

The Archaeology of Rivers: Processes and Patterns

Peter B. Campbell

Introduction

The archaeology of rivers is often defined as archaeology located in rivers, relating to narrow datasets of underwater deposits. However, riverine archaeology should be more broadly conceived as cultural entanglements with rivers (Edgeworth, 2011, p. 15). As found during a survey in the Tiber around Ostia and Portus (Campbell *et al.*, 2020), there is little understanding of the archaeology under water without that on land, which will surprise no one. However, we discovered that, equally, one does not get a holistic picture of Ostia and Portus without the underwater remains, an important observation that has been examined in only a handful of cases.

Rome, both in its location and development, is riverine archaeology in its truest form, as the city and culture were entangled with the river as an agent. The city was situated on hills to avoid flooding, but in close proximity to river features including the thalweg's depths and the shallows of the meander which afforded, respectively, boating and subsistence activities. The river acted as both a barrier and connector, keeping the enemy forces at bay while increasing the city's hinterland. But the Tiber also formed the tufa and travertine used to construct the city, as carbonate precipitated out of the river's waters over centuries (Flügel, 2013, p. 16). The water was mixed into *pozzolana* to create concrete, while two parts river sand was mixed with one part lime to create mortar (Vitruvius 2.5.1). The ability to bring great marble blocks to the city was possible through the river's property of displacement, which was also the reason that Egyptian grain was cheaper than that grown in Italy (Campbell, 2022, p. 27). The Tiber that flows, as well as the Tiber that is frozen in tufa, travertine, and concrete,¹ are but the briefest examples of the entanglements that form riverine archaeology. Rome is not simply located on the Tiber; it is composed of it on micro and macro scales. This chapter examines the archaeology of rivers and how riverine geomorphology guides patterns of behaviour, settlement, and deposition. It argues that disentangling riverine cultures from the river – above and below water – is simply not possible, and archaeologists must consider the riverbed at the same time as sites on land.

Processes in River Geomorphology

The processes underlying rivers result in elegant natural shapes, as they create bends that are proportional to the channel width (Leopold *et al.*, 2020, p. 295). A natural river is easily identifiable through the shape of its meanders, while the bedforms on a natural river bottom are easily recognizable by their repetitive shapes (Leopold *et al.*, 2020, p. 194). Riverine dynamics are complex, but the underlying principles are simple and, as a result, natural rivers have a predictability to their shape. For example, a river will not run straight for more than ten times its own width before meandering (Leopold *et al.*, 2020, p. 281). These natural laws mean that a riverine archaeologist can look at a map and identify areas impacted by human action, and more particularly where submerged deposits are likely located. All interventions in a river, no matter how small or limited, affect the flow and can therefore have a significant impact in the long term (Edgeworth, 2011, p. 30). Long straight runs of a

¹Travertine as ancient water materialized was the subject of Laura Pucci's scholarship at the British School at Rome.

river, rapid widening or narrowing, and abrupt turns tend to indicate human activity. Similarly, submerged archaeological deposits create irregular shapes among the natural bedforms, often with large scour marks surrounding archaeological features in marine geophysics data. This section examines the basic processes that impact riverine cultures and archaeology.

The primary forces in rivers are gravity and friction (Leopold *et al.*, 2020, p. 152). These dictate behaviour due to the enormous mass being moved even by small rivers. The most important feature is the *thalweg* (Fryirs and Brierley, 2012, p. 68), which is the line of greatest depth and the “deepest, fastest, and therefore most erosive water in a river” (Gooley, 2016, p. 84). Water movement is rivers’ defining characteristic, but the flow is not uniform. The *thalweg* shifts from one bank to the other as the river meanders. When water comes in contact with a surface, friction causes it to move more slowly. Flow along the banks can move as little as a quarter of the *thalweg*’s speed (Gooley, 2016, p. 74). The three-dimensionality of rivers is therefore critical, both the solid river bottom and the liquid flow (Edgeworth, 2011, p. 88). The topography of the river bottom affects water speed, and the flow rate impacts human activity. One cubic meter of freshwater weighs 1000 kg; the Tiber’s annual discharge is 7 million tonnes (Autorità di Bacino del Fiume Tevere, 2006, p. 836). As a terrestrial analogy, one can conceive of the Tiber’s *thalweg* as a train composed of endless cars moving at 7 mph² while the non-*thalweg* side of the river is travelling at 1.2 mph. Further, *eddies* – in simple terms, currents that flow in the opposite direction to the main flow – form along the banks (Gooley, 2016, p. 77). Erosion and sediment deposition behave differently at 6 knots versus 1.5 knots.

As a result of the *thalweg*, rivers follow a meandering pattern (Figure 1.1). A meander will have one bank that is concave and the other convex. The concave bank is the *thalweg* side of the river, where the water runs fastest and erosion is concentrated. This bank is the deepest part of the river, and it is known as the *erosional* or *cut bank* (Leopold *et al.*, 2020, p. 87). Cut banks are characterized by high ground composed of hard, older sediments, often appearing cliff-like, since the river is eroding them. Conversely, the convex bank is where the river’s flow is slowest and, due to flow rate, sediments being transported drop out of solution. Therefore, this is the *depositional bank* or *point bar*, because they often appear as shallow bars. This bank is extremely shallow, and the sediments are fine and soft. Flora and fauna differ based on bank characteristics, which affect subsistence activities. Consequently, riverbanks are the inverse of each other, displaying different characteristics for navigation, settlements, and subsistence activities. Rivers will have straight runs, but the *thalweg* will still favour one side rather than the middle of the channel (Leopold *et al.*, 2020, p. 281). By looking at a map one can identify erosional and depositional banks, which provides information about human activity in these areas.

