Holocene Shoreline Occupations and Water-Level Changes at Lac Mégantic, Québec

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Abstract. Archaeological questions concerning lake water levels are often related to the viability of past shoreline occupations. They become more complex when the lake's present "natural" level is unknown, as is the case at Lac Mégantic, southeastern Québec, which has a 12,000-year-long cultural sequence. One lakeside site, Plage-Duquette, was occupied during two periods, 8800–7800 and 6800–5800 cal BP, but its low elevation raises questions about its springtime viability. In 2003, an underwater survey identified the shoreline prior to damming in 1893. Related geological analysis of a submerged terrace indicated it was exposed for hundreds or thousands of years at an unknown time in the postglacial past. This is corroborated by lake studies in the Northeast that show a drop in water levels below today's values between 8800 and 5100 cal BP. The 4-m difference between mid-Holocene and pre-1893 levels at Lac Mégantic gives rise to a re-evaluation of prehistoric shoreline occupations. We conclude that the level of Lac Mégantic was significantly lower during the mid-Holocene than today and that this level modifies our understanding of Plage-Duquette and other sites.

Résumé. Les interrogations archéologiques sur les niveaux lacustres concernent souvent la viabilité des occupations riveraines. Elles se compliquent lorsque le niveau 'naturel' du lac est inconnu, en raison de l'aménagement de barrages. Toutes ces variables sont réunies au lac Mégantic, dans le sud-ouest du Québec, où la séquence culturelle remonte à plus de 12,000 ans. Ainsi, le site de la Plage-Duquette a accueilli une occupation importante à deux moments, 8800–7800 et 6800–5800 cal BP, mais sa basse élévation remet en question sa viabilité au printemps. En 2003, lors des prospections subaquatiques, nous avons identifié le rivage d'avant 1893, date du premier barrage sur le lac. Des analyses géologiques d'une terrasse submergée ont montré que cette zone a émergé pendant des centaines ou des milliers d'années à un moment post-glaciaire non identifié. Ce résultat semble être corroboré par plusieurs études de petits lacs dans le Nord-Est qui montrent une baisse généralisée des niveaux, par rapport au niveau actuel, entre 8800 et 5100 cal BP. L'écart de 4 mètres entre le niveau lacustre de l'Holocène moyen et celui d'avant 1893 au lac Mégantic entraîne une réévaluation des sites riverains préhistoriques. Deux conclusions principales découlent de cette étude: que le niveau du lac Mégantic fut sensiblement plus bas à l'Holocène moyen qu'aujourd'hui et que ce niveau modifie notre compréhension du site de Plage-Duquette et d'autres sites à proximité.

Lac Mégantic is a "finger lake" about 17 km long in Québec's Eastern Townships, near the United States border, and is situated on the northern Appalachian slope (Figure 1). Recent archaeological research near the lake's southern end has shown that this area contains the oldest known evidence of human occupation in Québec. Fluted points corresponding to the Early Paleoindian cultural phase (circa 12,100 cal BP; 10,300 radiocarbon years

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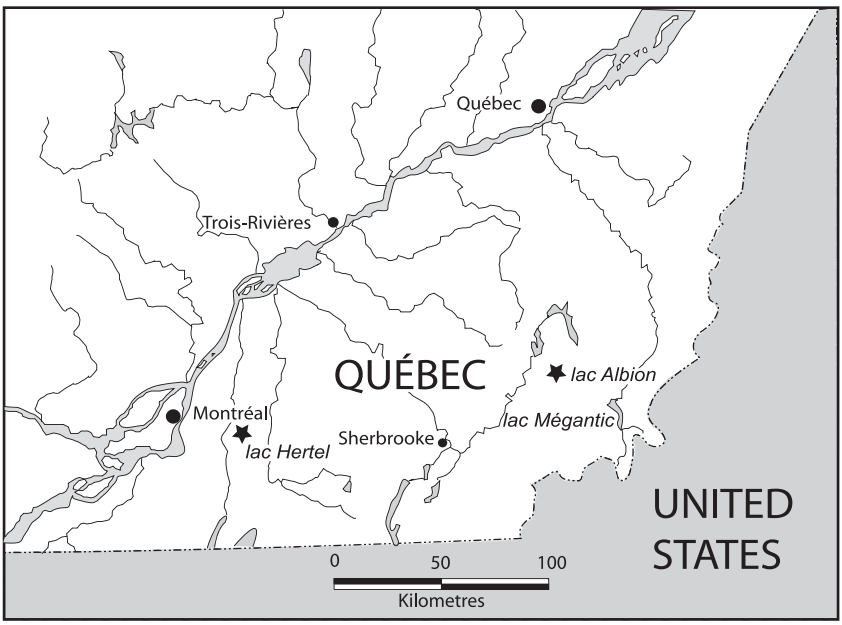

FIGURE 1. Lac Mégantic is situated on the northern Appalachian slopes, near the New Hampshire border.

[rcy][1]) have been found at the Cliche-Rancourt site (BiEr–14), located between Lac Mégantic and the smaller upstream Lac aux Araignées (Figure 2). The cultural sequence in the Méganticois[2] basin thus extends at least 12,000 calendar years into the past (Chapdelaine 2004), raising questions about links between the peopling of the basin and its environment, especially its hydraulic system. This Appalachian slope was the first area of southern Québec to emerge from its ice cover about 13,400 to 13,500 cal BP (11,550 BP) (Occhietti and Richard 2003). Meltwater caught in the Méganticois basin created the proglacial Lac Chaudière, which drained southward to the Atlantic through the Kennebec River basin for a time when waters reached 430 m above sea level (asl), about 35 m higher than the present lake. During its regression phase, Lac Chaudière moved northward with the retreating ice front and disappeared from the Méganticois basin by the time of the Champlain Sea transgression, about 13,100 cal BP (11,100 rcy) (Occhietti and Richard 2003). The Cliche-Rancourt site, at an elevation of 418 m asl, post-dates Lac Chaudière, but precise water levels in Lac Mégantic and its upstream feeder system are unknown at the time of the site's occupation about 12,100 cal BP (or 10,300 rcy).

Questions about the link between shoreline occupations and post-glacial water-level changes have arisen intuitively in the Northeast, as archaeologists noticed that site elevations cluster near shorelines. Lacking local data on water-level change, archaeologists tend to refer to a general paradigm according to which glacial meltwater inundated large areas, then drained as the ice cap retracted, allowing hydraulic systems to settle to today's levels. At Lac Mégan-

