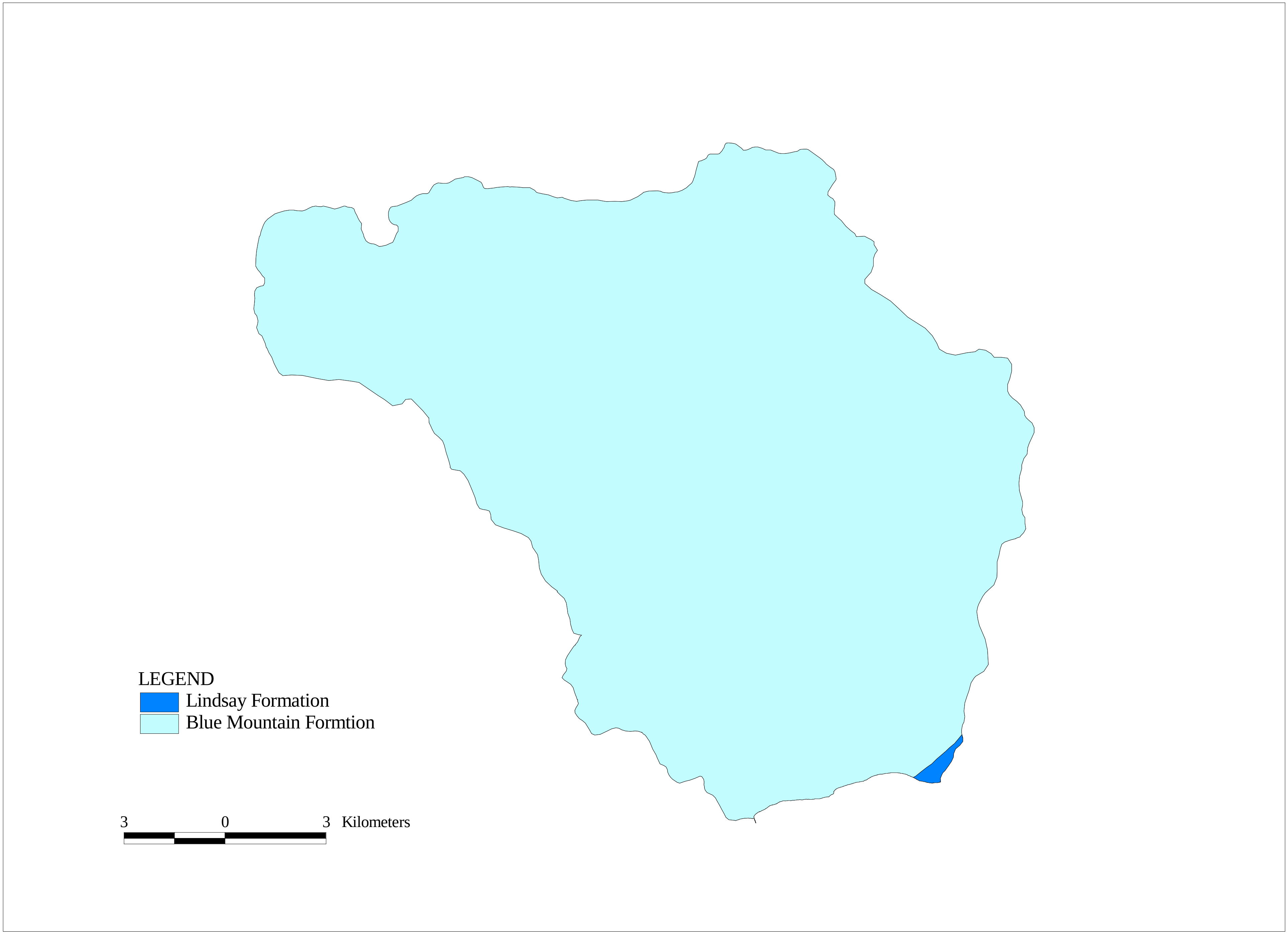


Figure Bo-2. Bedrock geology in the Bowmanville, Soper and Wilmot Creeks drainage basin.

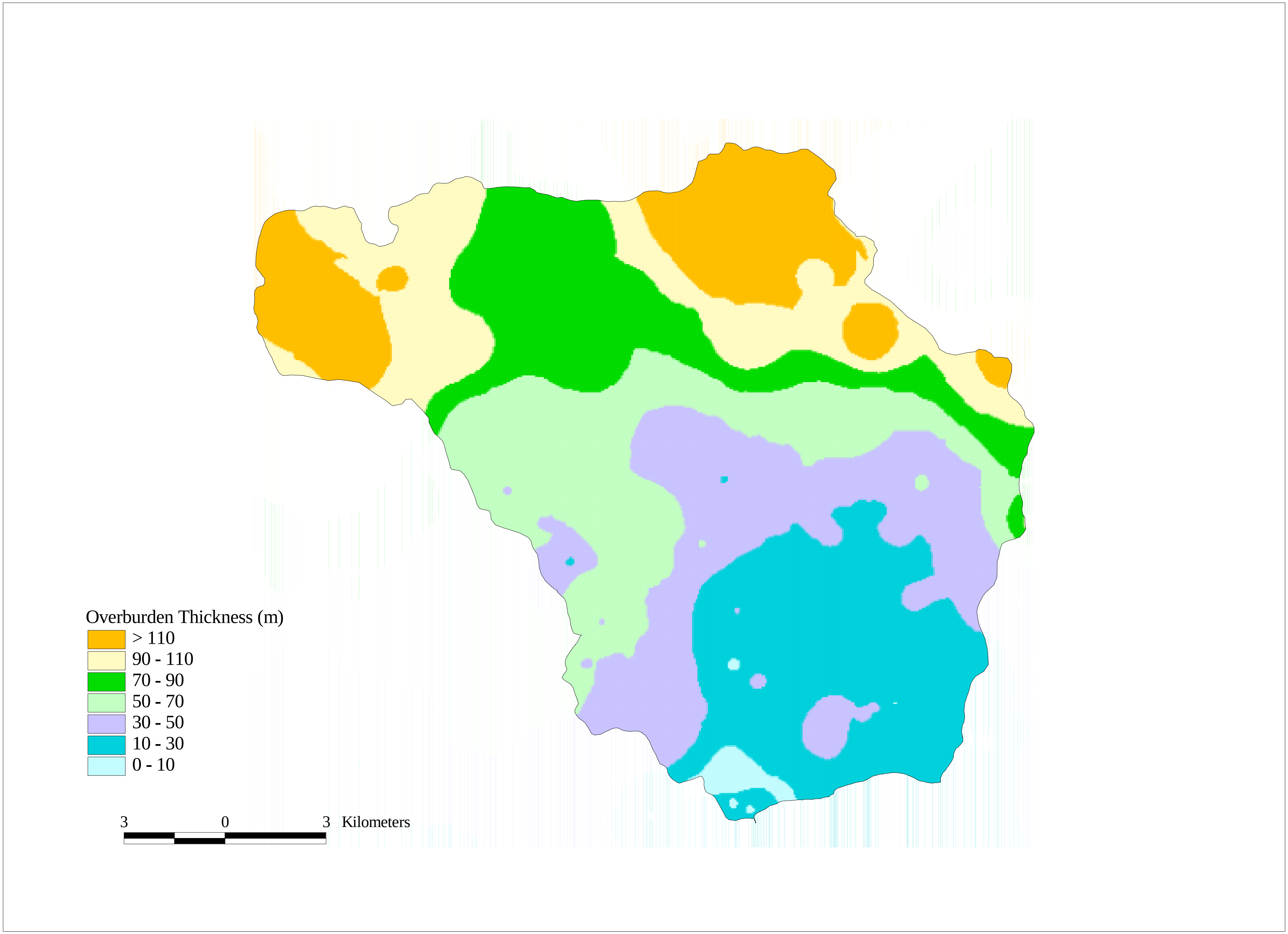


Figure Bo-3 Overburden thickness in the Bowmanville, Soper and Wilmot Creeks drainage basin.