² At flood, the Tiber’s current is 6 knots. Given the lower Tiber’s average dimensions, this is approximately 500 tonnes at a rate of 3.1 meters per second.

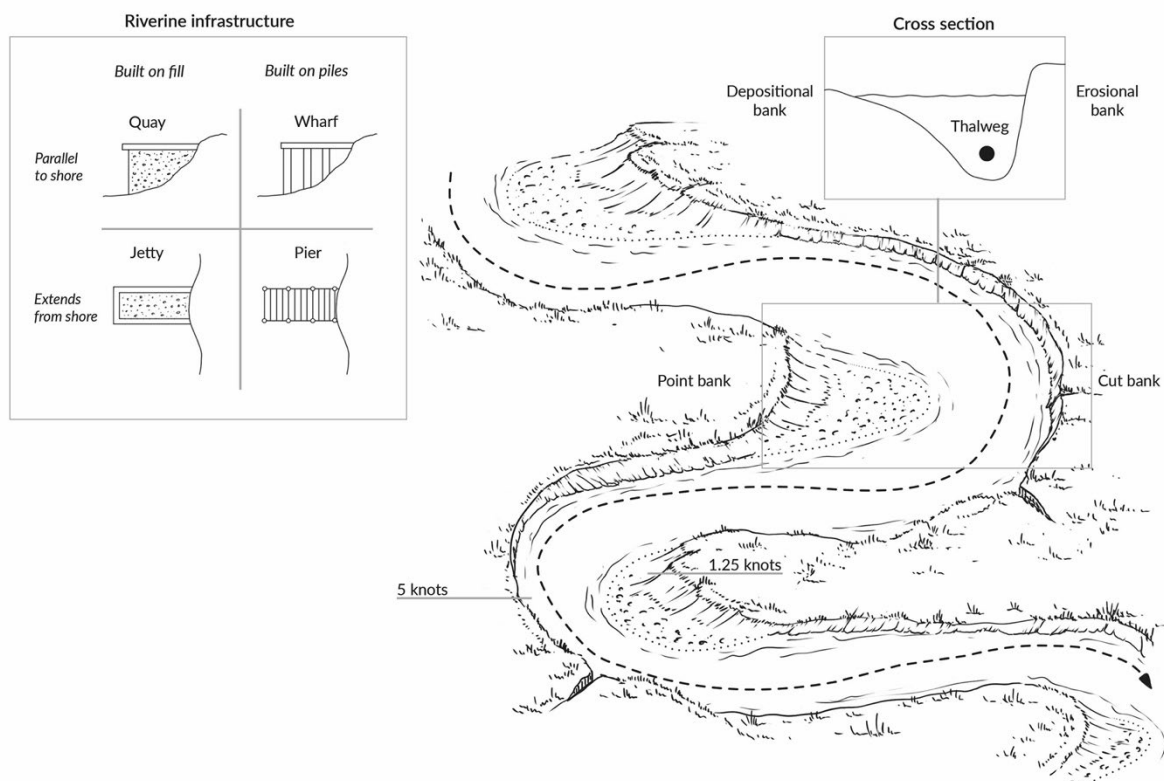


Figure 1.1 Key concepts and terms in riverine archaeology (Author; after Gooley, 2016, p. 81).

Meanders slowly shift downstream over time (Gooley, 2016, p. 81). If one sped up a river's flow to the rate of a century per second, then one could watch meanders working their way downstream like a rope being shaken side to side. As the meander moves, it creates depressions in its wake called *meander scrolls* which fill with slack water called *sloughs* (Leopold *et al.*, 2020, p. 317). *Slack water*, or *dead water*, is an area shielded from the river's flow, where the water hardly moves, if at all. Slack water is important for loading and unloading cargo or launching ships. Oxbow lakes are paleo-meanders left from the process of *avulsion* (Leopold *et al.*, 2020, p. 84), which is the abandonment of the river channel and the formation of a new one. The lesson for archaeologists is that rivers are ever-changing, even if they may appear static during one's lifetime. The older the archaeological site one is examining, then the more likely it has been impacted by fluvial geomorphology.

There are other river features that affect navigation and subsistence activities, such as riffles (gravel piles), pools (depressions), and snags (tree trunk obstructions) (Leopold *et al.*, 2020, p. 303). Like meanders, riffles and pools follow regular patterns and occur at intervals of five to seven times the channel width (Leopold *et al.*, 2020, p. 194). Tides in estuaries can increase sediment dynamics. In the Bristol Channel mouth of the River Severn, the Bristol Port Authority has mapped bedforms that are 4–5 m in height that shift as much as 25 m in a single day (M. Burrows pers. comm.). This impacts navigation and the spatial patterning of submerged sites.