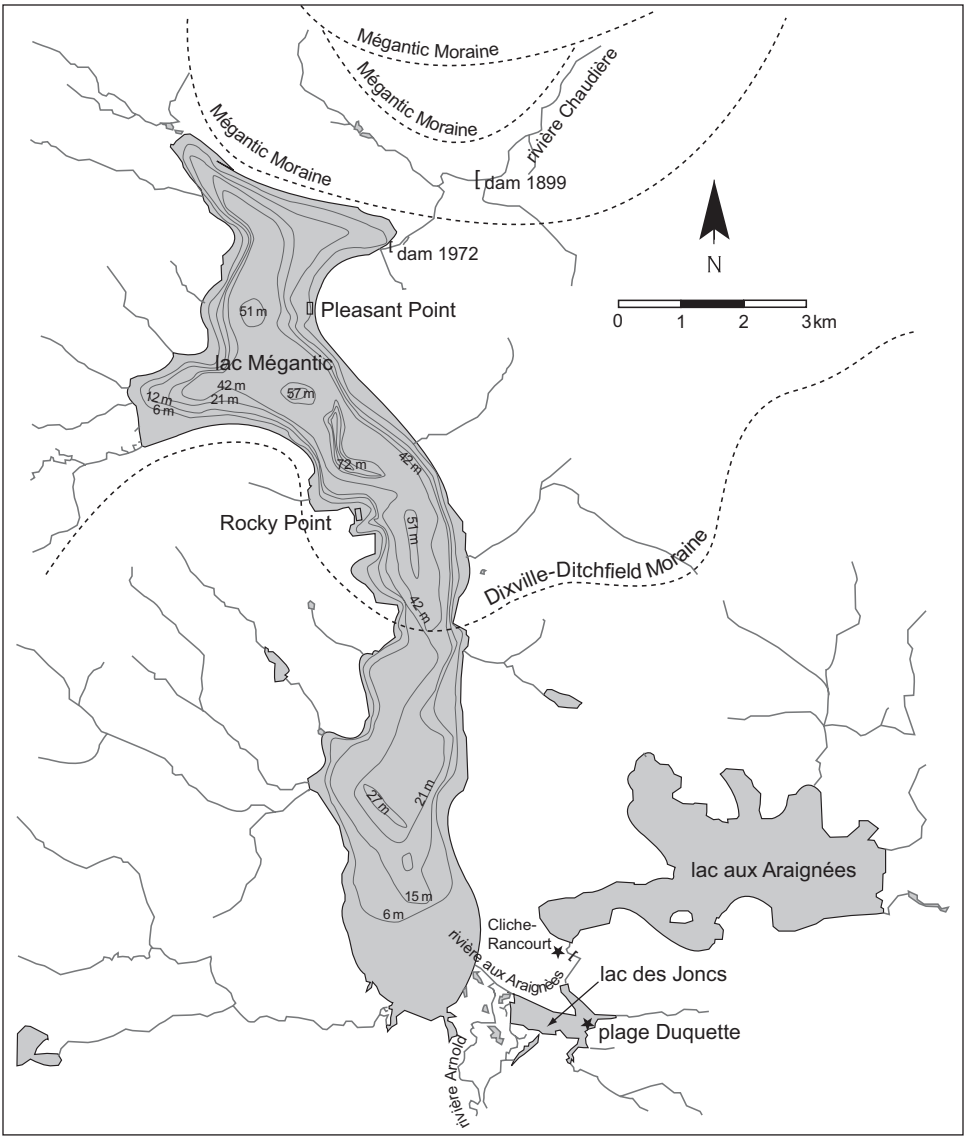

FIGURE 2. The Méganticois basin, showing the Trois-Lacs region where archaeological research is concentrated and the principal bathymetric contours of Lac Mégantic. The shallower southern portion corresponds to the Ditchfield moraine that crosses the lake here.

tic, this concept led archaeologists to discover a Paleoindian site on a terrace that was higher than important later occupations. The same idea, however, created problems in the interpretation of mid-Holocene sites around Lac Mégantic, especially the important Plage-Duquette site, which lies so low that it is presently submerged due to a small dam at the mouth of the lake. These problems seemed insoluble, since the lake's natural level was not recorded

prior to dam construction in the late 19th century. Local cottagers, in the context of a legal dispute over shoreline erosion, advocated a two-meter difference between the lake's natural and raised summer levels. This difference left no margin for spring floods at the Plage-Duquette site, compromising its interpretation as a base camp. In view of these conflicting data, an underwater survey sought evidence of other submerged sites and of the lake's natural shoreline. The new data on past shorelines were then compared to the elevation of the Plage-Duquette site, which served as a "reality check" for our reconstruction of prehistoric lake levels. In the process, we came to a better understanding not only of past levels at Lac Mégantic but also of the Plage-Duquette site itself.

PLAGE-DUQUETTE AND THE PROBLEM OF LAC MÉGANTIC WATER LEVELS

About 2 km from the Cliche-Rancourt site lies one of the Eastern Townships' major Archaic sites, named Plage-Duquette (BiEr–6). It contains lithic material from two technological phases: (1) a Neville-Stark Middle Archaic component (8800–7800 cal BP; 8000–7000 rcy) (Figure 3); and (2) an Otter Creek Late Archaic Laurentian component (6800–5700 cal BP; 6,000–5,000 rcy) (Figure 4). The site has a controversial recent history that is also tied to the lake's surface elevation. It was flooded in 1893 when a timber company raised Lac Mégantic to facilitate the log drive. Waters spilled onto a floodplain just upstream of Lac Mégantic, at the confluence of the Arnold River and the lower Rivière aux Araignées, thus greatly enlarging the Lac des Joncs (Rush Lake). The area now covered by the Lac des Joncs includes the lower channels of these two rivers and their surrounding lowlands. No lake levels from this period have been recorded. In 1956, a new hydroelectric dam again raised the two lakes to about 398 m asl. Technical problems with this dam led to wide fluctuations in lake levels, including a drop to 393.6 m in 1961. Coinciding with the lake's recreational development, these fluctuations led to a drive by local cottage owners for a new dam, completed in 1966, to stabilize levels. This dam has been regulated since 1972 by a provincial authority that maintains Lac Mégantic and the Lac des Joncs at a level of about 394.5 m asl (Phaneuf and Loewen 2004). However, in the light of perceived lakeshore erosion, cottagers have continued to press for judicial clarification on their true property limits, thus fuelling local controversy and scholarly debate on the pre-1893 or "natural" level of Lac Mégantic.

The Plage-Duquette site was discovered in the midst of this controversy by Jean Cliche in the fall of 1972 when lithic artifacts were found in knee-deep water at 394 m asl, along a newly re-exposed beach on the Lac des Joncs. For several years, artifacts were retrieved during autumn low-water periods, without precise archaeological recording but within a limited area (Graillon 1998). Scholarly interest in the site came later, along with questions about the prehistoric lake's surface elevation. In 1984, observations gleaned from submerged tree stumps in Lac Mégantic led cottagers to contend that "natural" summer levels prior to 1893 lay between 392.3 and 393.2 m. Spring floods raise the lake a meter or more; the Plage-Duquette site would thus have flooded in spring and been wet in summer, making its attraction to prehistoric groups hard to explain. Archaeologists asked whether the arti-

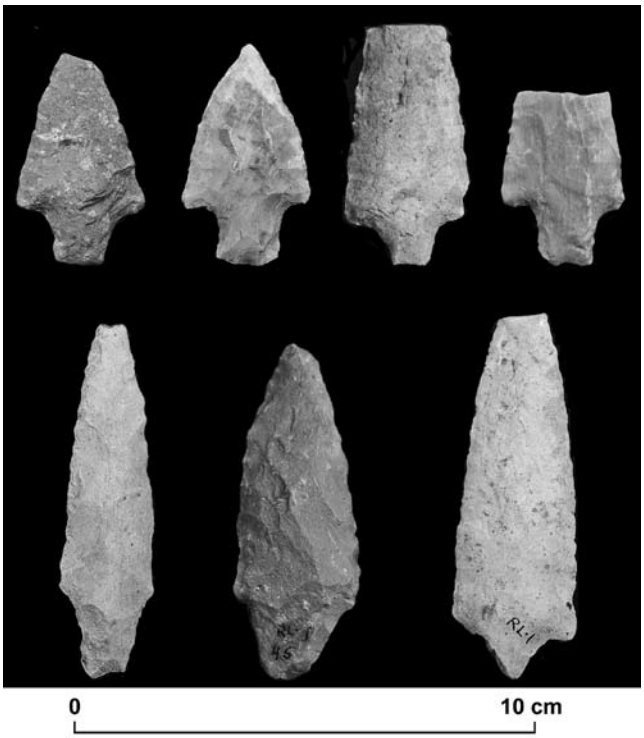

FIGURE 3. Neville and Stark projectile points from BiEr–6 (Plage-Duquette). The upper row shows Neville stemmed points with straight base; the lower row shows a very narrow Neville point at left, followed by two Stark points with the pointed or convergent stem.