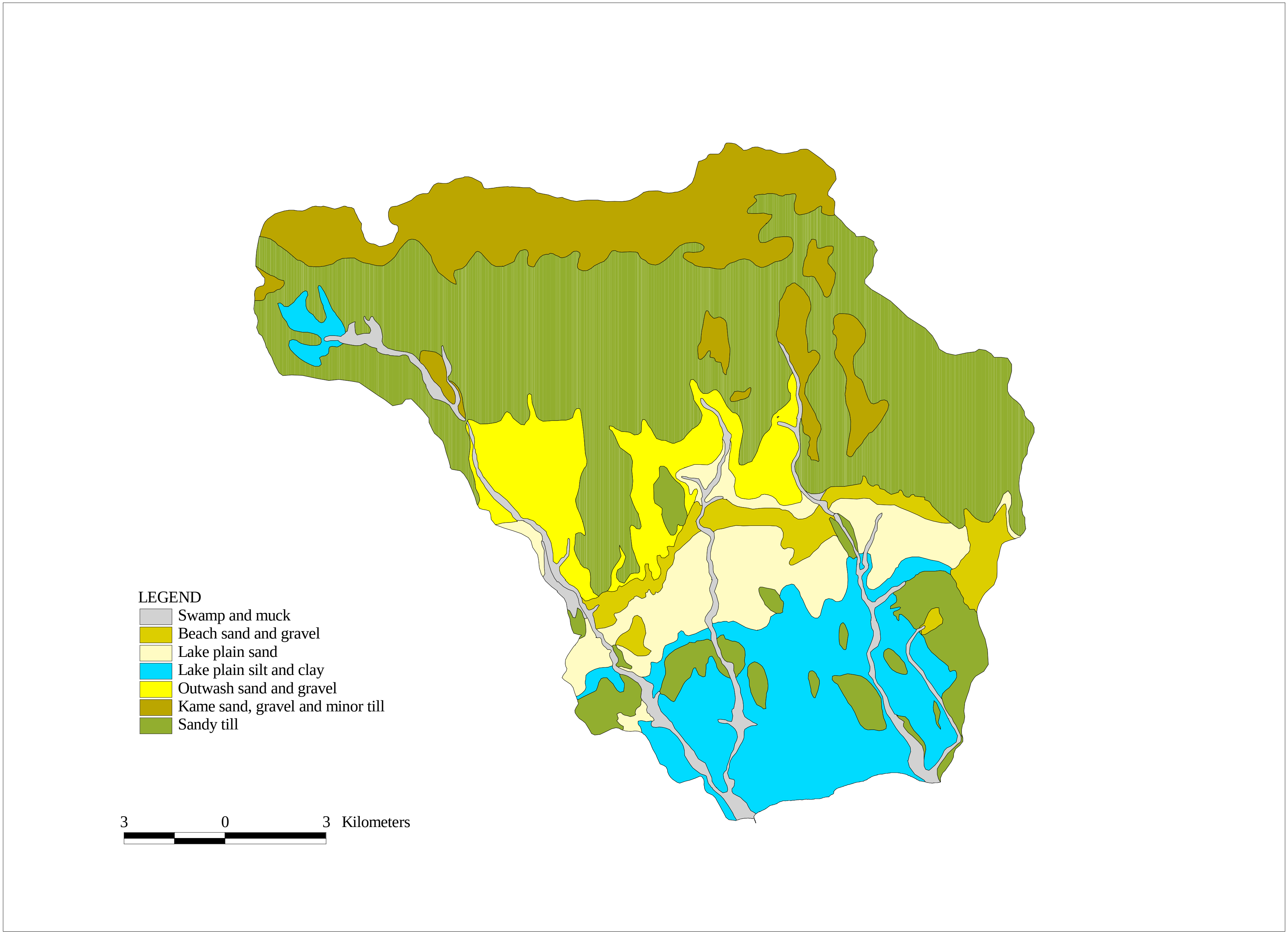


Figure Bo-4. Overburden geology in the Bowmanville, Soper and Wilmot Creeks drainage basin.

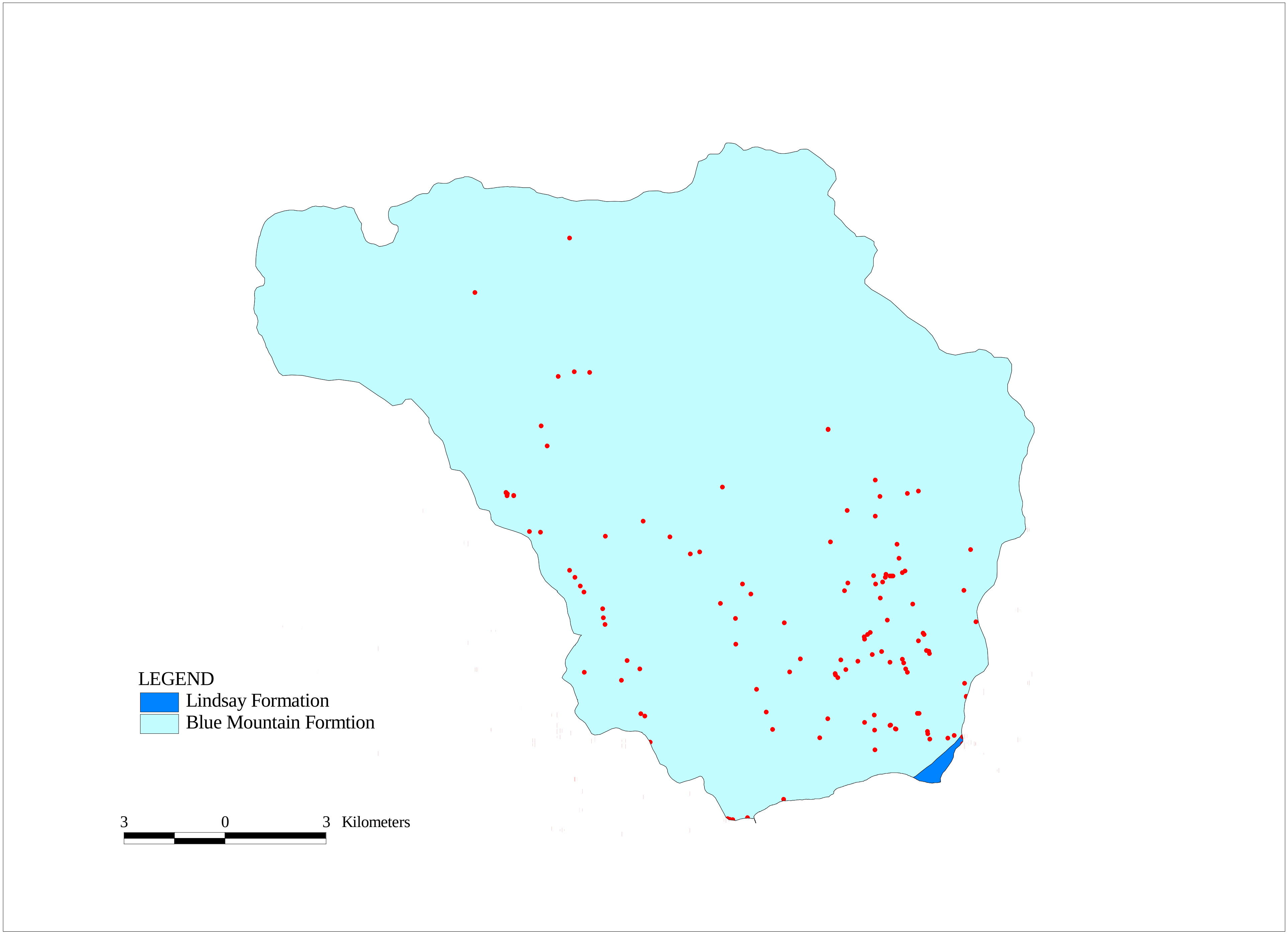


Figure Bo-5. Bedrock wells with specific capacities equal to or less than 5 l/min/m.