There is a critical distinction to be made between *upland* and *lowland* rivers, as they display different characteristics. Upland rivers are steeper and more energetic, resulting in rockier banks and deep-cut channels. These rivers are characterized by a gradient of more than half a meter per kilometre (Gooley, 2016, p. 60). Boulders are found along the banks and in the river, as well as riffles, and they have clear or “white” water. Navigation can be challenging and seasonal, as upland rivers may run dry at certain times of the year. They can also experience flash floods, which is derived from a technical term: *flashiness* (Gooley, 2016, p. 62). This refers to the capacity of the river to increase flow within a certain amount of time. Upland rivers generally have a high degree of flashiness, meaning that torrential flooding can strike quickly and increase the river’s height far above the mean. Note that this distinction of lowland and upland rivers based on characteristics simplifies a more complex discussion of river typology (i.e. braiding, meandering, anabranching, bedrock channelling). Lowland rivers are characterized by a gradual slope with a change of less than half a meter per kilometre. This makes them slower moving, less energetic, and typically broader. As a result, lowland rivers form wide meanders and typically transport sediment rather than stones, resulting in large alluvial plains and murky or “black” water (Gooley, 2016, p. 60). Lowland rivers are located near sea level, and navigation is possible year-round. They are less flashy, but do flood, sometimes dramatically. Not every river that enters the sea is a lowland river, such as the Orontes, which enters the sea at a steeper rate and therefore displays upland characteristics.

Rivers are far from two-dimensional, passive landscape features that serve as a backdrop for human activity. Instead, they are dynamic entities with agency, which possess different zones for human activity.

Patterns in Riverine Cultures

Since the 17th century, these geomorphological processes have been published along with means to mitigate their impacts on human activities. The engineer Cornelius Meyer was a specialist in riverine infrastructure, publishing *Dell’arte di rendere i fiumi navigabili* in 1696. Figure 1.2 shows Meyer’s illustration of the Tiber with a double-dashed line indicating the *forza*, or thalweg. A meander is depicted with the water flowing right to left, while the upper bank is labelled *Destra*, or right, and the lower bank *Sinistra*, or left. Orientation is based upon travelling with the river’s current, so the ‘right’ and ‘left’ banks indicate the direction of flow, a naming convention that continues in Rome and Paris. Meyer illustrates the thalweg passing along the outside bend of the meander with an erosional or cut bank. Shading and the cliff-like bank indicate that the water is deeper, while property lines show the land eroding into the river. Conversely, the upper bank is depicted as a point bar, illustrated with stippling and individuals walking in the shallow waters. Meyer captures the key elements of fluvial geomorphology, as well as illustrates Edgeworth’s critical observation that riverine infrastructure “can be properly understood only in relation to direction and force of flow” (2011, p. 87). Every riverine archaeology publication should, like Meyer, include the thalweg and direction of flow, as well as indicate bank type, in figures. Due to riverine processes, patterns of cultural use emerge.

