Māori rock art and associated freshwater taonga protection: A sensitivity-based knowledge convergence approach.

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1 Rock art vulnerability evaluation and protection

Māori rock art sites in New Zealand are intrinsically fragile and can be significantly compromised by adjacent land use activities. In particular, water use activities in the vicinity of rock art can adversely affect both surface condition of vulnerable rock art panels as well as nearby freshwater ecosystems in the cultural landscape (wāhi tūpuna). Freshwater ecosystems located within rock art cultural landscapes have particularly important associations (through provision of water, food and transport in addition to cultural and spiritual uses).

The preservation and management of rock art sites and freshwater taonga requires a good understanding of the cultural and historical context as well a scientific understanding of the biophysical setting. This 'co-understanding' is required to inform an evaluation of their sensitivity and vulnerability to modification and disturbance of local hydrological and hydrogeological environments (for example through irrigation practices, diversion of waterways, groundwater abstraction and sub-surface contaminant flows).

A way of communicating the presence of rock art, and thereby flagging a need to take it into consideration when assessing environmental effects, is through the use of sensitivity zones. Such zones need to be based both upon cultural and biophysical attributes and their definition necessarily requires a partnering (or convergence) of science and mātauranga Māori (indigenous local knowledge). Proposed activities within delineated rock art sensitivity zones will consequently need to show that the rock art and its associated cultural landscape are not adversely impacted.

Sensitivity zones are not intended to exclude activities, but rather to provide a planning support tool to ensure than any land or water-related activities do not compromise culturally important sites of considerable national significance.

This report sets out a framework and methods for the preservation of nationally important rock art archaeological sites and their associated freshwater ecosystems (springs, wetlands, streams). The scientific and cultural basis for this work is the product of a series of workshops and hui during which different knowledges (biophysical science and mātauranga Māori) were shared. It is intended that this document be further developed through consultation with planning authorities and that it be adopted within freshwater resource management contexts including National Policy Statement limiting setting processes.

2 Sensitivity of rock art to local water-related activities

Vulnerable rock art sites and related freshwater ecosystems are potentially sensitive to:

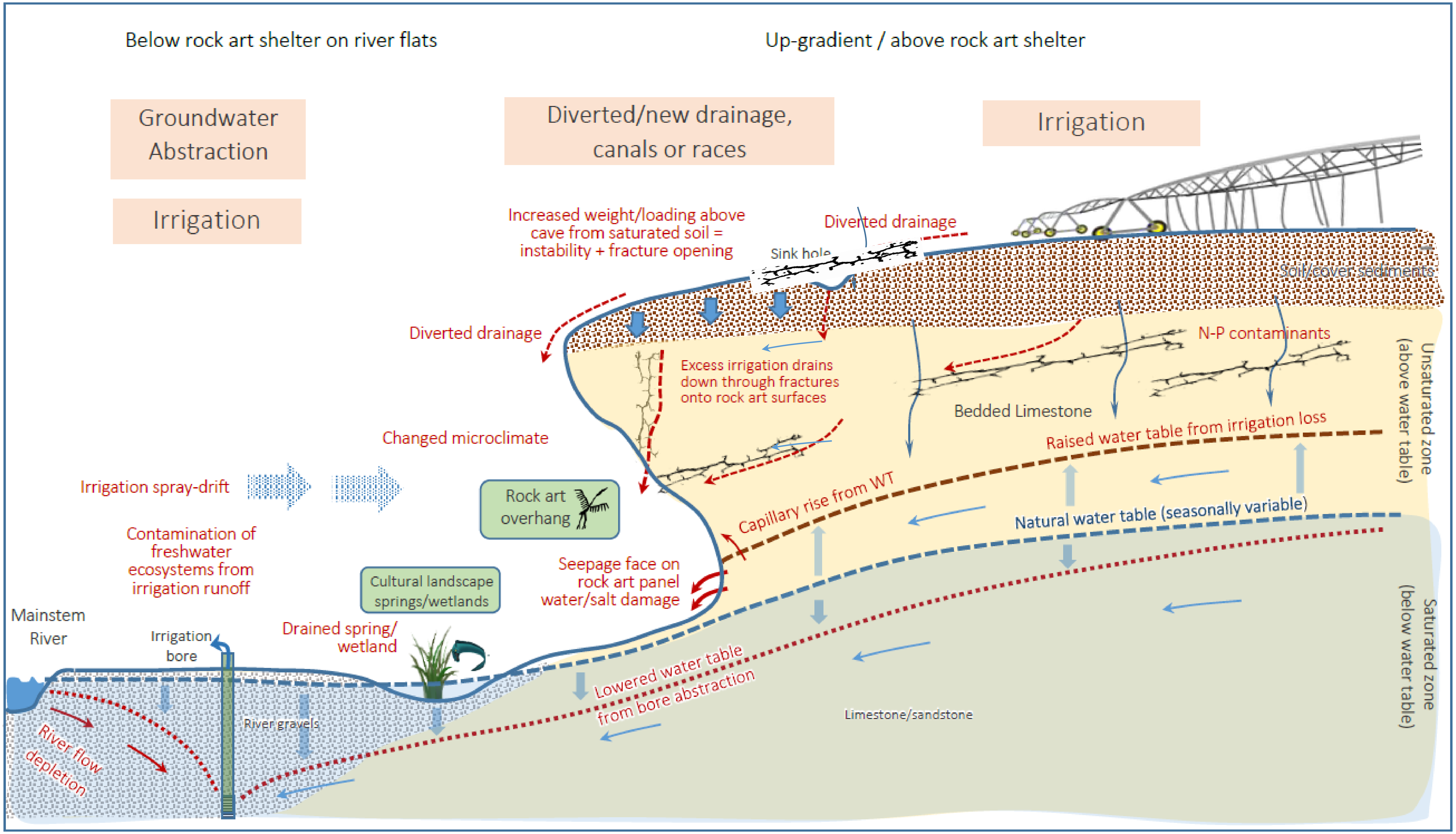
- Small changes in the local groundwater environment – changes in water table height (rises, declines or seasonal range in level)
- Changes in the local microclimate (increased air moisture, irrigation spray drift)
- Changes in local drainage systems (diversions, new channels, ponding)
- Increased saturated weight of overburden above an overhang/cave
- Changes in water chemistry of natural seepages onto the rock surface and into freshwater ecosystems

Activities which may induce local hydrological changes and impact on the vulnerability of rock art and associated freshwater ecosystems are schematically illustrated in Figure 1.

The activities fall into three categories:

- Irrigation
- Groundwater abstraction
- Drainage diversions/water conveyance/other excavation activities

Figure 1: Conceptual diagram of rock art sensitivities. Text in red = potential threats to rock art and local freshwater environments due to irrigation, groundwater abstraction and flow diversions/excavations



2.1 Vulnerability to irrigation activities

The greatest threat to rock art relates to the modification of the local hydrogeological (groundwater) environment. This has potential to change the moisture conditions of rock art panels and cause erosion, degradation/alteration of pigments, discoloration, salt deposition, rock surface flaking and moss/lichen growth. Changes in groundwater levels and flows can also adversely impact freshwater ecosystems such as springs, streams and wetlands which are part of the connected cultural landscape of the site.

A higher water table may create a seepage face at the base of the rock face (i.e. the water table rises so that it intersects the rock face). This is also associated with a 'capillary fringe' whereby water is wicked up from the water table to higher levels (potentially in the order of 10-20cm) by capillary action. Figure 2 shows a conceptual cross section through a rock art overhang to illustrate the seepage face and capillary fringe.