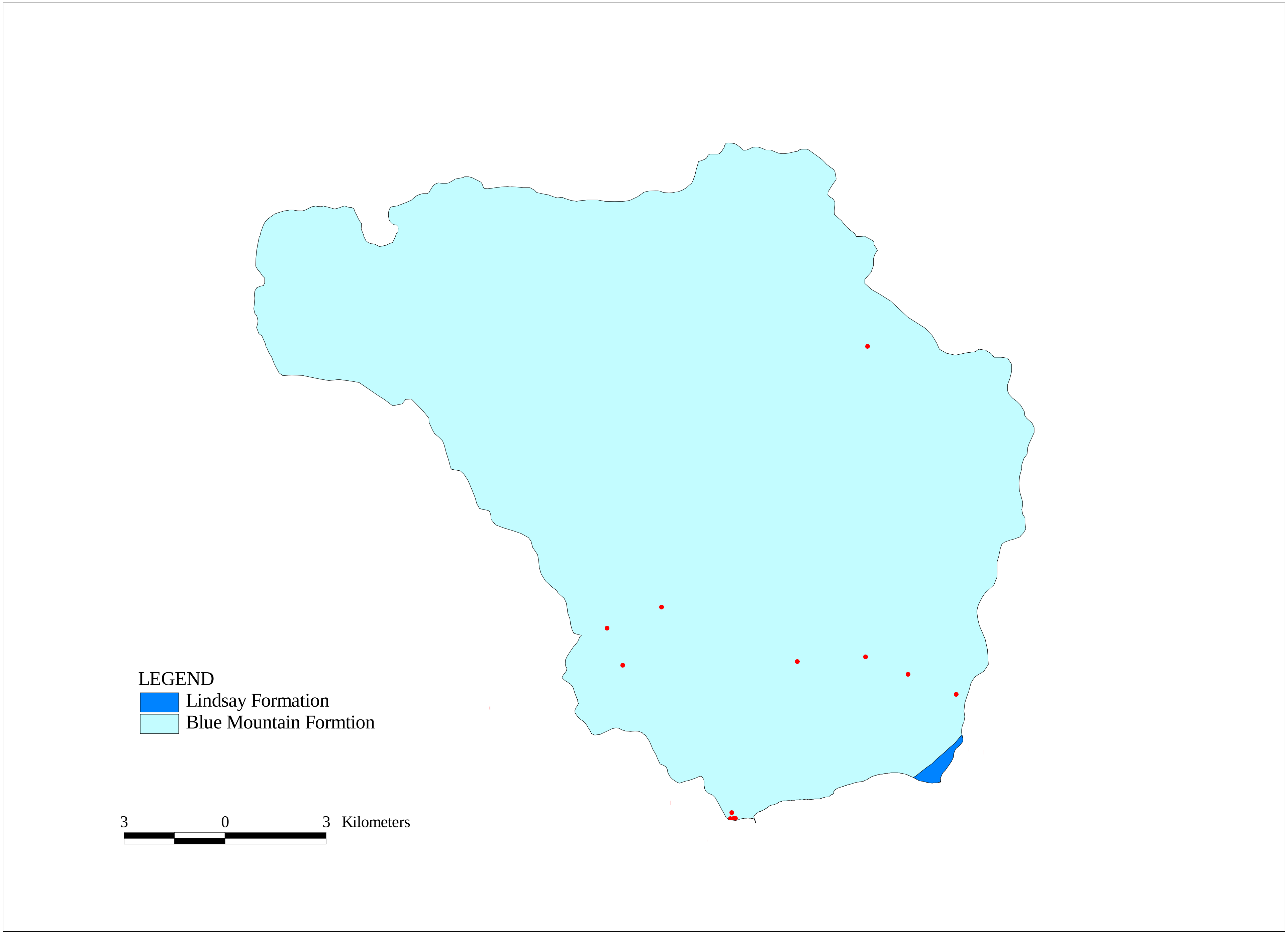


Figure Bo-6. Bedrock wells with specific capacities between 5 and 25 l/min/m.

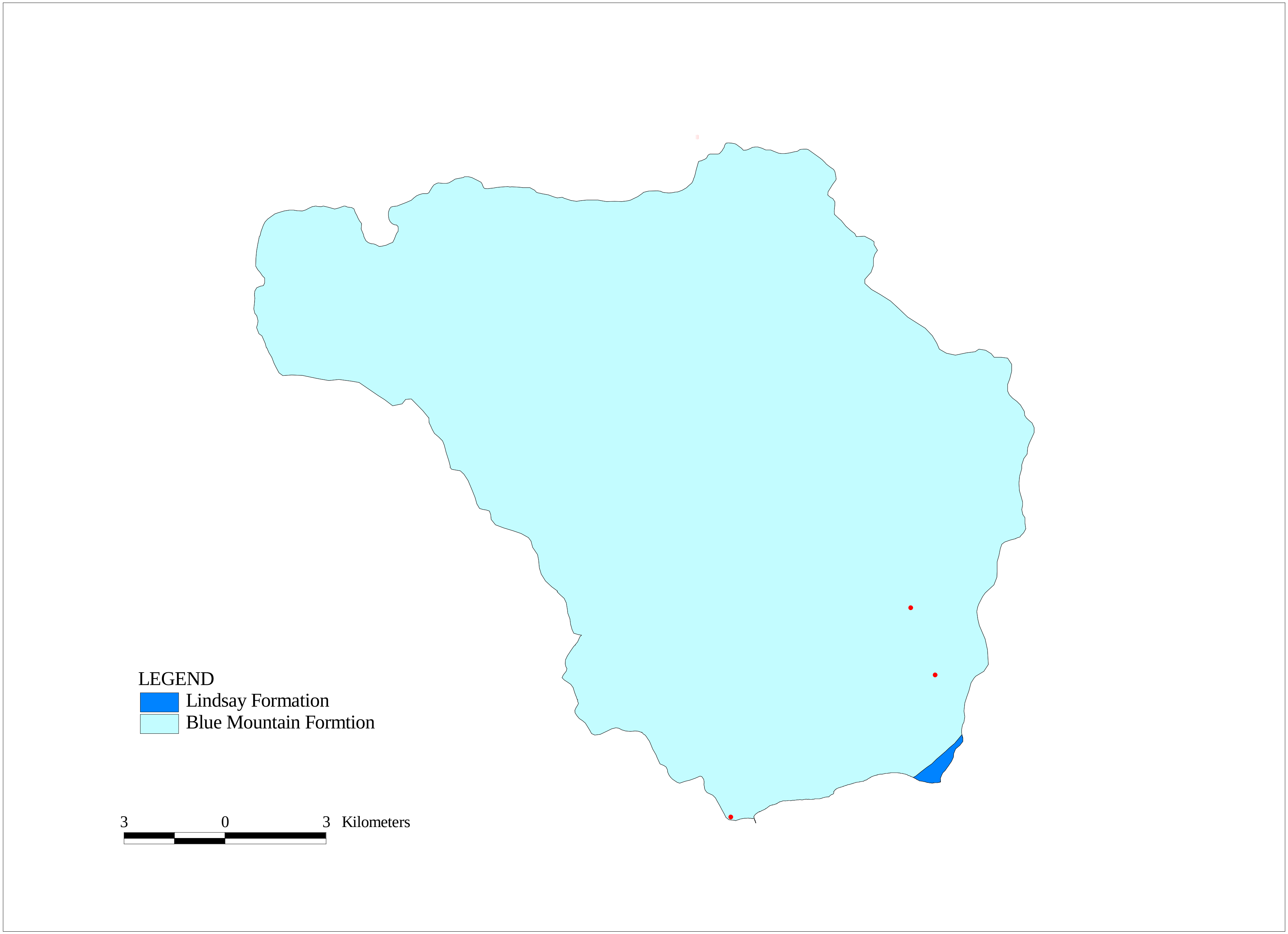


Figure Bo-7. Bedrock wells with specific capacities between 25 and 50 l/min/m.