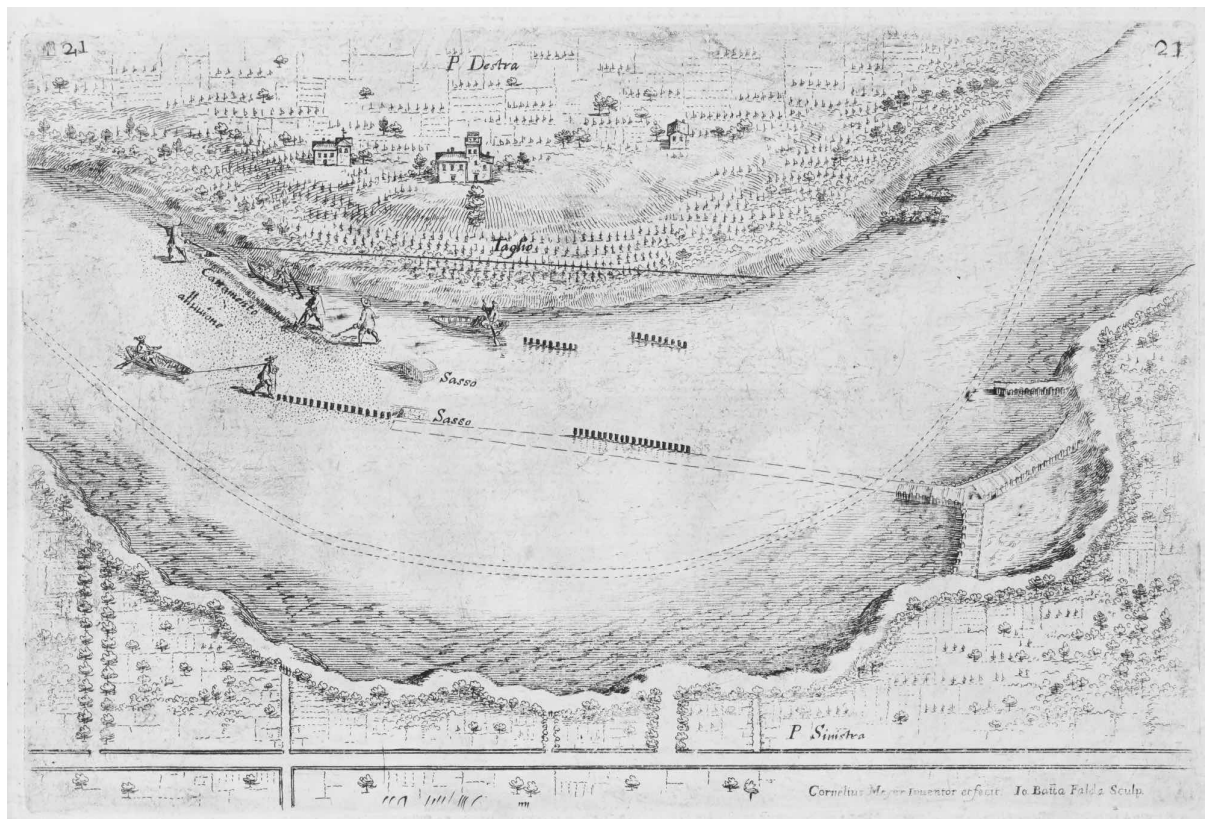


Figure 1.2 Meyer's illustration of the Tiber's thalweg, and erosional and depositional banks (Royal Academy of Art).

Navigation

Scholarship has generally portrayed rivers as two-dimensional spaces where watercraft freely operate, replicating a similarly passive role to roads. In reality, rivers are complex three-dimensional entities where vessels have limits to movement, with the two most critical aspects being the thalweg and bottom topography.

Navigation is the tension between the inexhaustible forces of the river and atmosphere with the intelligent forces of the mariner and towing crew (Campbell, 2022, p. 26). Watercraft movement is a relationship with the thalweg as the fastest flow and the centre of friction. Vessels travelling downstream always 'ride' it, since the thalweg's depth decreases the chance that a vessel will run aground and the water speed ensures the quickest possible journey. Vessels travelling upstream have a contingent relationship between the thalweg and the slower-moving portions of the river. As the deepest line in the river, the thalweg is the safest part, but it offers the greatest resistance for the people or animals towing the vessel. Therefore, the individual steering the vessel maintains a balance between the thalweg and the slower-moving water at the edge of the bank, assessing water speed and depth. Due to eddies, the water close to the bank may actually move in the opposite direction to the main flow, a property that some cultures exploit for upriver travel (Edgeworth, 2011, p. 83). These properties mean that downriver travel often has a minimal crew, while upriver travel requires a team. The three-dimensionality of rivers is why towpaths on both sides of the Tiber do not necessarily equate to three concurrent channels of ship movement (Malmberg, 2015, p. 192).

Movement is also contingent upon seasonal and daily factors. Wind, for example, changes over the course of a day and affects movement in estuaries (Keay *et al.*, 2021). River height and water speed change seasonally, most notably on the Nile, and movement against a river's current is a significant consideration (Cooper, 2014, p. 137). The Nile reaches peak discharge during the summer, while the Tiber's peak discharge is between November to February (Aldrete, 2007, p. 66). The rhythms of these two rivers set the tone of maritime activity across the Roman Empire, along with the seasonal trends for Mediterranean navigation.

Knowledge of riverine processes is critical when ships experience difficulty. Grounding is necessary if a vessel is taking on water. Mariners understand that grounding on the erosional bank has a higher survival rate than on the depositional bank. The cut bank allows passengers and crew to exit directly onto the high bank, while the point bank may leave the vessel grounded a distance from shore. While searching for the USS *Cairo*, which sank during the American Civil War, maritime archaeologists understood that the captain would have steered the vessel to the cut bank after it struck a mine, which allowed them to locate the remains of the ironclad (Bearss, 1964, p. 14).

Watercraft design is dependent on river conditions, requiring a hull with a shallow draft that decreases friction by reducing surface area and permits movement in shallow areas where flow is diminished. There is also a distinction between upland and lowland river vessels, as lowland vessels are often keeled, as they may operate in the coastal margin (Boetto, 2011), while upland river vessels are often flat-bottomed barges or rafts (McGrail, 2004, pp. 180, 195). Sea-going naval vessels were designed for specific fleet tactics that could not be deployed in rivers, so riverine naval vessels were specialized, as exemplified by the Late Roman Mainz vessels (Höckmann, 1993).

Settlements

Settlements on rivers follow certain behaviours based on river geomorphology. The most readily visible on maps are asymmetrical settlements, as they have unequal halves on either side of the river. This is evident from settlements such as neolithic Çatalhöyük, Iron Age Babylon, and medieval Paris, but Roman cities exemplify asymmetrical cities, including Antioch, Arles, London, Lyon, Pisa, and Vienne. Rome, with Trastevere located across the Tiber, is the exemplar of this settlement type (Figure 1.3), while recent research on Isola Sacra has shown the extent of Trastevere Ostiensis, Ostia's cross-river half (Keay *et al.*, 2020). Positioning the river between the city gives distinct advantages for military control of the waterway, securing trans-riverine bridges and fords and providing access to resources on both banks.