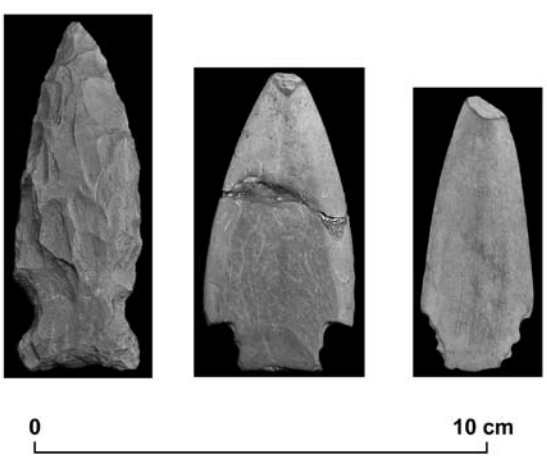

FIGURE 4. Laurentian Archaic projectile points from BiEr–6 (Plage-Duquette). The left specimen is an Otter Creek point and the two others are polished stemmed points with notches on the stem.

facts had been found *in situ* or had eroded from higher ground since 1893. However, fieldwork on the low terrace behind the beach did not locate any prehistoric occupation, thus excluding the idea of a higher ground origin for the artifacts and confirming the site's original elevation of 394 m asl (Chapdelaine 2002). In light of these data, the site's function within a regional scheme was uncertain. While its role as a base camp was indicated by the large number, size, and diversity of stone tools, the risk of flooding suggested a seasonal camp.

Understanding of the 12,000-year local cultural sequence and especially the *circa* 3,000-year sequence at Plage-Duquette was thus tied in multiple ways to the question of local water levels. Both tested and untested information circulated and both archaeological and legal goals were being pursued, obscuring the question of lake levels during the mid-Holocene. While levels in the glacial retreat phase and since 1893 were known to be higher than for the intermediate period, the lack of data forced archaeologists to apply pre-1893 levels to all of prehistory since the retreat of proLac Chaudière.

Recent palaeoecological research has refocused the problem of the Plage-Duquette site. A small lake about 30 km north, Lac Albion, was studied to determine its level throughout the Holocene (Lavoie and Richard 2000). Presently, this lake holds a meter of water and measures about 500 m across. Core analysis showed that its level was as high as today's level before 11,000 cal BP (9,800 rcy), 2 m below today's level from 11,000 to 4400 cal BP (9,800–3,900 rcy), then rose to today's level. In addition, an intermediate level prevailed between 6900 and 6100 cal BP (6,100–5,300 rcy), when waters stood one meter below today's level (Figure 5; see Dieffenbacher-Krall and Nurse [2005] and references therein). The finding of a prolonged low-water period in the mid-Holocene corresponds broadly with other small lakes in the Northeast. It also places the debate on Lac Mégantic's pre-1893 level in a context of continuous hydrological change.

While this study leads us to inquire whether the Méganticois basin also had lower waters during the mid-Holocene, the 2-m variation found at Lac Albion cannot be inferred for a larger body of water such as Lac Mégantic. Evidence from the Great Lakes may indicate that larger watersheds experienced greater absolute changes. Lewis *et al.* (2004), after taking into account isostatic effect, inferred water levels of tens of meters below present outlets in the Erie and Michigan-Huron basins, linked to a severe dry climate between about 8700 and 7800 cal BP (7,900–7,000 rcy). St. Lawrence river waters fell to 10 m below present levels during the mid-Holocene, then rose to briefly surpass present levels about 2,200 years ago (Clermont and Chapdelaine 1992; Dionne 1988a, 1988b; Hétu 1994). The Great Lakes and St. Lawrence examples, while underscoring the need for a basin-by-basin approach to Holocene water levels, suggest that change in Lac Mégantic may have been greater than the 2-m range found at Lac Albion.

Lake levels are an important factor in understanding the placement of prehistoric sites, as well as in planning regional surveys. Sites from early to mid-Holocene times may presently lie in water or wetlands while those from the late glacial period may be found relatively far from water today. Additionally, data from the low-lying Plage-Duquette site, occupied during two cultural phases separated by

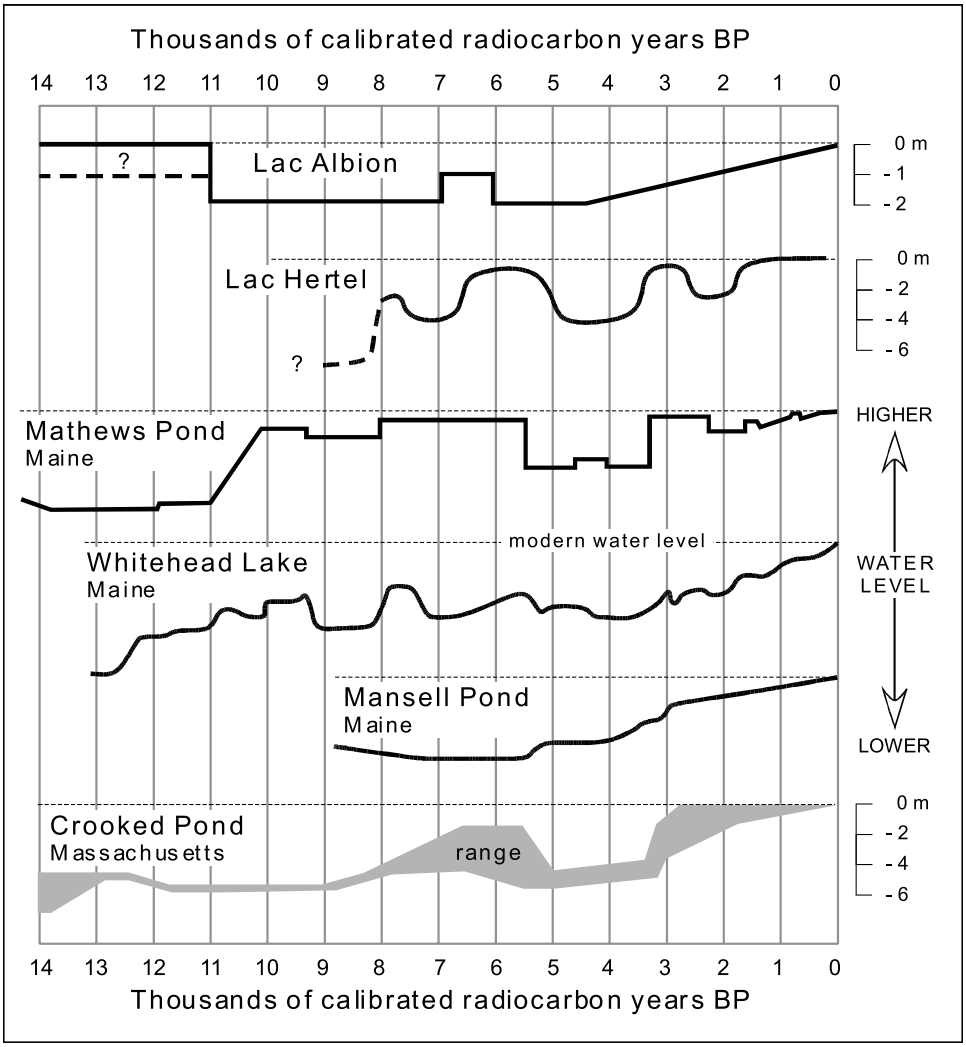

FIGURE 5. Postglacial water level changes around the Méganticois (after Dieffenbacher-Krall and Nurse 2005). All the water level curves shown here indicate mid-Holocene water planes lower than during the late Holocene. Most overall trends are reasonably synchronous within the margins of error related to radiocarbon dating of local, time-transgressive events. Within these trends, some lakes apparently react differently during given time periods. Such individual behaviour points to the role of aquifer character in each watershed rather than hydroclimatic changes in seasonal precipitation regime and evapotranspiration.

a hiatus of 1,000 years, may suggest that lake levels fluctuations were linked to site occupation. We have thus sought to frame these variables in the Méganticois context through underwater surveys aimed at finding past shorelines and submerged cultural remains and through comparison of cultural and hydrological phases over the past 12,000 calendar years.