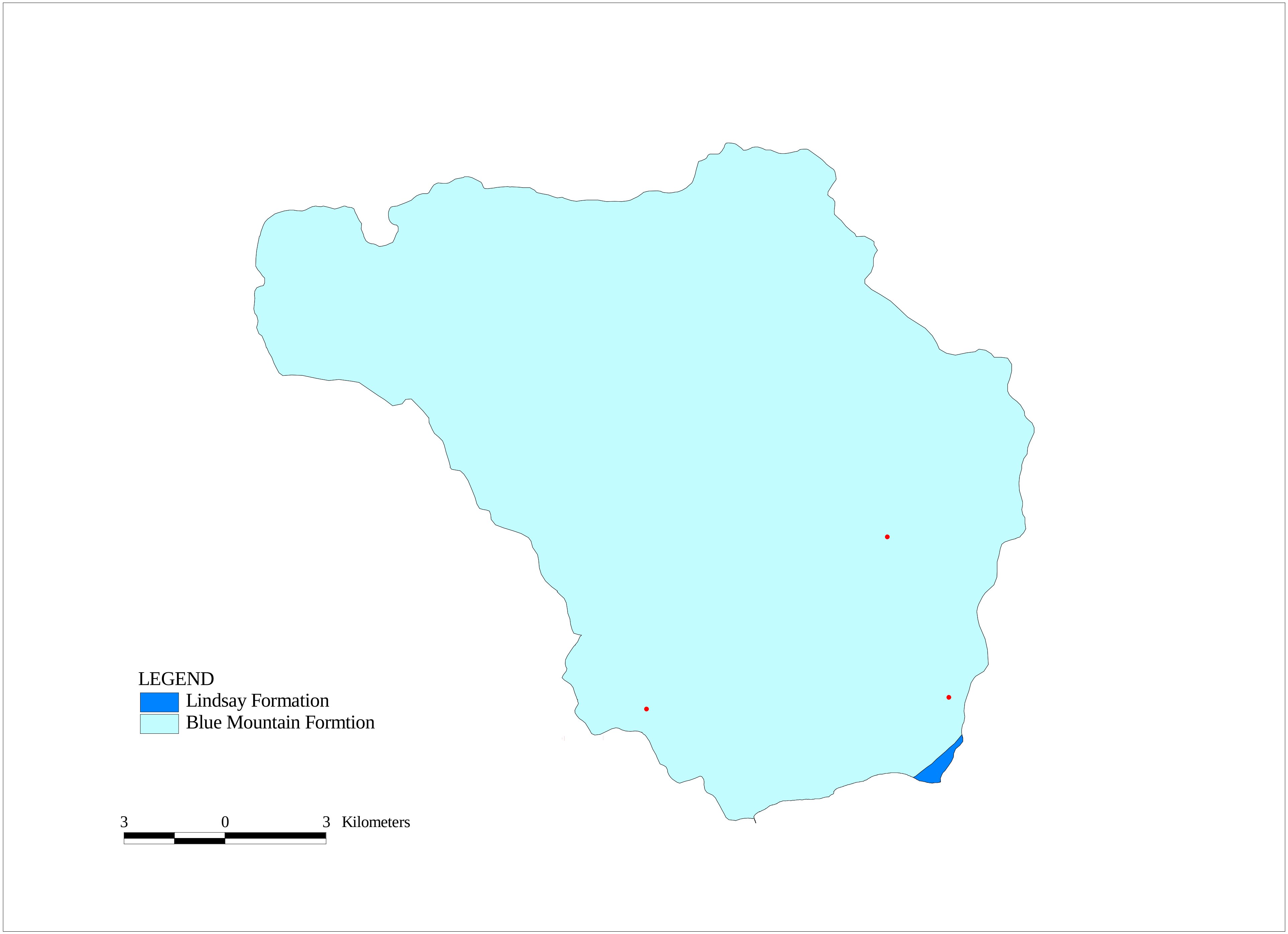


Figure Bo-8. Bedrock wells with specific capacities higher than 50 l/min/m.

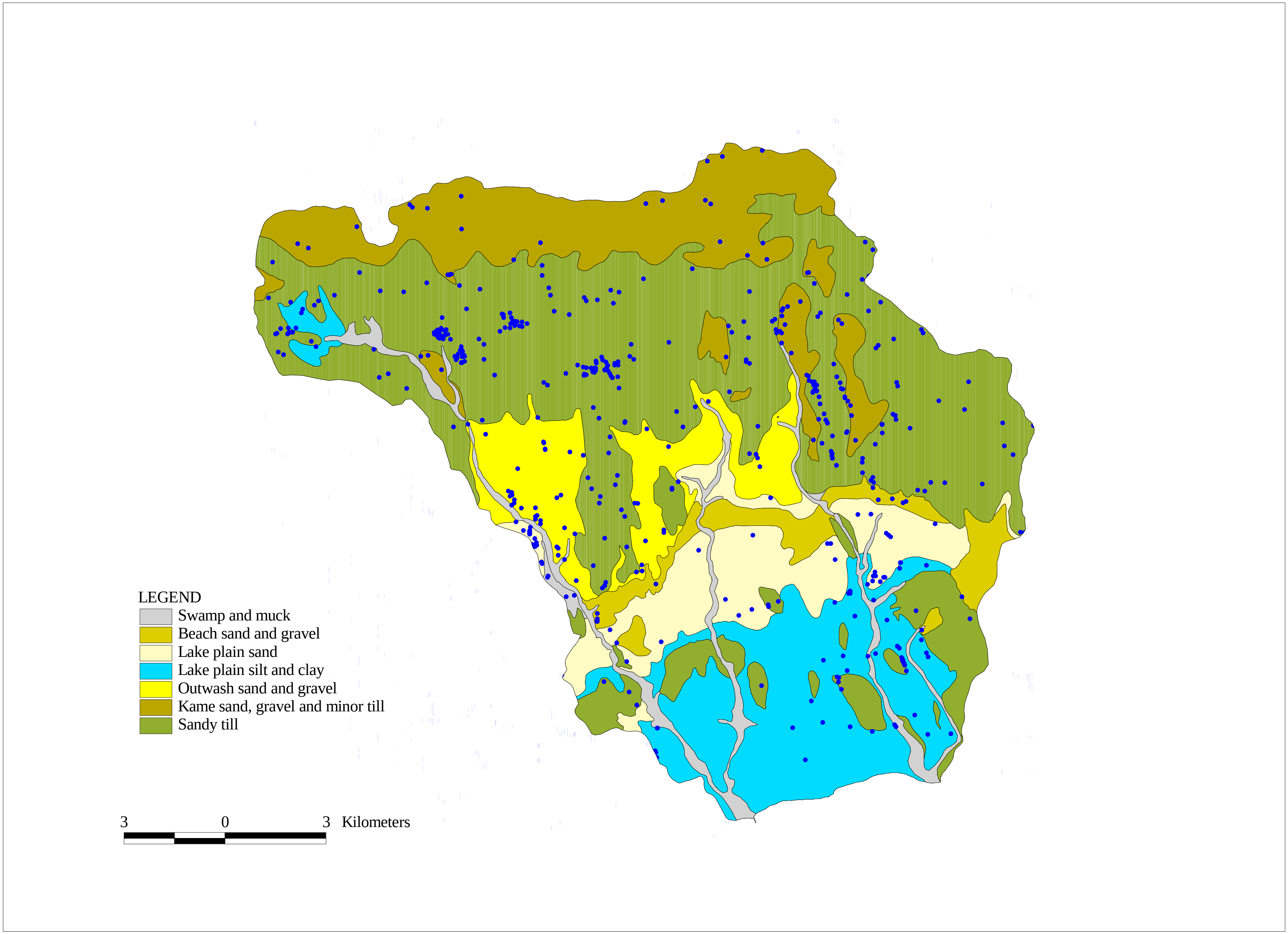


Figure Bo-9. Overburden wells with specific capacities equal to or less than 5 l/min/m.