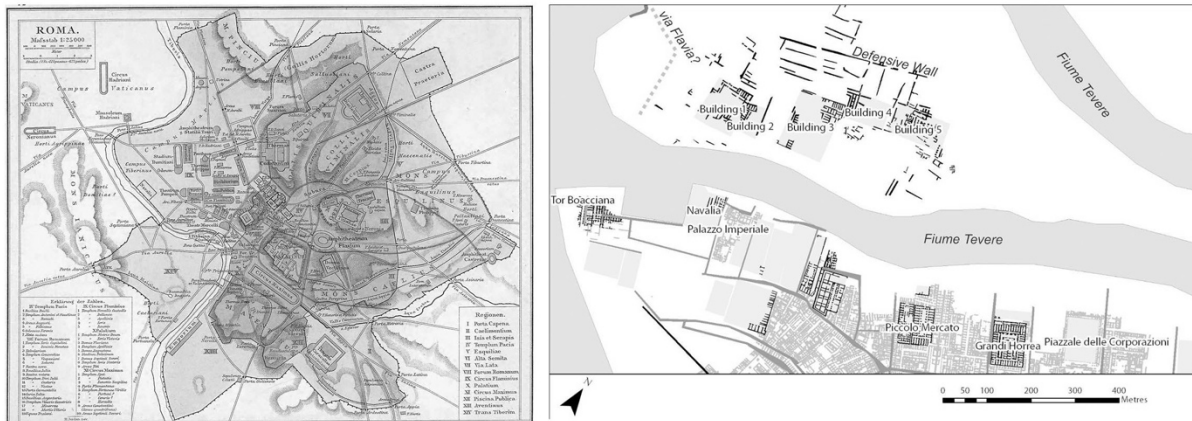


Figure 1.3 Examples of asymmetrical riverine cities at Rome and Ostia (Droysen, 1886, fig. 12; Keay *et al.*, 2020, fig. 6.6).

The reason for asymmetrical cities is evident through fluvial geomorphology. On lowland rivers, the cut bank is the deeper channel and provides access to the thalweg, but it is also situated on higher ground that is composed of compacted sediment. During a flood, the cut bank drains quickest due to the higher ground, sediment permeability, and proximity to the thalweg. As a result, city centres typically develop on the cut bank for better structural stability and to facilitate maritime activity – it is typically the larger half of a city.

The depositional bank is composed of soft sediments and is lower-lying. The approach of watercraft is more difficult due to the point bank, so piers may be necessary to bridge the shallow waters. This side of the city is generally smaller, though the depositional bank has certain advantages. Point banks are where clay settles out of solution, although clay is also available along paleomeanders. Ceramic production is typically located close to the clay banks (Wickham, 2015, p. 149). Small settlements follow these patterns, but cities may expand beyond the initial cut bank and point bank. This is the case with Rome, which developed the point bank of Trastevere across from the cut bank of the city centre, and over time further cut banks/point banks were integrated.

Riverine forts are typically located on meanders, occasionally on the depositional bank (e.g. Durostorum, Chester, Glenlochar). The meander provides increased sightlines and an enemy's exposure as they pass around the point bank. A prominent medieval example is the Castle of Julius II at Ostia, which was built on the cut bank of a tight meander that served as a choke-point for river traffic. However, in 1557 flooding cut the meander's neck to form an oxbow, known today as Fiume Morto, and the castle's strategic position was lost (Salomon *et al.*, 2016).

Islands are likewise a common feature in cities (e.g. Rome, Paris, Karnak) beyond the obvious advantages of protection and control of the waterway. In terms of fluvial processes, islands split the thalweg (Gooley, 2016, p. 76), thereby creating two thalwegs, and erosional and depositional banks which double the benefits of these fluvial resources.

While city centres are generally built on the thalweg side of lowland rivers, upland rivers may exhibit different behaviours due to seasonal differences and a rocky substrate. Upland rivers are more commonly built on stone foundations, which allows city centres to exist on

either bank. Adding to the complexity of settlement patterns is the role of tributary rivers, such as Alexandria Oxnus, as positioning between two rivers affords increased protection. It is common to see cities incorporating tributaries into their civic design.

Maritime Infrastructure

Riverine infrastructure follows certain patterns due to the constant force of the flow, bottom topography, and bank characteristics. There are four common types of infrastructure: quays, wharves, jetties, and piers. As Figure 1.1 illustrates, these are distinguished by their construction and orientation. Quays and jetties are solid and built on fill, while wharves and piers are built on piles (Dear and Kemp, 2005, pp. 290, 427, 450, 631). However, quays and wharves run parallel to the bank, while jetties and piers extend into the river. Being on piles, wharves and piers have a limited short-term effect on the river's current, while jetties and quays alter the flow. The choice between these four types by a competent engineer depends on the bank type and location of the thalweg, as the river behaves differently with each. In general terms, jetties are found on the cut bank, while piers are on the depositional bank. The former redirects the thalweg and creates an area of slack water, while the latter does not affect the flow. Similarly, quays are found on the erosional bank to access the thalweg, though they are also found on the downstream side of a meander where the thalweg shifts across the channel downstream from a point bank to the cut bank. Wharves are found along straight runs of a river, generally on the depositional side. Another type of infrastructure used on point banks is known as a *hard*. As the name implies, the soft sediment of the point bank is reinforced with wooden piles or discarded ceramics (Blue, 2002, p. 145), which solidifies the bank and prevents channel migration. The excavations at Pisa have revealed thirty ships sunk while moored along the cut bank of a meander, while some areas are reinforced with a palisade and piers (Kaniewski *et al.*, 2018).