THE HYDROLOGICAL AND GEOLOGICAL CONTEXT

Lac Mégantic is a fairly typical "finger" lake lying within a valley formed by glacial gouging and blocked at its downstream outlet by an end moraine deposited during a halt in the ice cap's retreat. Its watershed of about 777 km^2 extends from the Appalachian peaks of the New Hampshire and Maine border as far northwest as Mont Mégantic and the village of Nantes. It is fed from the south by two important tributaries. One is the Rivière aux Araignées that is twice interrupted by lakes, the Lac aux Araignées and the Lac des Joncs. The other is the Arnold River, named after Benedict Arnold who used it as an invasion route into Canada in 1775. In all, 16 streams drain directly into Lac Mégantic. Today's lake holds 88,507,000 m^3 of water, measures about 17 km by 3.5 km (2,642 ha), and descends to a maximum depth of 75 m (Centre d'expertise hydrique du Québec 2003). Its official elevation is 396 m asl, which represents its highest spring level since 1972, although its level during the navigation season is maintained at about 394.5 m. The lake's official bathymetry indicates a deeper northern portion and a shallower southern portion. In the northern portion, steep slopes descend 45 m to a flat bottom that is punctuated by several ice-block pits that attain a depth of 55 to 75 m. The southern portion, somewhat smaller in area, also has steep slopes and a flat bottom but contains no pits and has a depth of only about 21 m, having been partially filled by the Ditchfield moraine that crosses the lake at this point. Bathymetry also reveals that in several areas around the lake the bottom forms a gently sloping terrace to a depth of 4 to 5 m, then drops abruptly. The edge of this submerged terrace lies between 391 and 392 m asl. Finally, in some areas, official bathymetry suggests the presence of a second, lower terrace lying between 388 and 389 m asl (TRAK 2002).

The amount of water exiting the lake annually, about 375,000,000 m^3 on average, is more than four times the lake's volume. Retained by a dam at its egress into the Chaudière River, which flows 135 km north to the St. Lawrence, the lake's average outflow is about 12 m^3 per second, but varies seasonally from 4 m^3 in August to 60 m^3 in late April. Record low and high outflows during the 25-year period from 1976 to 2000 are well beyond this range (0.3 and 198 m^3/second). Outflow is above average during about three months from early March to mid-June when two-thirds of annual outflow occurs. In April, fully a quarter of annual outflow exits the lake. At no time during the 25-year study period did summer outflow cease entirely, indicating a constant net surplus in the basin's hydrological balance (Centre d'expertise hydrique du Québec 2003). The fact that the Méganticois basin is 85% forested today plays a role in stabilizing outflow and retaining water in the hydrological system (Thériault 1997: 4). This was not so before recent reforestation. In the early 20th century, when logging and agriculture coincided to greatest effect, spring runoff was accelerated, resulting in frequent severe floods. Artificially rapid spring runoff and naturally low summer rainfall meant that, as recently as 1970, lake outflow could cease in August. The twentieth century has shown that hydrological balances, water outflow and lake levels are affected by vegetation as well as by precipitation.

Local geography consists of granite summits overlain with glacial sediments. Crests flanking the lake are in the range of 650 to 1,100 m, while Appalachian

summits rise to 1,200 m. This landscape emerged from the icecap and post-glacial meltwater in stages during the 14th millennium cal BP. Beginning about 13,500 cal BP (11,550 rcy), when the Appalachian divide was freed of ice, the Méganticois basin was flooded by proglacial Lac Chaudière whose waters drained southward across the Appalachians by way of the Coburn Gore (Arnold River/Mud Creek) and the Araignées passes, situated at 430 m asl. The Dixville-Ditchfield Moraine, which bisects the present lake (Figure 2), was deposited when the ice-margin stabilized here briefly about 13,400 cal BP (11,400 rcy) (Occhietti and Richard 2003). About a century later (13,300 cal BP), the north shore of Lac Chaudière corresponded to the Cherry River-East Angus Moraine. Subsequently, Lac Chaudière extended northward, following the retreating ice. Its final drainage from the Méganticois basin remains imperfectly dated. Three closely spaced moraines at the northern end of present Lac Mégantic were formed between 13,300 and 13,150 cal BP (11,400–11,200 rcy). During this period, Lac Chaudière likely still flooded the basin and drained across the Appalachians (Larocque 1983; Shilts 1981). A century later, however, at the time of the Champlain Sea transgression in the St. Lawrence Valley about 13,100 cal BP (11,100 rcy) (Richard and Occhietti 2005), the basin's hydrography resembled that of today, with a northward drainage system and a chain of individualized lakes. Soon after, the ice-margin lay north of the St. Lawrence Valley and the Chaudière River flowed into the Champlain Sea (Shilts 1981: 49). Since these dramatic changes during the ice cap's 400-year retreat from the Appalachians to the Laurentians, the basin's hydrology has remained fairly stable.

Within this long phase of relative equilibrium, low-frequency changes in water levels have been documented at many lakes across eastern North America, especially in New England and adjacent areas (Almquist *et al.* 2001; Dieffenbacher-Krall and Nurse 2005; Lavoie and Richard 2000; Newby *et al.* 2000; Schuman *et al.* 2001). They are dated in terms of centuries and appear to become important for archaeology when their amplitude surpasses that of a lake's annual (high-frequency) fluctuation. At Lac Mégantic, for example, low-frequency fluctuations leave visible geological features when they surpass the lake's annual range of about two meters. Lake-level changes of such amplitude would affect occupation of shoreline sites and signal environmental changes to which past populations adapted.

THE UNDERWATER SURVEY

In September 2003, an underwater survey at the Plage-Duquette site and at two locations on Lac Mégantic sought evidence of prehistoric occupations on shorelines flooded since 1893. Survey strategy was influenced by incertitude concerning pre-1893 lake levels and thus evidence was also collected in view of establishing past water levels that were lower than those of today. Presently, the summer level of Lac Mégantic and the Lac des Joncs is maintained at 394.4±0.30 m above sea level. We presumed that this elevation is higher than the pre-1893 level even though no data survive from the period before the first dam. Two studies, commissioned by the local cottagers' association, contended that pre-1893 summer levels ranged from 392.3 to 393.2 m asl, the lower elevation being the base of the present dam at the lake's outlet into the Chaudière River (Déry 1984; Rouillard 1984). While

these elevations remained unverified, the summer range of 0.9 m corresponds with more recent studies. Dam management data from 1976–2000 show that summer levels vary by 0.9 m, while record low- and high-water marks for this period are separated by 1.9 m (Centre d'expertise hydrique du Québec 2003).

Since 1893, four dams have existed at the head of the Chaudière River, of which the present dam, operational since 1972, appears to be the lowest (Cadieux 2004; Kesteman 1985: 270–279; Phaneuf and Loewen 2004; Thériault 1997: 14). Known historical levels from the period 1893–1972 range from 393.6 m to 398 m asl, shown on maps and confirmed by aerial photographs from the mid-1960s. Present levels are regulated since 1993 by a residents' agreement fixing the summer range at 394.4±0.30 m. Thus, only the pre-1893 "natural" shoreline is submerged today. Continuous recording since 1976 shows September low and April high records of 393.8 and 395.7 m asl respectively (Centre d'expertise hydrique du Québec 2003). The latter elevation, rounded off to 396 m, presently constitutes the lake's level on official maps.

The official bathymetric map of Lac Mégantic has depth contours at 3-m intervals. It shows two point-shaped terraces at a depth of about 6 m, on opposite sides of Lac Mégantic. Since these features appear to form part of an intermittent terrace around the lake, we supposed that the edge of this elevation might correspond to the pre-1893 shoreline. Fieldwork focused on these terraces to increase the chance of finding prehistoric artifacts.

At the Plage-Duquette site on the Lac des Joncs, research focused on searching for lithic artifacts in now-flooded areas of the site, and on discovering the site's natural boundaries underneath the present lake. It was thought that the site might have been bordered by the lower Rivière aux Araignées, now flooded by the Lac des Joncs. No memory of the river's pre-1893 location near the Plage-Duquette site has survived. Above the Lac des Joncs, the river's natural channel exists for 700 m, descending 10 m from the Lac aux Araignées (406 m asl). Before 1893, the river continued to descend over a greater distance toward the Plage-Duquette site, before levelling off and turning toward Lac Mégantic. Discovering the drowned river's exact course was an implicit objective linked to establishing the site's natural boundaries.