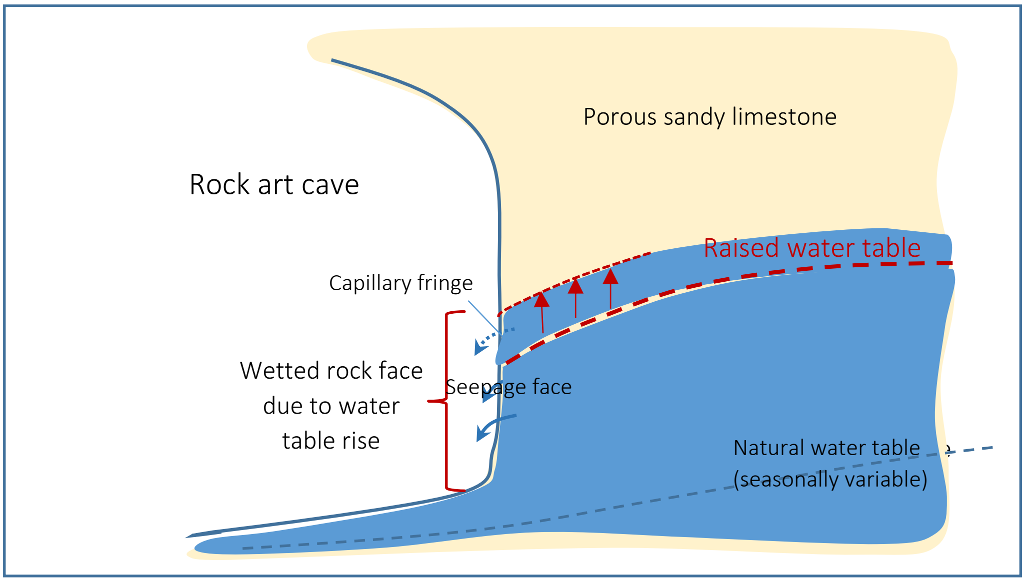


Figure 2: Conceptual cross-section through rock art cave showing seepage face and capillary fringe associated with a water table rise.

Losses of water from nearby irrigation above the rock art bluff is the most likely cause of water table 'mounding' within the underlying limestone aquifers. This is especially likely when the irrigation water is derived from a remote source, or from a deeper aquifer in the area (i.e. is not derived from the aquifer to which it is returned). The less efficient the irrigation practice - for example using a border dyke system - the more water percolates through the base of the soil zone and reaches the water table causing it to rise. It is estimated that up to 30% of irrigated water can be lost to the underlying groundwater system.

Before percolating irrigation water reaches the underlying water table, it may be diverted laterally in the unsaturated zone (the zone above the water table) along more permeable zones or along fractures or limestone bedding planes (conceptually shown in Figure 1). This ‘short-circuited’ water may discharge onto the rock art surface carrying with it dissolved contaminants, such as nitrate and phosphate, which may precipitate on to the rock surface and damage rock art.

A further consideration with regards to irrigation practices in the vicinity of rock art is the potential for spray drift and microclimate modification. Depending upon prevailing winds and other local conditions, persistent spray drifting needs due consideration in the location and design of irrigation systems.

2.2 Vulnerability to groundwater abstraction

The dropping of groundwater levels, although probably not of significant concern to rock art panel integrity, has potential to adversely impact nearby culturally significant freshwater ecosystems such as wetlands, lakes, springs and streams which are part of the rock art shelter’s cultural landscape. Groundwater abstraction from bores below rock art shelters (usually from adjacent river terraces) is the largest potential cause of water table drawdown. The drawdown can cause springs and wetlands to become dry when pumping is occurring and will also impact on the flow in nearby rivers. Figure 1 conceptually shows the impacts of the lowered water table (dashed red line).

2.3 Vulnerability to drainage modifications, construction and quarrying activities

Activities such as excavating and earth moving, construction of open channel water conveyance structures and the diversion of drainage systems can also locally affect groundwater levels. Leakage of water from unlined irrigation canals or water races can raise groundwater levels. Vibration and dust associated with such activities may also adversely affect rock art.