Slipways are positioned on cut banks relative to the thalweg. They are composed of jetties, which are never built perpendicular to the flow, but are typically angled at 45 degrees. Examples include the jetty at Tor di Nona and the 'Molo Republicano' at Ostia (Marchetti, 1891, p. 48; Santa Maria Scrinari, 1984). This design limits erosion of the infrastructure while maintaining the position of the thalweg, as well as protects vessels that are launched from the full force of the water. The jetty creates a slack water basin while providing access to the deep water of the thalweg just outside and allowing for the safe loading of cargo or hauling out of vessels. Shipyards likewise follow specific patterns. The majority of shipbuilders' practice is not *shipbuilding* but ship repair (N. Howe pers. comm.). Shipbuilders may only build a few vessels during their lifetime, but they will repair many over the course of a year, which requires hauling vessels onto land. Mediterranean shipyards are carefully oriented – similar to tennis courts – to the sun. Tennis courts are positioned north-south so the sun's glare does not disadvantage either player (Gooley, 2016, p. 60). Shipyards are oriented east-west due to the heat of the sun, as this prevents the warping of timbers on one side and not the other. The rule is that "the shipbuilder's shadow should never be cast on the ship" (N. Vlavianos pers. comm.), which ensures an even distribution of heat on the timbers over the course of the day. Shipsheds, which block exposure to the sun, prevent warping and negate the requirement for this orientation. Launching watercraft requires slack water, which can either be natural such as in a slough or manufactured through a jetty. In tidal estuaries

outside the Mediterranean,³ slipways are not always at acute angles to the thalweg since ships are launched at high slack tide (Rankov, 2013, p. 41). The end of a ship's use-life typically results in it being abandoned in non-navigable channels; ship graveyards follow specific behaviours (Richards, 2008), which are visible along the Tiber.

In contrast to jetties, bridge pilings are built perpendicular to the flow and present a narrow front surface to redirect the flow around the pile. Bridge design can be divided between upland and lowland based on the features of these river types (Figure 1.4), primarily flashiness (Gooley, 2016, p. 63). The substrates differ as well, with most upland rivers having rocky banks while lowland rivers run through alluvial plains. Upland Roman bridges typically have a greater height or incorporate a raised arch, while lowland bridges have less height and a level surface. Therefore, a river's flashiness can predict bridge design. Examples of upland bridges include Alcántara, Pira Delal, Pont Julien at Calavon, and Ponte Augusto at Narni. Lowland bridges include Römerbrücke in Trier, Pont de Sommières, Ponte d'Augusto at Rimini, and those in Rome. Military bridges, such as Caesar's over the Rhine (Caesar 4.17), are typically situated downstream of a meander, a strategy to decrease visibility by obscuring it within the landscape.

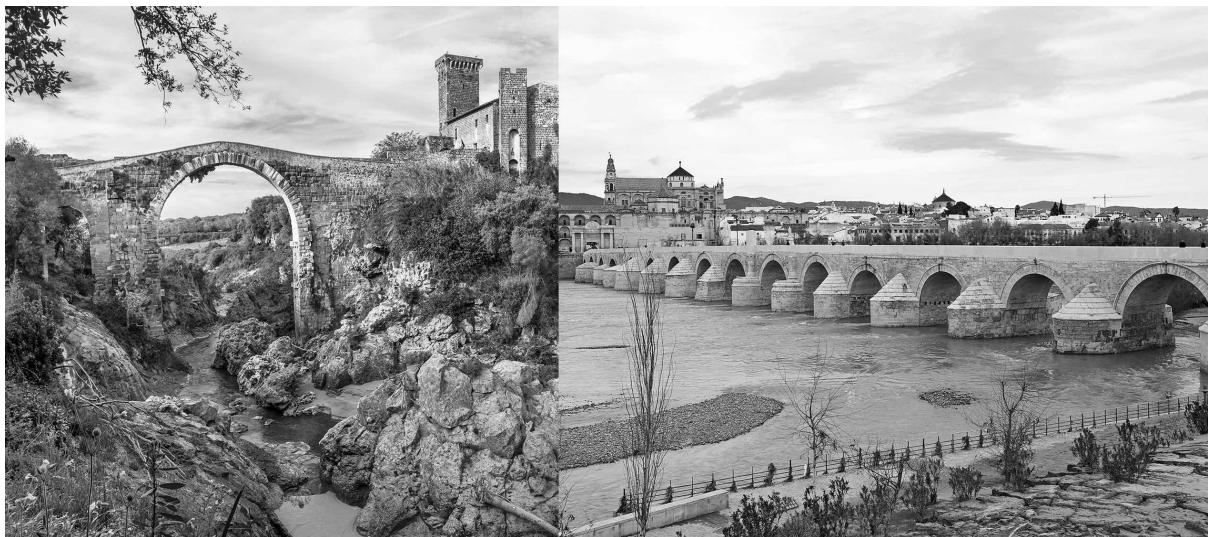


Figure 1.4 Left, an upland bridge, Ponte dell'Abbadia at Vulci, and, right, a lowland bridge, Puente Romano at Córdoba (Freesurf69/Dreamtime; Joserpizarro/Shutterstock).