Survey Areas and Methods

During the survey in early September 2003, the lake stood at 394.4 m and its outflow at the low rate of 3 m^3 per second. Underwater elevations were measured in relation to the water's surface, using calibrated cords that were extended to the surface with small floats (plastic water bottles). Elevations were considered to be accurate within 10 cm.

The first survey area included the Plage-Duquette site (Figure 2) and extended 50 m from the present shoreline (Figure 6). This shallow area was first surveyed on foot. Sand has been trucked to the beach to improve its appeal and cover the clayey natural soil. Erosion at the Plage-Duquette site is influenced by winds that push sediments shoreward and by a current that moves parallel to the shore in a westerly direction, at speeds ranging from nil in late summer to noticeable in spring. Two teams of divers then swam routes in deeper water beyond the survey grid, as far as the remains of a *circa* 1900 stone-ballast quay on the lake's north shore. Maximum depth in the middle of the lake was about 1.4 m. Finally, divers examined

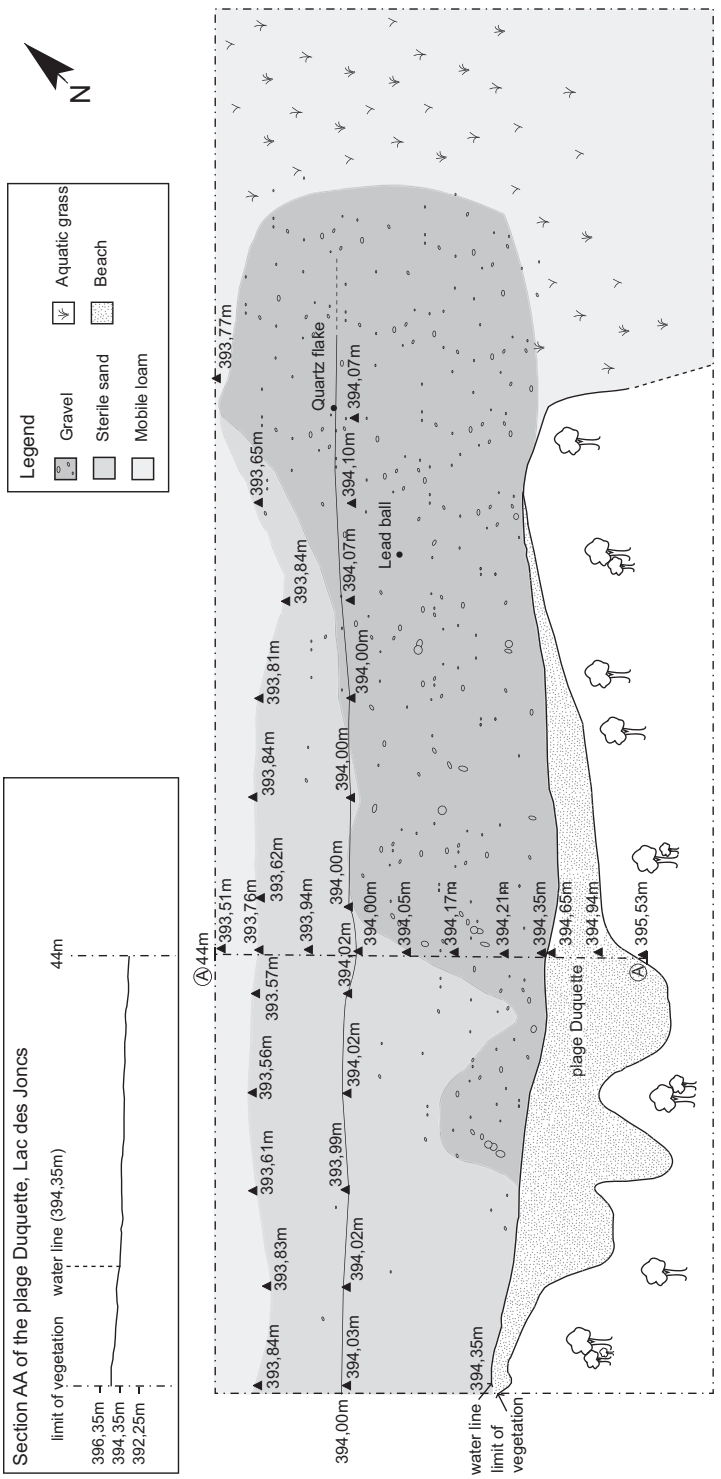

FIGURE 6. Underwater topography at the Plage-Duquette site, surveyed in September 2003. The northern limit of the clay substrate appears to indicate the pre-1893 shoreline near the junction of the Rivière aux Araignées and the upper end of the Lac des Joncs.

the Rivière aux Araignées just below the Lac des Joncs at the site BiEr–9, situated about 1.35 km downstream of the Plage-Duquette site.

On Lac Mégantic, the first survey area targeted the submerged portion of Rocky Point, located on the west side of the lake (Figure 2). A survey grid 150 by 50 m was established in a north-south orientation, parallel to the shoreline (Figure 7). The outermost points of the survey area were near the drop-off ledge to deeper water, at a depth of about 6 m. The area between the survey grid and the shore was surveyed by snorkelling. Erosion at Rocky Point is influenced by prevailing north-westerly winds that have created a shoreline cut. Eroded sediments are transported offshore and finer loamy particles are moved southward across the submerged point, accumulating in the adjacent bay.

The third area, on the east side of Lac Mégantic, also targeted a submerged point indicated by the bathymetric map (Figure 2). The nearest placename is Pleasant Point, some distance to the south. A 50-m^2 survey grid was established from waist-deep water and, as at Rocky Point, the residual band was surveyed by snorkelling. In this area, offshore winds create a beach.

Survey baselines were positioned by multiple (n=5) averaged GPS readings, whose accuracy was tested by taping and considered to be accurate within 0.7 m (Cadieux 2004). Within the survey perimeter, 10-m wide corridors were laid out with cords. Depths were recorded at the ends of the corridors and at intervals along their lengths. Two divers spent about 90 minutes surveying each 100-m-long corridor. In addition to seeking cultural evidence, they recorded underwater topography. At a depth of 5 m, visibility was sufficient to allow divers to keep track of each other and observe the bottom without difficulty. Ultimately, no prehistoric cultural remains were found, although historical artifacts observed at Rocky Point included *circa* 1900 cooking utensils and tableware and the wreck of the *Campagna,* a log-boom tug built on the lake in 1893 and abandoned in 1926 (Bourque *et al.* 1995: 80–84).

Survey Results at Plage-Duquette

The Plage-Duquette site is a beach of fine sand about 10 m wide and about 100 m long in an east-west orientation (Figure 6). The sand's upper edge lies at 395.5 m asl, where a low talus begins. The beach's submerged portion (below 394.4 m) is characterized by sand mixed with pebbles and gravel, covering a hard clay substrate that is exposed in some places. Finer sand and gravel particles appear to have been moved westward along the beach by the slight current. This type of bottom prevailed to a line about 40 m from shore, where the depth was about 50 cm (393.9 m asl).

At the 50-cm isobath, the bottom changed in nature. The bottom was composed of a loamy, organic deposit called *gyttja* that was soft and volatile, making visual survey difficult. Apparently alluvial in nature, this deposit represents a siltation process that is ongoing. Its depth is unknown. Divers probed it in several places by thrusting an arm into it up to the shoulder (about 1 m), without finding a more compact substrate. In the middle of the lake therefore, the deposit's base lies below 392 m asl.