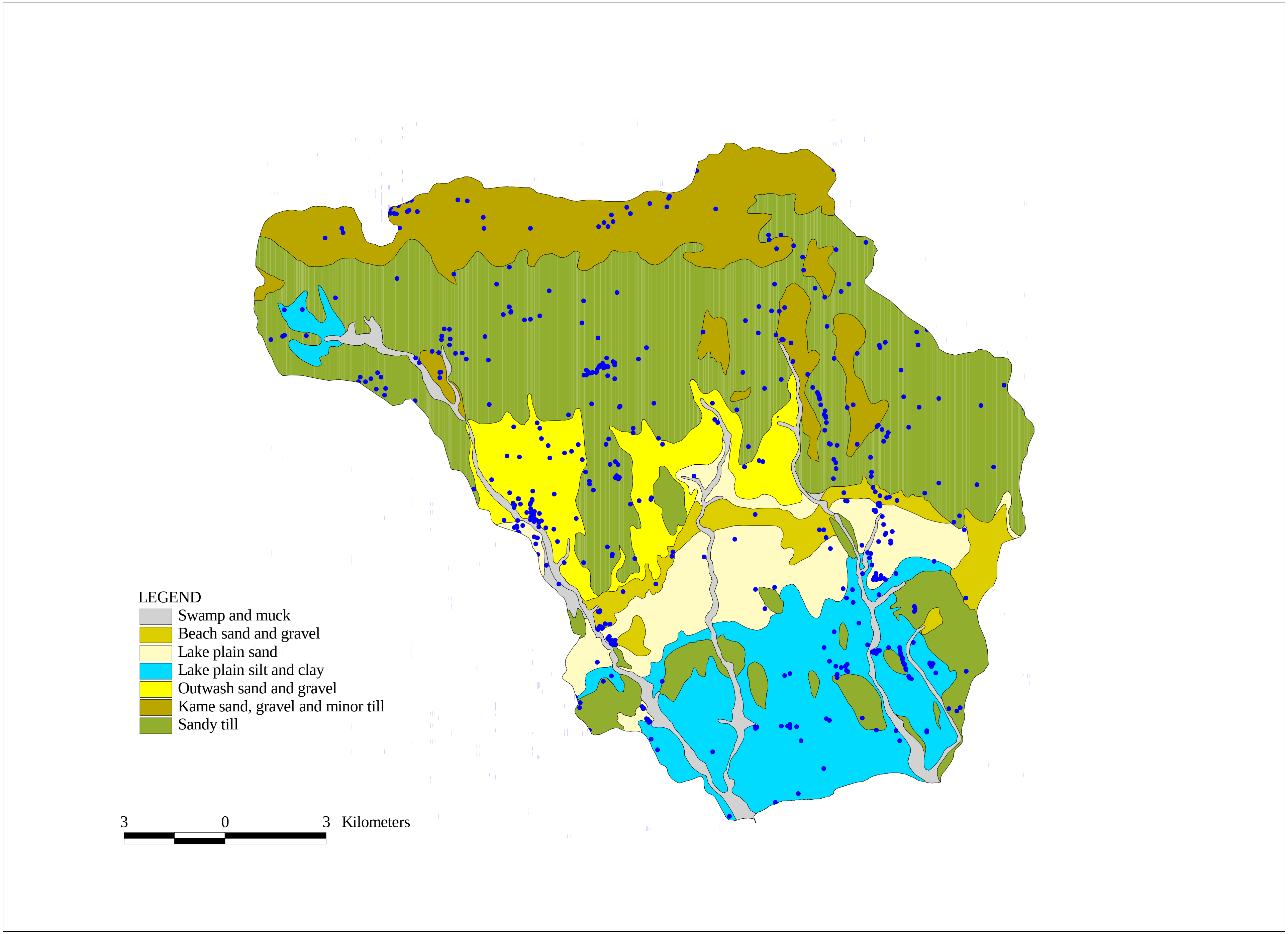


Figure Bo-10. Overburden wells with specific capacities between 5 and 25 l/min/m.

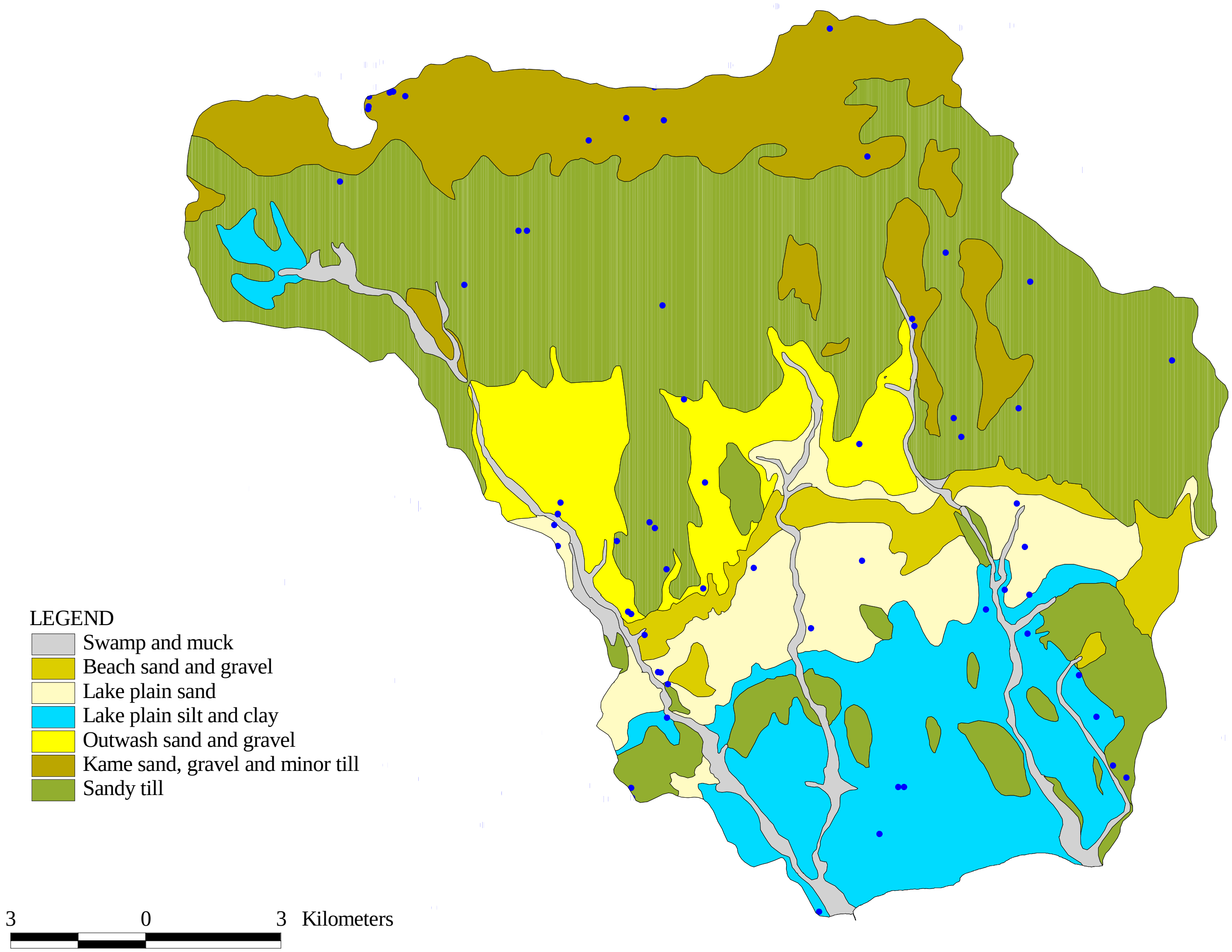


Figure Bo-11. Overburden wells with specific capacities between 25 and 50 l/min/m.