Not all maritime infrastructure consists of built structures. However, natural modifications of the riverine environment rarely survive in the archaeological record. The discovery at Pompeii of approximately a hundred cypress trees planted at regular intervals (3 m) along the Sarno River (De Simone, 2017, p. 47) is an example of a natural infrastructure. Trees are critical for dissipating wind strength (Gooley, 2016, p. 123) and mooring vessels according to Roman law (*Dig.* 1.8.1), but also to stabilize the bank to resist flooding and prevent erosion. Coniferous trees limit undergrowth by acidifying the soil, which provides access along the riverfront, which is important for towpaths. The trees lining the Sarno reveal a complex understanding of how to modify the riverine environment by cultivating natural species. Another example relates to one of mariners' major concerns: the fouling of ships' hulls by

³ As an enclosed basin, the majority of the Mediterranean does not have a tidal range; however, the currents follow the tidal cycle.

saltwater marine species such as *Teredo navalis*, or shipworm. The bivalve mollusc can consume a ship's hull, causing it to sink. Besides hauling the vessel on shore, the treatment for shipworm is anchoring in freshwater (Fishlock, 2012, p. 10). This anti-fouling property of freshwater is found upstream from the Tiber's first meander, which acts like a plumbing P-trap to prevent brackish water from passing upstream.

The river itself is a natural anchorage, which is often misunderstood by archaeologists familiar with marine harbours. Anchoring in the rivers was commonplace in antiquity (Morton, 2001, pp. 114–116), which is evident from the anchors found during the underwater excavations in the Rhône at Arles (Marlier, 2013). A river's constant flow provides a steady force for the vessels to 'lay-back'. Due to the directional force, rivers can hold a greater concentration of anchored ships than a port, where a circular pivot is required for ships swinging around their anchor (Department of the Army, 1971, fig. 7.6). Some riverine settlements such as Ostia (Vött *et al.*, 2020) have constructed interior harbour spaces; however, it would be a red herring to equate the size of the interior harbour with Ostia's full maritime capacity. The entire river channel serves the same protective function as a harbour space, which is why rivers are important natural harbours. The practical size of Ostia's harbour is therefore the length of the river at least up to Capo Due Rami. Inscriptions speak to the size and importance of the five guilds of *lenuncularii* at Ostia (Casson, 1965) which served as lighters for anchored vessels; lighters would not serve vessels moored in Ostia's small interior harbour. Built infrastructure along the banks, such as quays and wharves, serve as moorings in the same manner as interior spaces in marine harbours, while jetties create slack water for the unloading of heavy cargo. River channels continue to serve as protected spaces for ships, without requiring the further construction of interior harbour spaces within them, in this manner today.

These riverine patterns can be used to hypothesize the location or design of infrastructure, such as Rome's *navalia*. Rankov examined the suitability of the Tiber's shipshed locations (2013); however, fluvial geomorphology can contribute. At Ostia, shipsheds were likely located on a cut bank to access the thalweg at an angle, similar to Velsen and Haltern (Rankov, 2013, p. 46) or the Molo Republicano, rather than an interior harbour space (Vött *et al.*, 2020). In Rome, the slack water created by the slough below the Campus Martius (north of Tiber Island) is oriented with the flow and accesses the thalweg. This location corresponds with Livy's description of the *navalia* (45.42.12), as opposed to the Porticus Aemilia (Cozza and Tucci, 2006), where the river is a straight run without slack water and is oriented 90 degrees to the flow.

Site Formation Processes

Site formation processes refer to the natural and cultural transformations that archaeological sites undergo during the gap between the lived past and ruined present (Tilley, 1994; Schiffer, 1995). Coined by Keith Muckelroy (1978) to describe transformations to shipwrecks, it has been updated to a process-based definition of the physical, chemical, and biological processes impacting sites (Ward, Larcombe and Veth, 1999). Riverine sites should also be studied in relation to site formation processes, though fluvial processes present their own physical impacts, which are often more dynamic than those affecting sites at sea.

River-specific site formation processes include erosion through meandering, with structures on the cut bank being far more affected than those on the depositional bank. Channel migration can be considerable (Edgeworth, 2011, p. 45), which is most visible with the Fiume Morto and a concern in Roman law relating to property along rivers (*Dig.* 43.12.6–10). Similarly, compression is the process of subsidence due to soft sediment consolidating downwards over time. As a result of sediment differences, depositional banks will be more affected by subsidence than cut banks; a greater rate of subsidence can be seen at Trastevere Ostiensis than at Ostia (Zevi, 1972). Siltation is often the most visible site formation process, including coastal progradation. Increased siltation rates occur due to erosion from agriculture, grazing livestock, and climate change (Leopold *et al.*, 2020, p. 391); in the 2nd century AD, Pausanias compared coastal progradation in the rivers Achelous and Maeander due to agriculture and livestock (8.24.11). This process is the reason that Ostia is currently 5 km from the modern Mediterranean coastline. Siltation in river channels, however, differs from coastlines, as bedforms naturally migrate and archaeological features become visible at different times. Human activity, such as the Aswan High Dam, can decrease sedimentation. Arguably, the present is the best time to conduct underwater archaeological research in the Nile, as bedforms are being eroded without being replenished due to the dam. While riverine archaeology has not yet engaged to a great extent, site formation processes are significant for understanding change over time.

Discussion

We now arrive at a critical component of the archaeology of rivers. This chapter has emphasized the three-dimensional nature of rivers and how flow and submerged topography impact human activity. However, archaeologists are faced with a fourth dimension – time – as they attempt to reconstruct where meanders, riffles, and islands were located during a precise time period. Just as cities that lay in ruin require interpretation to reconstruct them, paleomeanders, oxbow lakes, and coastal progradation reveal the river's past. It is necessary to understand rivers in all their dimensions in order to interpret the entanglements between cultures and rivers.