The diversion of surface drainage systems so that they cause localised ponding or flooding in the vicinity of rock art or result in an enhanced water flow close to the site or channel water over the rock face should also be considered in the context of rock art sensitivity.

3 Identification and recognition of Māori rock art using a sensitivity zoning methodology

Māori rock art sites in New Zealand are intrinsically fragile and are threatened, often seriously and irrevocably, by adjacent land use activities. Water use activities in the vicinity of rock art can adversely affect both surface condition of vulnerable rock art pigments as well as nearby freshwater ecosystems which are an integral component of the cultural landscape (wāhi tūpuna).

Rock art sites are always associated with freshwater ecosystems (through provision of water, food and transport, in addition to being intimately associated with cultural and spiritual practices). The preservation and management of rock art sites – including their freshwater taonga – requires a good understanding of their sensitivity or vulnerability to activities or planning decisions that modify and disturb local hydrological and hydrogeological environments. For example, as a result of irrigation practices, diversion of waterways, drainage, water and effluent storage, groundwater abstraction and sub-surface contaminant flows.

A way of communicating the presence of rock art, and thereby flagging a need to take them into consideration when engaging in resource management planning processes, is through the delineation of sensitivity zones.

Three tiers of rock art sensitivity zone are proposed:

1. **Geological sensitivity zone:** based on the mapping of outcropping limestone areas where rock art is exclusively located[1];
2. **Hydrological effects sensitivity zone:** based upon a calculated distance for avoiding the effects of activities such as irrigation, water abstraction and construction activities on the rock art site;
3. **Wāhi tūpuna zone:** these are maps which define the extent of the immediate cultural landscape and specific freshwater ecosystems intimately associated with a rock art shelter or group of rock art sites.

The first two zones are based upon scientific evaluation, whilst the Wāhi tūpuna zone is identified and mapped by tangata whenua using mātauranga Māori. The delineation and layering of the zones is designed to facilitate a coherent and structured convergence of different knowledges – of biophysical science and mātauranga Māori.

3.1 Geological sensitivity zone

Rock art in South Canterbury and North Otago is, with a few rare exceptions, associated with outcropping limestone. The use of mapped limestone outcrops (with 200m buffer to account for mapping resolution and the fact that art is often applied to detached limestone boulders that have carved off from the face of the outcrop) is therefore proposed as a *broad-scale*

[1] Note that rock art is most often found on limestone, but not exclusively. Limestone is the most problematic rock type in terms of vulnerability due to its porosity.

indicator that there is a *high probability* that rock art will be present in the mapped area. This zone (shown in Figure 3 on a regional scale) provides a simple primary 'alert' to planning authorities and applicants that rock art is likely to be present.

Examination of the GNS 1:250,000 (QMap) geological map for South Canterbury (Aoraki Map 15[2]) reveals that limestone distribution is limited to the Opihi and Lower Waitaki catchments as shown in Figure 3. The limestone belongs to the 'Kekenodon Group' and is generally characterised as being pale, coarse-grained, often quite sandy and of early Eocene age (about 25 million years old and deposited in a warm shallow sea). The limestone can range in in thickness from only 10m to about 130m (but is typically 30-40m thick) and is well-bedded with bands of nodular concretions and cross-bedding[2]. Some layers are rich in fossil shells with rare local large mammal fossils (such as early dolphins and penguins). The limestone is invariably underlain by calcareous, glauconitic quartz sandstone ('greensand').

[2] Cox, S.C., Barrell, D.J.A. (compilers) 2007. Geology of the Aoraki area. Institute of Geological and Nuclear Sciences 1:250,000 geological map 15.