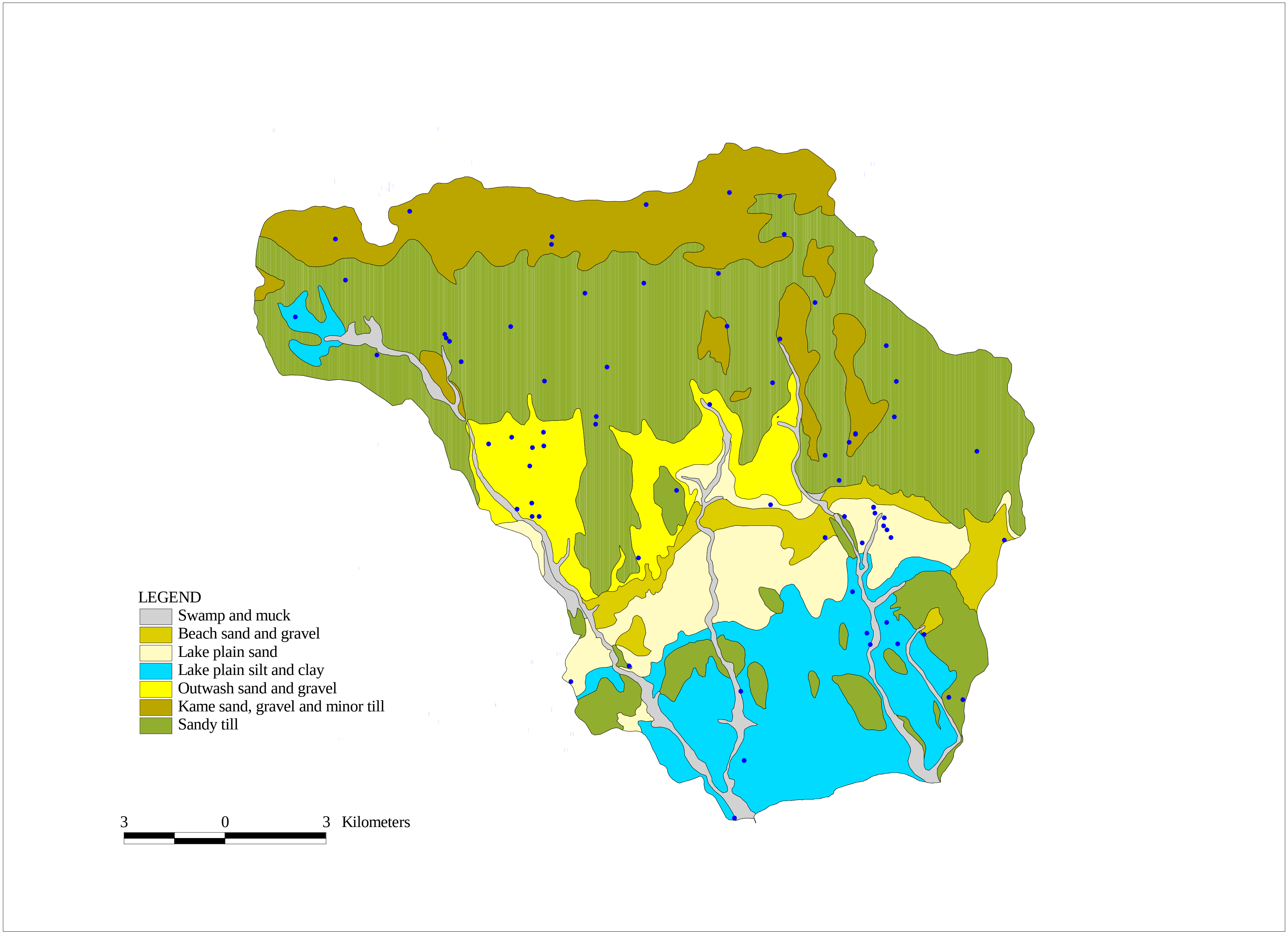


Figure Bo-12. Overburden wells with specific capacities higher than 50 l/min/m.

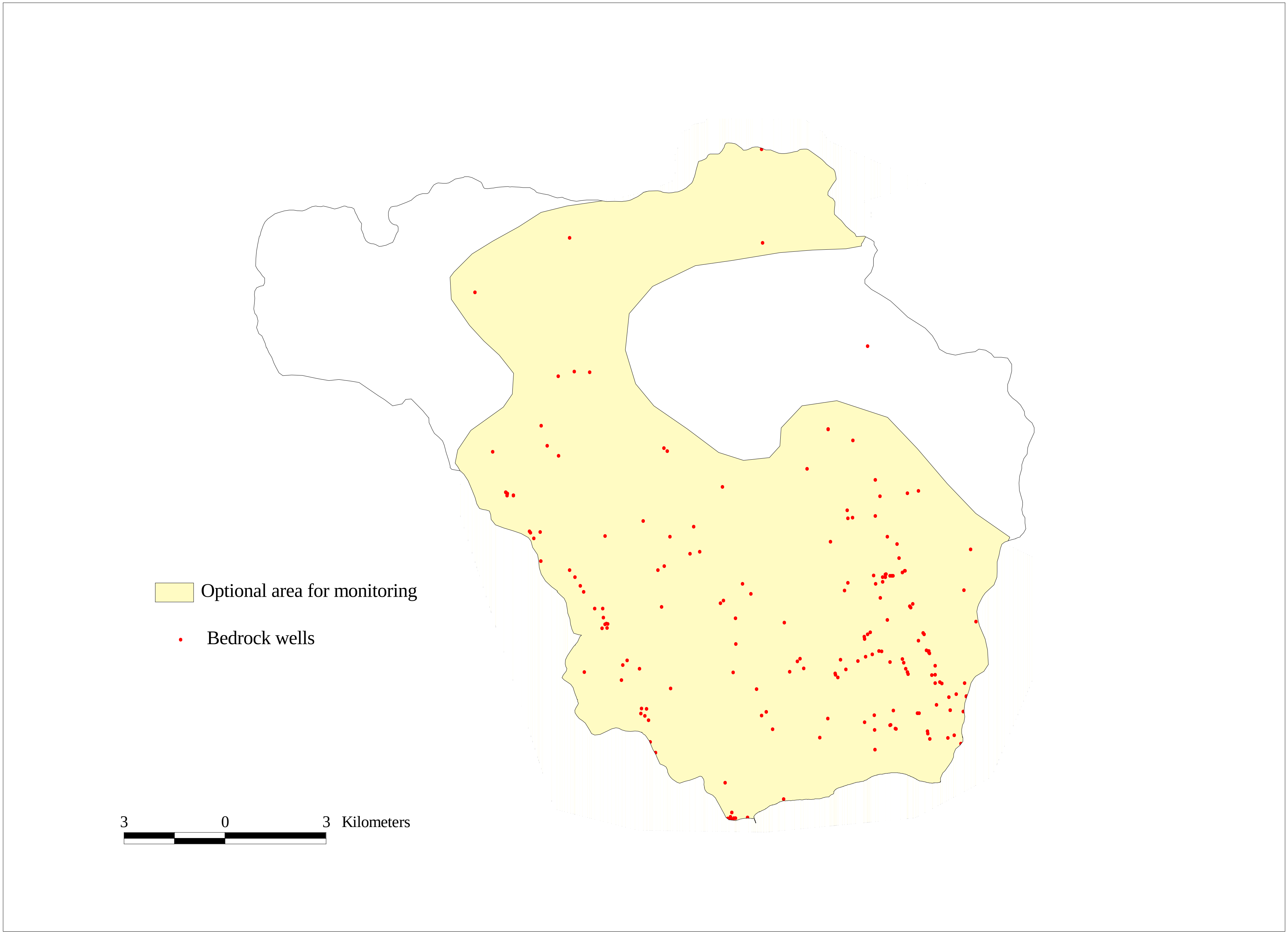


Figure Bo-13. Optional area for monitoring groundwater in the bedrock.