Arguably, riverine archaeology to date could be characterized as archaeology *in* rivers, rather than an archaeology *of* rivers. The distinction is critical. Assemblages presented as archaeology in rivers are typically descriptive – art historical interpretations of numismatics or armour – with limited engagement with the cultural context of deposition beyond location information. However, it is the cultural context that provides the most significant interpretation. The narrow focus on archaeology *in* rivers neglects the broader environmental features within riverine landscapes – lagoons, floodplains, and alluvium. Removing the river from, for example, shallow lagoons, marshes, and saltpans ignores critical resources and activity areas that cultures found to be symbiotic.

Exceptional scholarship such as Joël Le Gall (1953), Gregory Aldrete (2007), and Brian Campbell (2012) highlights the significance of rivers in the Roman world. However, these formative publications rarely explore underwater archaeology or how fluvial geomorphology relates to behaviour. There is an opportunity to move the discourse forward by integrating underwater data with existing research on rivers within Roman cultures.

Toward a Theory of Riverine Archaeology

This chapter has examined how riverine processes and resulting cultural patterns have been poorly defined by archaeology, despite the clear entanglements between land and water. Archaeology missed these patterns not due to a lack of understanding river geomorphology, but due to a lack of theory (Edgeworth, 2011, p. 27). As humans, our observations are theory-laden; each of us are theory-builders (Campbell, 2023, p. 25). I have argued elsewhere that scholarship has a terrestrial focus that practises “sea-blindness” relating to the role of maritime activity in the Roman world (Campbell, 2022, p. 24), which includes rivers. Without applying maritime theory to rivers, one imposes pre-existing paradigms on the data. For many, these paradigms are outdated approaches such as historical particularism or cognitive landscapes (Campbell, 2020). Theory is necessary to see new things and, for this reason, a theory of riverine archaeology must be further developed. Rivers are poorly theorized in archaeology, perhaps because rivers defy ‘thingness’ (Harman, 2016). Defining a river is a challenge since its course and water level are ever-changing (Franconi, 2015, p. 7); it is a matter pondered since Heraclitus and Cratylus in the 5th century BC (Plato 402). It is hard to say where a river starts – a single spring is often chosen but it equally could be any number – or where it ends – deltas meander for miles, and far out at sea one can still find oneself in the deep brown river water. Rivers are ambiguous yet ever present in the broad expanse of flood waters or the subterranean flow of drought.

Rivers defy thingness or boundaries because rivers are entanglements that are neither natural nor cultural (Edgeworth, 2011, p. 15). Rather than existing as passive landscape features or mediated by the human mind, rivers in these terms are agents (Franconi, 2015, p. 16). The interaction between agents does not have a predetermined outcome, but they interact in complex ways – entanglements which offer a more nuanced approach than determinism, processualism, or post-processualism. We may perceive a river as unchanging, but it always is: Ostia is now far from the sea, the Fosse Traiana no longer runs a straight course, and Karnak is no longer an island. However, the river is also changed by human interactions, stubbornly redirected along a new path by ruins. Edgeworth’s concept of the archaeology of flow is therefore critical, for “once incorporated into the archaeologist’s way of seeing . . . flowing water . . . can radically transform the perception of past landscapes, adding another dimension to archaeological interpretation” (2011, p. 9). Rivers can be conceived as social-shaping and socially shaped, simultaneously natural and Anthropocene entities of enormous agency, termed *hyperobjects* to denote entities of vast geographical and temporal scale (Morton, 2013). At the same time, the water composing a river is a *hyperfact* (Normark, 2014), which exists as neither natural nor cultural since the essence of water remains despite however many ways humans use it. Water can be harnessed to break apart mountains, such as *ruina montium* hydraulic mining (Pliny 33.73), or it can erode naturally, as with the Fiume Morto. Advancing riverine theory into contemporary philosophy offers fresh insight into old datasets, as well as perspectives on new ones.

Conclusion

Rivers are complex three-dimensional entities, which have traditionally been viewed as two-dimensional landscape features. Fluvial geomorphology processes impact human activity and result in patterns useful for identifying sites and behaviours. Rivers offer complex yet valuable information that requires not simply studies of archaeology *in* rivers, but the study of entanglements between terrestrial and submerged deposits.

The challenge presented to archaeologists is not only reconstructing the human past but the river's past. Interpretating riverine sites requires reconstructing ancient river courses. One can conceive of *Tibers* in the plural when discussing the archaeology of the river, since there are centuries of drowned Tibers beneath the Mediterranean and paleomeanders within Lazio's fields. Rome's tufa and travertine buildings are the disembodied archives of Pleistocene Tibers (Flügel, 2013, p. 16). If an archaeologist aims to understand the Tiber during the Roman Period, for example, its course and related human activity differ from the Neolithic Tiber. Understanding the past is necessary for rivers great and small due to their dynamism, for the underlying geomorphological forces are the same for the Nile as a garden stream, causing ever-changing meanders of water.

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Chapter 1: the archaeology of rivers: processes and patterns

Campbell, Peter B.

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