At the BiEr–9 site just below the Lac des Joncs, the channel bottom lies at a depth of 1.5 to 2 m, or between 392.4 and 392.9 m asl. It is composed of compact alluvial sediments with some depressions of an unknown nature. The

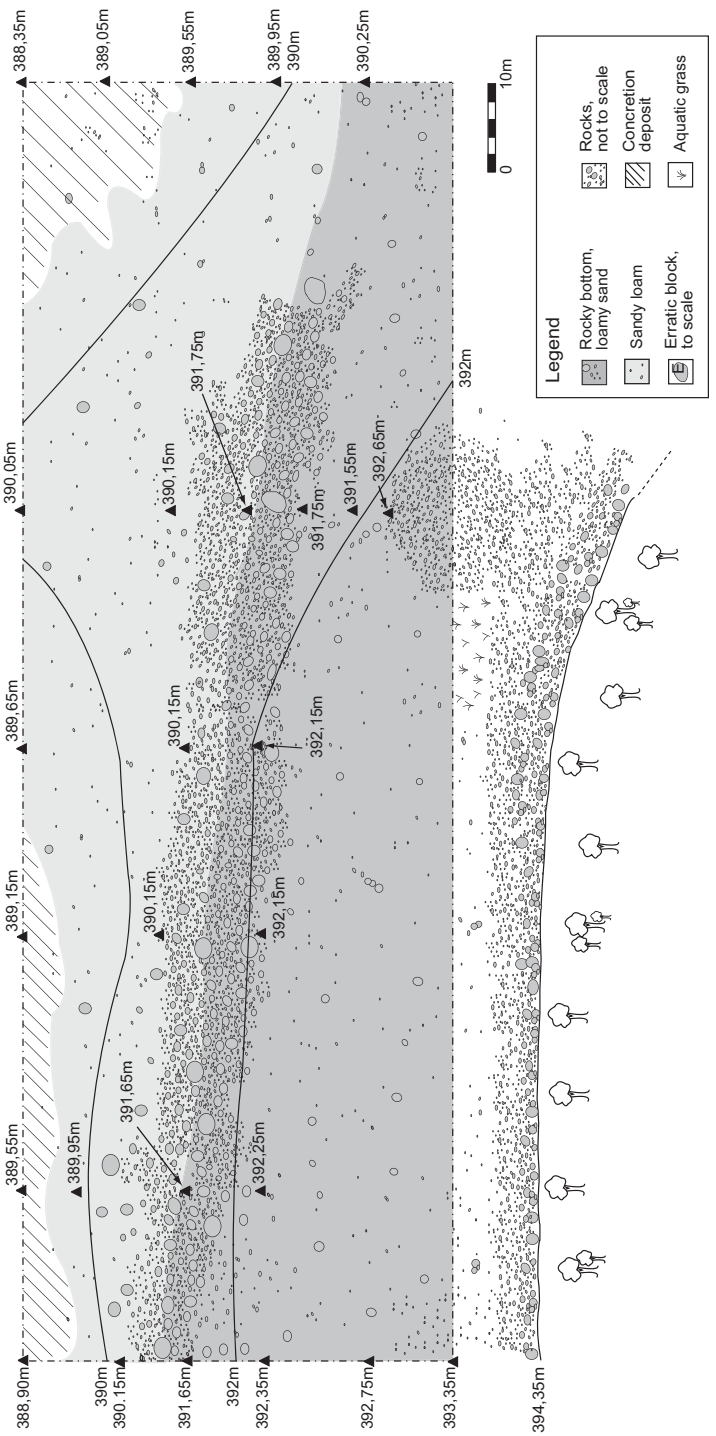

FIGURE 7. Underwater topography at Rocky Point, surveyed in September 2003. The pre-1893 shoreline is represented as a rocky band some distance from the present shoreline; below this rocky band, the concretion deposit extends to the edge of the survey area.

right bank is steep and cut into the clay subsoil, and the shoreline rises to form a well drained terrace. The left bank, in contrast, slopes gently and emerges as a low levee separating the river and the boggy area between the Lac des Joncs and Lac Mégantic. These findings indicate that the clay terrace on which the Plage-Duquette site is located extends underwater to the bank of the pre-1893 Rivière aux Araignées. The lower edge of the terrace lies at about 393.8 m asl. Since the stream turns westward at this point, the terrace has likely been partly eroded away and with it, part of the Plage-Duquette site. The lost portion of the site lay below 393.8 m asl.

The former riverbed, now submerged by the Lac des Joncs, is presently silting up in a process that appears to be linked to an artificially high water plane since 1893. At the Plage-Duquette site, the streambed appears to have been quite broad, covering most of the Lac des Joncs. The channel elevation next to the Plage-Duquette site remains unknown but, based on divers' arm probes, it was below 392 m asl.

At the site BiEr–9, which is just below the Lac des Joncs, the bed of the Rivière aux Araignées lies at about 391.9 m asl. The channel's compact bottom suggests that post-1893 silting is minimal. Throughout the Lac des Joncs, the morphology of the north (right) shore suggests that the original channel of the Rivière des Araignées may have followed this straight shoreline.

The following geological sequence may thus be proposed:

1. The original, post-glacial streambed followed the right bank of the Lac des Joncs;
2. The streambed meandered southward, eroding the terrace on which the Plage-Duquette site is located and widening to form the bed of the prehistoric Lac des Joncs; and
3. Post-1893 siltation is filling the streambed and original lakebed.

Survey Results at Rocky Point

The second survey location, Rocky Point, is on the west side of Lac Mégantic (Figure 2). The Ditchfield moraine crosses the lake at this point and creates a series of points on the western shore. About 100 m from shore, a rock several meters in diameter rises to the lake's surface, creating a navigational hazard. It forms the point of a terrace that is the submerged portion of Rocky Point, sloping gently to a depth of about 6 m before dropping off more steeply. The shoreline is an eroded cut, lined by granite rocks up to a meter or more in diameter (Figure 7). A fairly abrupt slope rises from the shoreline and is covered by forest vegetation. Below the shoreline, rocks of progressively smaller size have been carried downhill to a depth of about 50 cm and are mixed with coarse gravel, sand pockets, and small patches of aquatic grass. Particle size decreases with distance from the shoreline, with loamy sand predominating from 393.8 down to 392 m asl (0.55 to 2.35 m depth). This shoreline erosion deposit becomes progressively thinner, revealing a pebbly to rocky substrate. These sediments represent a reorganized glacial till that originated in the shoreline cut and has been sorted according to size, with the most mobile particles moving farthest downhill from the shoreline.

About 50 m from shore, the bottom briefly forms a steeper slope, passing from 392 to 390 m asl (2.35 to 4.35 m in depth) over a distance of 5 to 10 m. This decline is characterized by a rocky talus, similar to that forming the present shoreline cut, with particle size

decreasing downhill from granite blocs more than a meter in diameter down to pebbles and gravel. At the base of this decline, the bottom levels off somewhat, again forming a gentle slope. Smaller particles down to fine silt cover the slope down to an elevation of 389 m asl. There can be little doubt that the rocky decline corresponds to the pre-1893 shoreline cut. Water levels before 1893 thus appear to have fluctuated between 390 and 392 m, about 3.8 m below the present range of 393.8 to 395.7 m asl.

Below 389 m asl, no eroded glacial sediments are found and the bottom takes on a different aspect. Very fine sand and clay have concreted to form a crust-like surface layer in which angular sandstone blocks up to 40 cm across and 10 cm thick are occasionally embedded. The concreted layer can be broken with a diving knife, revealing a thickness of 2 to 10 cm and a composition including numerous micro-strata that range in colour from dark grey to rust-brown, with the latter dominating. Concentrated iron oxides explain the rusty colour and the concreted texture. This deposit continued beyond the survey area (388.4 m) and is presumed to extend to the drop-off to deeper waters some 10 to 30 m further offshore.

This concretion layer may succinctly be described as an *ortstein*, which is an iron-cemented, podzolic B soil horizon (François Courchesne, pers. comm., Montréal, 2005). As organic acids produced in the soil's humic upper layer leached downward, they dissolved aluminum and iron oxides in the soil's mineral layers. These oxides were carried down to the surface of the water table, where they concentrated and precipitated when the water table dropped. The layer is thus situated at the water table's upper level. While rainwater was required to transport the oxides to this level, exposure to air was required for these oxides to precipitate. The layer's stratified composition indicates it was formed in a cyclical process. Such a leaching-and-drying formation cycle is known as a reduction-oxidation phenomenon and is not understood as an underwater process. Its occurrence is widespread on Goldthwait Sea sandy terraces in the Quebec North Shore area where it created impermeable layers now supporting peatlands.