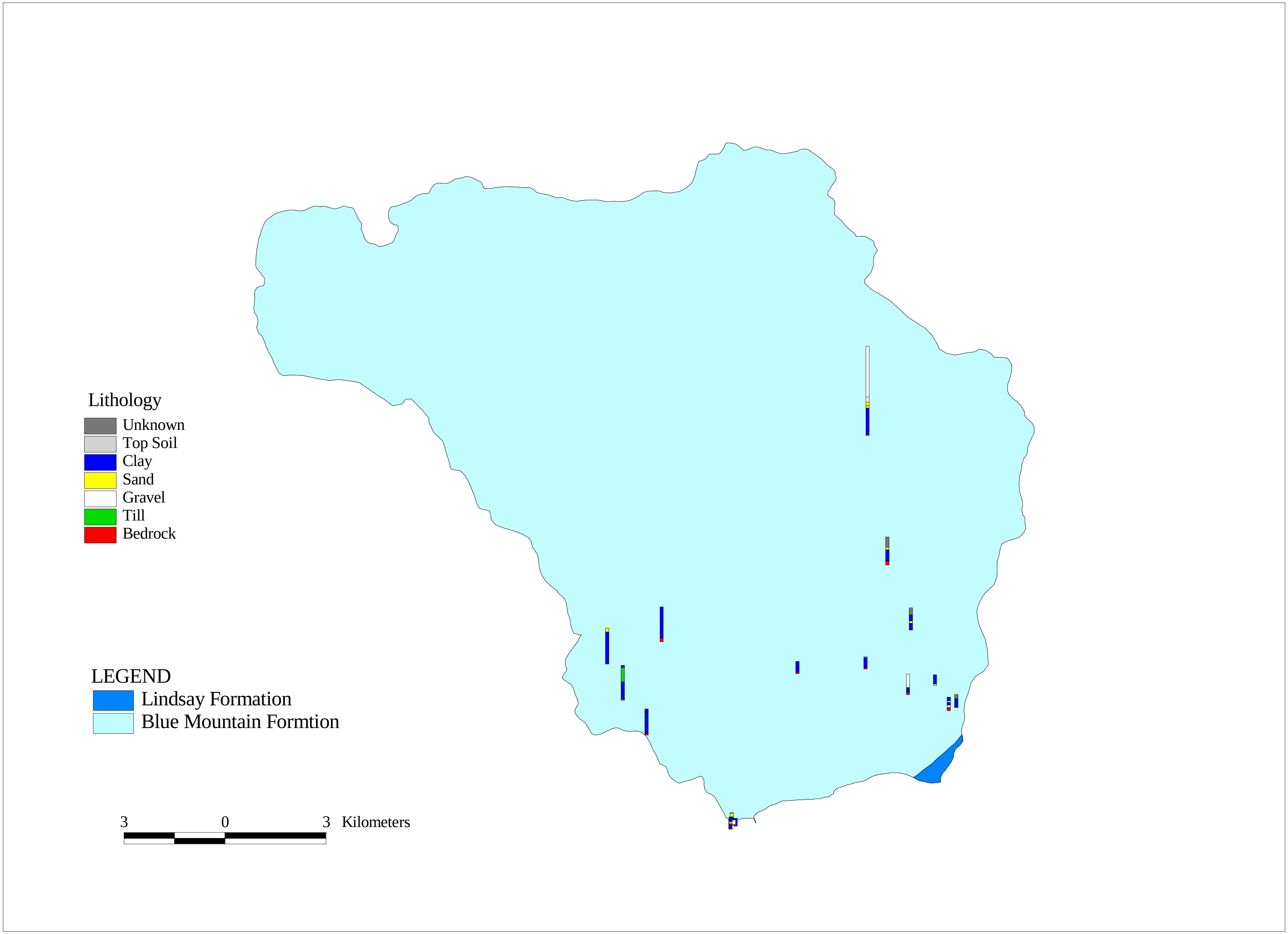


Figure Bo-14. Panel diagram showing the geologic logs of bedrock wells with specific capacities higher than 5 l/min/m.

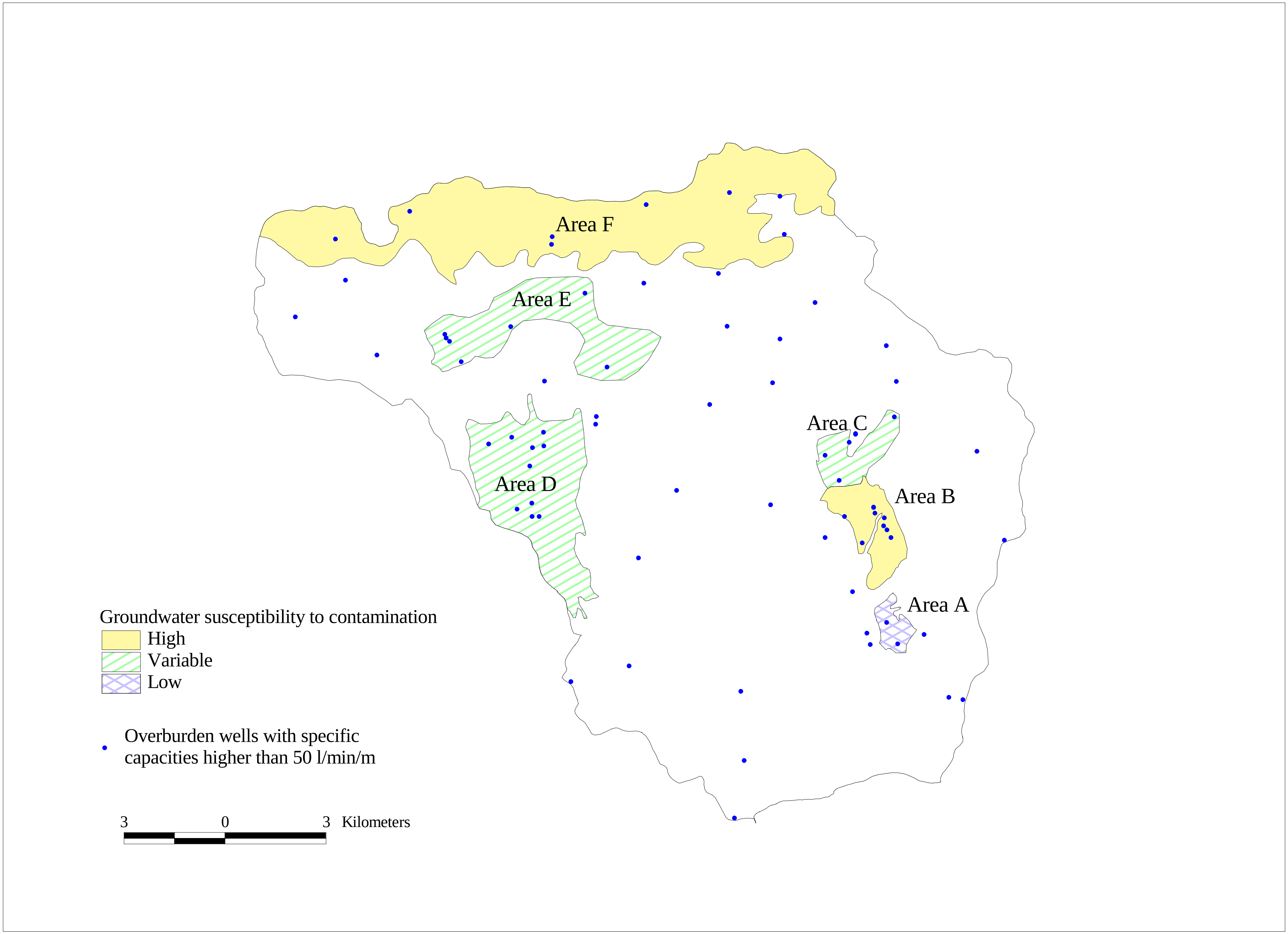


Figure Bo-15. Suggested areas for monitoring groundwater in the overburden.