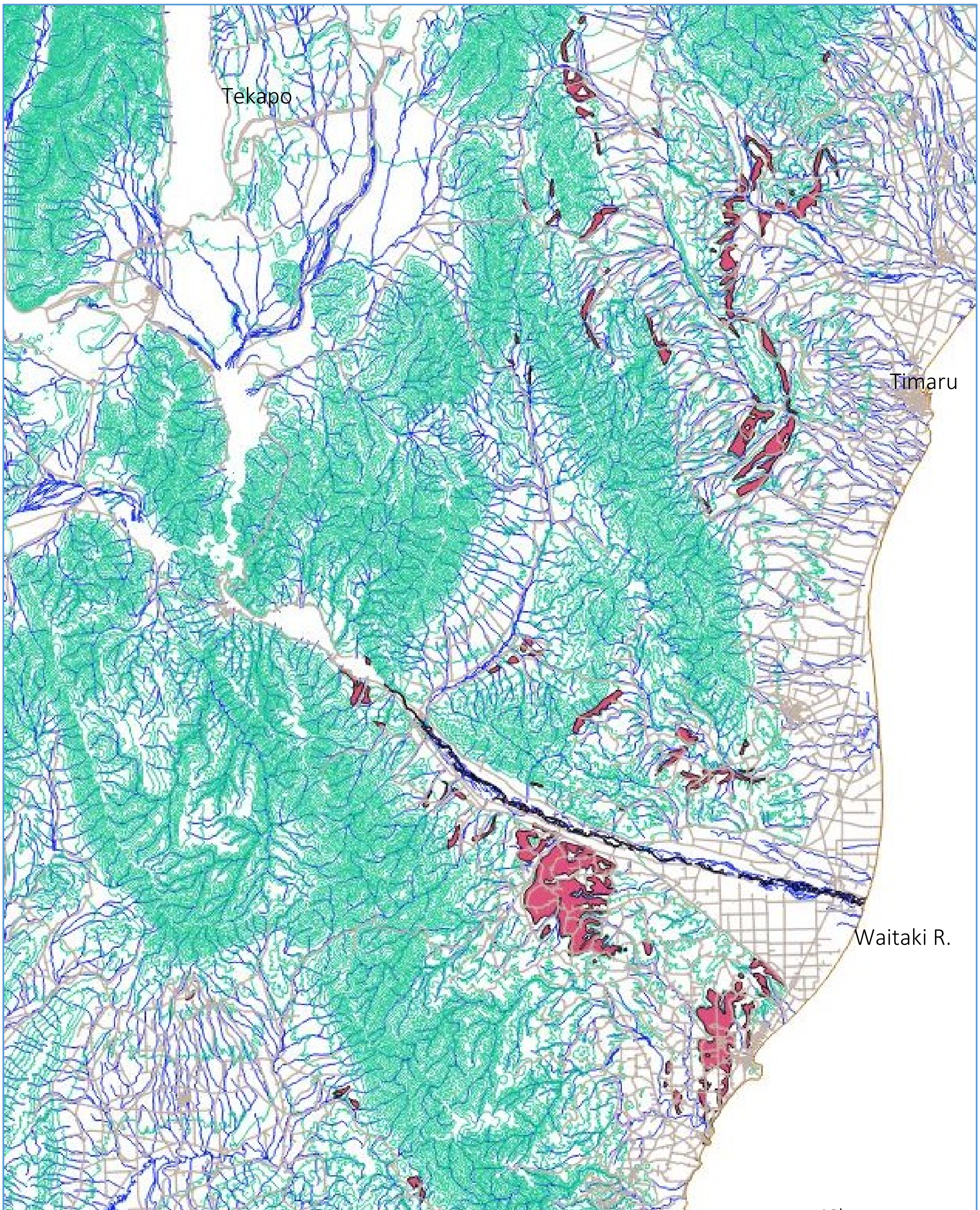


Figure 3: Distribution of limestone in the Opihi and Lower Waitaki catchments (dark red shaded areas) corresponding to the location of most Māori rock art. Data source: GNS 1:250,000 geological map (Aoraki).