A reduction-oxidation formation process signifies that past water levels oscillated below this concretion level for a period of hundreds or thousands of years. The superficial layer at Rocky Point indicates that this terrace was not submerged at some time during the Holocene. Summer levels during this time were below 388.4 m asl, i.e., the lowest elevation in the survey area, and the flood level was about 389 m asl. These levels are about 6.5 m below the present range of 393.8 to 395.7 m asl and about 3 m below pre-1893 levels.

The following sequence of hydraulic phases for Lac Mégantic is thus visible:

1. A period of low water, below 389 m asl, allowed the concretion deposit to form;
2. Fluctuation within the range of 390 to 392 m asl formed the pre-1893 shoreline; and
3. Following a period of higher-than-today water levels since 1893, the present dam maintains an elevation of 394 to 396 m asl, creating the present shoreline cut.

Survey Results at Pleasant Point

The last area to be surveyed, dubbed Pleasant Point after the nearest place name, is located on the eastern shore of Lac Mégantic. As at Rocky Point, a sub-

merged terrace in the form of a point on the bathymetric map explained the choice of this area for the survey. Once on site however, no clearly defined submerged terrace or point could be observed. The survey covered a nearly square area about 100 m across and attained a depth of about 4.5 m (389.8 m asl) in the southwestern portion. Although the underwater slope was found to be continuous, its composition was divided into two distinct areas along the contour of 392 m asl. The higher area was covered by coarse to gravely sand mixed with granite rocks ranging from a few centimeters to a meter in size. The lower area was covered with fine, compact, loamy sand with a sporadic presence of granite rocks.

The sharp transition between the two areas agrees with evidence from Rocky Point that pre-1893 water levels peaked at 392 m asl. At Pleasant Point, however, hydraulic erosion is governed by directly offshore winds and wave action that combine to form a gently sloping beach. Coarser material above 392 m represents post-1893 sorting of the glacial till shoreline. Finer sediments below this elevation no doubt include material eroded from the adjacent shoreline since 1893 but, overall, the deposit resembles the extensive shoals that form a terrace in the lake's south-eastern corner, near the Lac des Joncs. Similar downwind deposits deeply bury the granite substrate along much of the lake's eastern littoral and have been formed throughout the Holocene. Their presence below 392 m asl at Pleasant Point thus appears to indicate an older process than the post-1893 sorting observed above this elevation.

Integrating the Survey Results

Much as the study of land features such as end moraines and raised shorelines provides data on higher-than-today lake levels in the immediate post-glacial period, so too do underwater features provide information on lower-than-today levels. The pre-1893 level of Lac Mégantic may be established within an annual range of 390 to 392 m asl, based on the observation of a former, drowned shoreline at Rocky Point and corroborative observations at Pleasant Point. Spring floods could have been higher. Such a level, about 4 m below the present level, does not imply a significant difference in the lake's area nor in the surrounding landscape except in low-lying shorelines, especially in the upstream area around the Lac des Joncs. Before 1893, the Lac des Joncs did not exist as such, even though the streams flowing into this area, the lower Rivière aux Araignées and the Arnold River, slowed down and filtered through a flat lowland before reaching Lac Mégantic. Near the Plage-Duquette site, the bed of the Rivière aux Araignées lay at or below 392 m asl and the river's left bank rose to 393.8 m asl at the site. Water levels in the river were identical to those of Lac Mégantic, generally between 390 et 392 m asl and rising to 393 m or higher in April. With ground lying below 393 m being flooded annually, the Plage-Duquette site at 393.8 to 394.5 m was a poor choice for a year-round site.

During an earlier phase of the Holocene, based on observations at Rocky Point, waters in Lac Mégantic generally remained below 389 m asl. At such levels, the present area of the Lac des Joncs would have been a habitable plain. Spring flooding would have been limited to areas below 390 m, fully exempting the Plage-Duquette site and its surrounding plain. The two rivers that met here would have been faster flowing, drawn by the lower level of Lac Mégantic. The

Rivière aux Araignées channel would have been deeper and fairly straight, formed by bedrock and boulders as in its upstream cascade today, below the Lac aux Araignées. Pools may have formed below the Plage-Duquette site where the river flattened out, creating an environment where fish congregated.

These two prehistoric hydrological phases cannot presently be dated, but they may have a chronological parallel in water-level phases observed at Lac Albion (Lavoie and Richard 2000). Based on this parallel, it may be hypothesized that Lac Mégantic's low-water phase, below 389 m asl, occurred between 11,000 and 4400 cal BP (8200–3900 cal BP) and that the pre-1893 phase of lake levels in the range of 390 to 392 m asl began about 4,400 years ago (3,900 rcy).

RELATING PAST WATER LEVELS TO CULTURAL OCCUPATIONS

When lake levels and their reconstructed chronology based on the Lac Albion study and other lake-level studies (Figure 5) are compared to the elevations of dated occupations in the Méganticois basin, the hydrological and cultural sequences reveal interesting parallels. The reconstructed cultural sequence in the Méganticois basin, starting around 12,100 cal BP (10,300 rcy), includes material from nine contexts, including the Cliche-Rancourt and Plage-Duquette sites.[3] All the dated sites lie below 430 m asl, which is below the shoreline of the proglacial Lake Chaudière that existed before 13,500 cal BP (11,500 rcy). The lowest sites are at or near present lake levels and in order for them to be tenable as occupation sites, a lower-than-present lake level must be presumed.[4]

Figure 8 shows the dated Méganticois cultural sequence including site elevations. We have also shown the highest possible lake level at the time these sites were occupied. We have assumed that for these sites to be attractive, exceptionally high spring floods remained at least a meter lower. Below this "ceiling," we have assumed a lake level range of 3 m; by comparison, in today's controlled lake, the absolute 25-year range is 2 m. We have added a meter to account for exceptional spring floods in an uncontrolled lake. In addition, today's lake remains near the bottom of its annual range from early June to late October, suggesting that uncontrolled summer lows might occasionally drop further. Thus, we have assumed that, for a site to be attractive, the summer lake level was about 4 m lower. For example, for a site at 394 m asl to be attractive, exceptional spring floods could rise to 393 m asl, typical floods could rise to 392 m asl, and typical June to October lake levels could be as high as about 390 m asl.

In this way, the highest possible summer lake level can be ascertained for each low-lying occupation. Summer lake levels were 414 m asl or lower about 12,100 cal BP (10,300 rcy). This maximum dropped to 393 m asl by 9400–8800 cal BP (8,500–8,000 rcy), at BiEr–8, and to 390 m by 8300 cal BP (7,500 rcy), at the Plage-Duquette site. At Plage-Duquette, maximum levels were also at 390 m asl in 6800–5800 cal BP (6,000–5,000 rcy). The lowest levels thus occurred during the 9,400–5,800 cal BP period (8,500–5,000 rcy). Subsequent maximum levels, from 4700 to 500 cal BP (4200–500 rcy), rose to the range of 393–396 m asl. This elevation curve over time broadly parallels that of Lac Albion water levels. However, our maximum possible elevations are higher than those suggested by the underwater survey results. The pre-1893 shoreline cut indicates a summer level