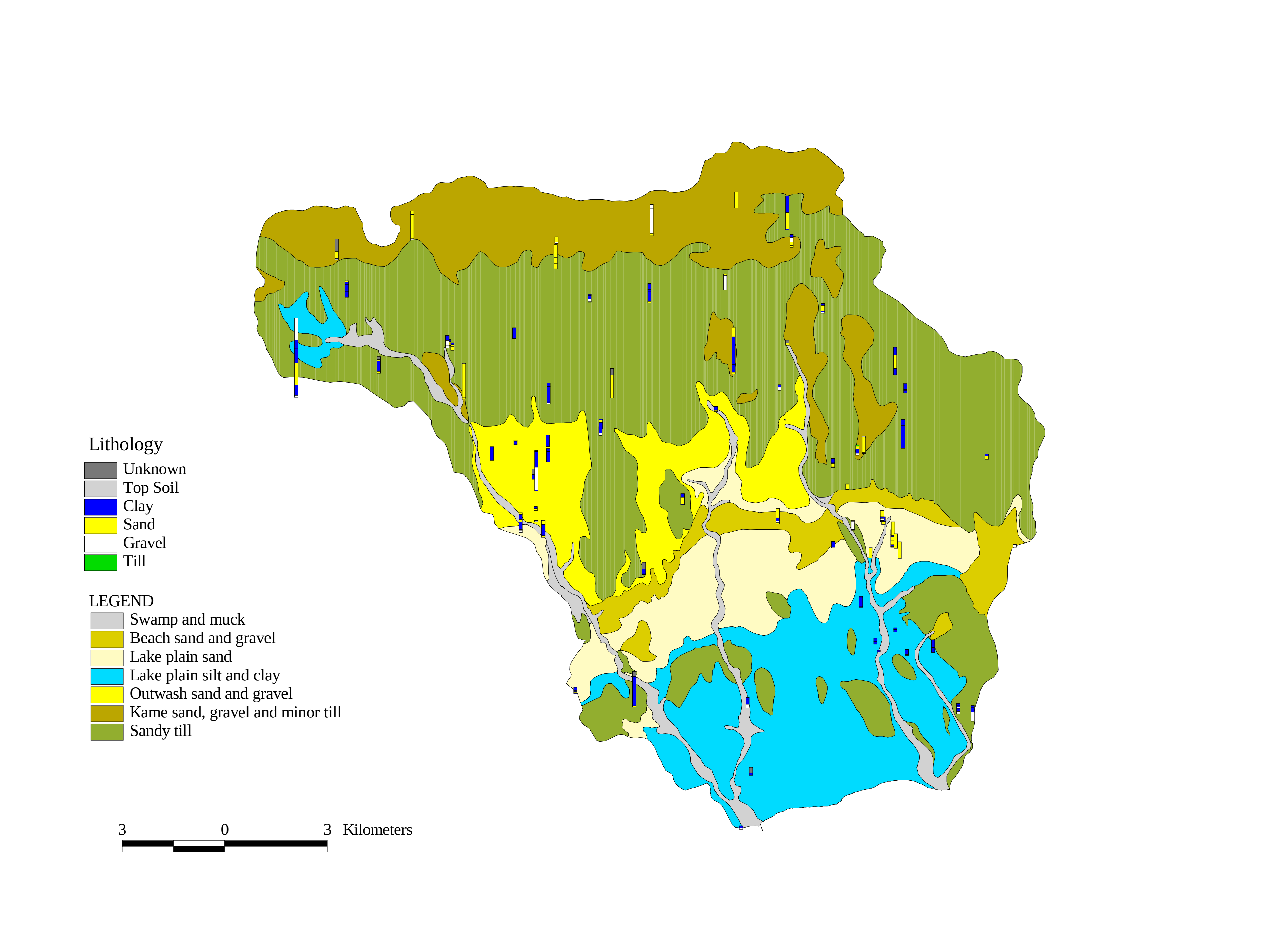


Figure Bo-16. Panel diagram showing the geologic logs of overburden wells with specific capacities higher than 50 l/min/m.

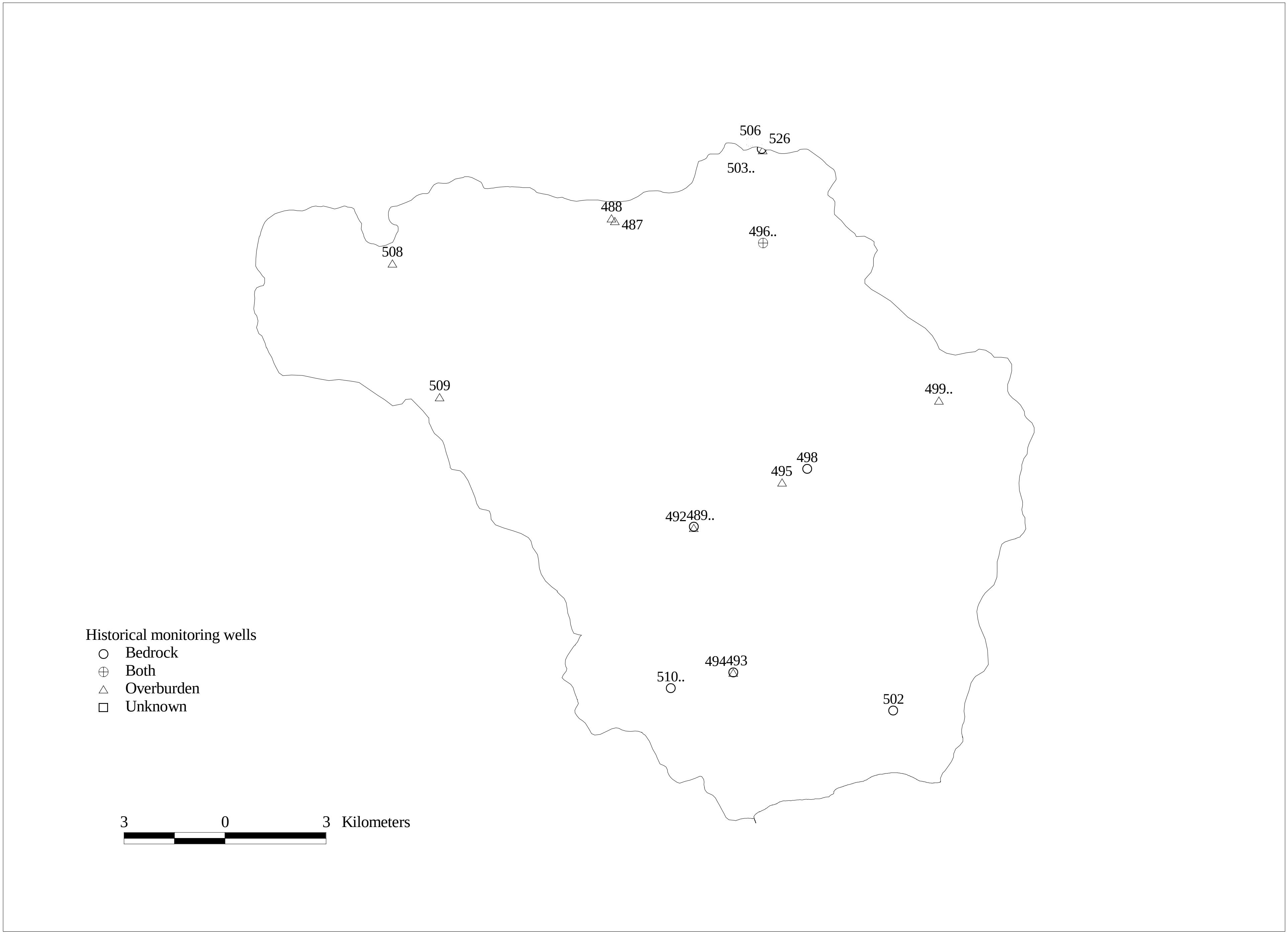


Figure Bo-17. Locations of historical monitoring wells in the Bowmanville, Soper and Wilmot Creeks drainage basin.