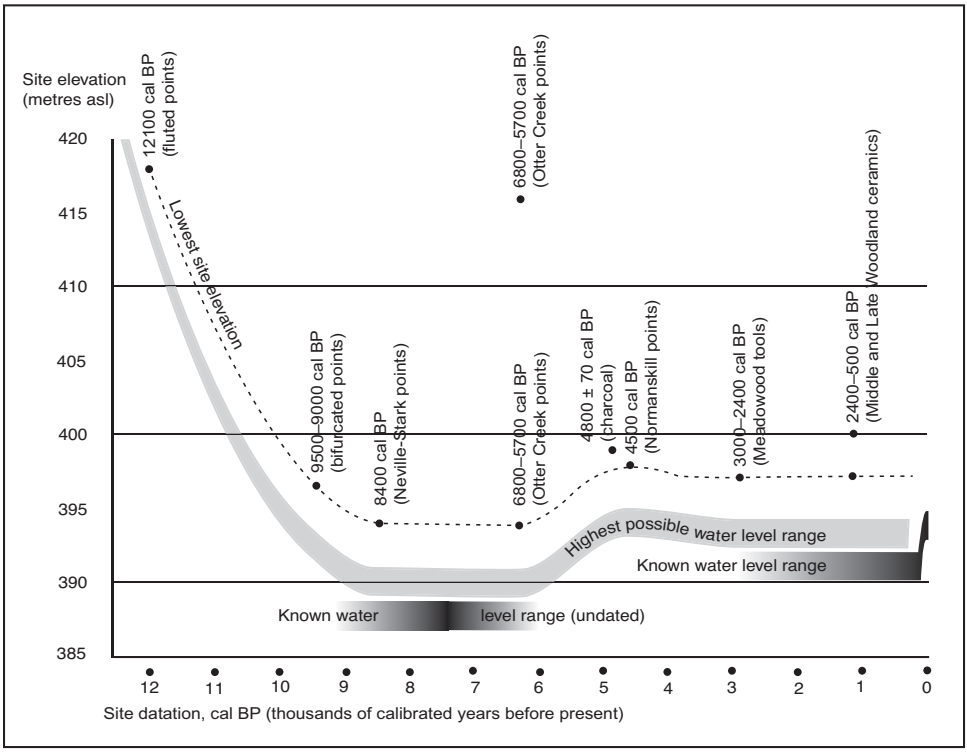

FIGURE 8. Date-elevation synthesis of Méganticois sites, showing maximal water levels as may be deduced from the elevations of low-lying, dated site occupations. Known pre-1893 water levels are lower than the deduced maximal levels.

of about 390 m asl, 3–6 m below our maximum possible level for this period. Additionally, elevations of the two lowest occupations at Plage-Duquette, dated to 8300 and 6800–5800 cal BP (7,500 and 6,000–5,000 rcy), furnish a maximum possible summer level of 390 m asl, while evidence from Rocky Point indicates a summer level below 389 m asl. A site elevation 4 m above the summer lake level may be an absolute minimum, but the preferred minimum was closer to 6 m above the summer lake level, or 3 m above the highest spring floods.

The Plage-Duquette and Lac Albion data lead us to inquire about another possible parallel between occupation phases and water level changes. A cultural hiatus seems to have occurred at Plage-Duquette about 7800–6800 cal BP (7,000–6,000 rcy), suggesting that the terrace may have been abandoned during this millennium. Meanwhile at Lac Albion, during a period of similar duration but somewhat later, between 7000 and 6000 cal BP (6,200–5,200 rcy), levels rose from two to one meter below the present level, then returned to previous low levels. Comparable rises of several hundred years occurred in other Northeastern lakes (Figure 5). We may ask whether a parallel phenomenon occurred in the Méganticois basin during the Plage-Duquette cultural hiatus, interrupting or perturbing occupation at this site. A return to low levels would then have

allowed Plage-Duquette to be reoccupied during the Vergennes (Otter Creek points) phase of the Laurentian Archaic, between 6800 and 5800 cal BP (6,000–5,000 rcy). The site's final abandonment after the Vergennes occupation suggests that higher waters may have returned to Lac Mégantic, as also suggested by site elevations from 4700 cal BP (4,200 rcy) onward and by rising waters in Lac Albion from 4400 cal BP (3900 rcy) onward.

Parallels between occupation periods and water level changes suggest that proximity to water was the principal attraction of the Plage-Duquette site. The site sufficiently optimised local conditions for an important campsite to be established during two periods. These conditions appear to have included a nearby transition in the Rivière aux Araignées from a rock-strewn cascade to a flatter, deeper channel where migrating fish rested before scaling the rapids. They also included a margin of security from floodwaters backing up from Lac Mégantic and from marshy lakehead conditions in general. What remains unknown is the configuration of Lac des Joncs whose primary function of absorbing Lac Mégantic floods likely subjected it to much greater seasonal fluctuation than is presently the case.

CONCLUSIONS

By combining the underwater survey results with the findings from Lac Albion (and other lakes) and archaeological data from the Méganticois basin, a five-phase history of water levels in Lac Mégantic is proposed:

1. 13,000 to 10,750 cal BP (11000–9500 rcy): relatively high levels, characterized by instability and a hydrological system with large seasonal variations (maximum lake elevation probably above 400 m asl);
2. 10,750 to 8800 cal BP (9,500–8,000 rcy): a phase of stability with an unknown, likely moderate water level (maximum lake elevation probably below 400 m asl);
3-. 8800 to 5100 cal BP (8,000–4,500 rcy): a low level of the entire lake system (maximum elevation below 389 m asl) with a possible brief rise in the period 7800 to 6800 cal BP (7,000–6,000 rcy);
4. 5100 cal BP (4,500 rcy) to AD 1893: a moderate, fairly stable level with small fluctuations (maximum elevation about 392 m asl); and
5. Since 1893: a moderately high water level controlled by dams (maximum elevation about 396 m asl).

The Méganticois underwater survey was planned to search for prehistoric cultural materials in shoreline areas thought to have been inundated by dams since 1893. It also sought topographical evidence of the pre-1893 shoreline, whose elevation is not documented historically. While no prehistoric cultural material was found, the pre-1893 shoreline cut was observed between 390 and 392 m asl, about 4 m below the present shoreline cut between 394 to 396 m asl, which corresponds to the lake's artificially maintained range. In addition, a concretion formed by reduction-oxidation (Ortstein soil horizon) was observed at 388 to 389 m asl at Rocky Point, indicating that lake levels remained below this elevation for some time during the Holocene, before the rise to pre-1893 levels. This evidence of low water levels can be compared to data from Plage-Duquette. This important site, occupied during two distinct cultural phases between 8800 and 5800 cal BP (8,000–5,000 rcy), lies at 394 m asl and would have been attractive only if spring floods

did not surpass 393 m asl, meaning that normal lake levels from early June to late October were about 3 m lower. Synchronization of the Lac Albion water-level sequence and the Méganticois cultural sequence suggests that Lac Mégantic experienced a low-water phase about 8800–5100 cal BP (8,000–4,500 rcy). These low levels, according to the Rocky Point observations, were below 389 m asl. Within this low-water phase, levels may have risen temporarily to provoke a cultural hiatus at Plage-Duquette about 7800–6800 cal BP (7,000–6,000 rcy), although a comparable temporary lake-level rise at Lac Albion occurred later. Finally, according to the elevations of dated archaeological sites, the increase to 19th-century high levels began about 5100 cal BP (4,500 rcy).

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NOTES

1. cal BP = calendar years before present (1950); rcy = radiocarbon years before present (year 1950), uncalibrated.
2. *Méganticois* is a newly defined geographic term and the name of a long-term project (Chapdelaine 2004) corresponding to an area within a long trans-Appalachian corridor extending from the Upper Chaudière River to the Dead River in Maine. Archaeological research has been concentrated in a smaller central area of three connected lakes: Mégantic, des Joncs and aux Araignées.
3. The sites are: BiEr–14, BiEr–6, BiEr–8, BiEr–9, BiEr–3, BiEr–21, BiEr–19, BiEr–15 and BiEq–5/6.
4. Artifacts from the Archaic Period in general, and the Neville-Stark complex of the Middle Archaic in particular, have been found underwater in the Lac aux Araignées, near McMinn Island and along the shore of the BiEr–3 site (Graillon 1997). The Lac aux Araignées is dammed and its present water level (406 m asl) is 1 to 2 m higher than its natural level.

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