Figures 4 and 5 show typical limestone bluffs near Duntroon in the Lower Waitaki catchment and on the Opihi River where rock art is found. Figure 6 shows a rock art panel in Frenchman's Gully in the Opihi catchment.

Figure 4: Otekaike Limestone (Kekenodon Group) bluff near Duntroon in the Lower Waitaki Valley where there is an extensive rock art panel in a well-developed overhang at ground level. This outcrop shows the nodular and bedded nature of the limestone, and characteristic ‘honeycomb’ weathering particularly well.

Figure 5: Otekaike Limestone (Kekenodon Group) bluff on the Opihi River (near Hanging Rock) where there are a number of rock art sites. This is a very typical setting for rock art shelters.

Figure 6: Maori rock art in a limestone overhang at Te Manunui, or Frenchman's Gully, Opihi catchment. This panel depicts the famous 'birdmen' as well as a dolphin.

Most recorded rock art sites all fall within the mapped limestone areas, or within a few hundred metres of a limestone boundary. There are some exceptions, however. The displacement of some sites outside the boundaries can also be explained by the spatial accuracy of the geological map – estimated to be +/- 100m (exceeding 250 m in some places)[2].

Since rock art is almost always located on cliff overhangs or bluffs at the very edge of outcropping limestone (and there may be detached blocks of limestone containing rock art in some places) the limestone map needs to be reviewed and adjusted using local knowledge together with the locations of rock art sites. A further consideration relates to areas where there is very thin cover layer of younger (Quaternary age) sediment on top of the limestone. If the local topography cuts through the cover layer it (i.e. where there is a gully for instance) to expose limestone, the map scale may not show the presence of limestone.

The accuracy of the limestone map can be initially addressed by placing a 200m buffer around the mapped limestone areas prior to 'auditing' it by plotting the recorded sites and adjusting boundaries where necessary.

3.2 Hydrological sensitivity zone

In additional to the generalised limestone outcrop sensitivity zones, an 'inner sensitivity zone' is recommended to provide protection for recorded specific rock art localities. This takes the form of a fixed radius around the site – the dimensions of which are based upon a simplified groundwater flow model which has been used to examine the sensitivity of typical sites to activities which can modify the hydrogeological environment.

Because there can be a significant degree of caution and cultural sensitivity around releasing the precise locations some rock art sites to the wider public, rather than provide a map or GIS layer which pin-points the sites, a map showing only inner sensitivity zone is regarded to be more appropriate.

The hydrological sensitivity zone is designed to take into account the potential adverse effects of groundwater abstraction or irrigation application in the vicinity of a rock art site. Two groundwater models have been used to simulate representative effects of irrigation losses (water table mounding) and irrigation abstraction (water table reduction) and to determine typical distances at which these activities may have a significant impact. The models make assumptions regarding typical rates of groundwater abstraction and irrigation loss as well as aquifer properties in order to provide a scientific basis for a generic buffer radius.

3.2.1 Groundwater modelling

The USGS finite difference groundwater flow code – MODFLOW (2000) – has been used to simulate a hypothetical aquifer for two geological scenarios (Figure 7 illustrates this distinction):

- Limestone aquifer: For simulation of irrigation loss water table mounding. Rock art sites are sensitive to water table mounding when irrigation occurs above them on the limestone outcrop (or on a thin soil/sediment layer covering the limestone).

- Gravel aquifer: For simulation of large-volume groundwater abstraction for irrigation. Bore abstractions result in water table drawdowns which may impact freshwater environments in the cultural landscape. This groundwater environment is associated with low-lying permeable gravel aquifers below rock art bluffs (the gravels may lie on top of or against the buried limestone).

The 'base model' was set up as follows:

- $2km^2$ representative aquifer volume.
- A single unconfined layer with a thickness of 30m.
- Grid spacing of 50m.
- A constant head condition of 20m set around the perimeter of the model (i.e. saturated thickness = 20m).
- Models run in transient mode for a period of 120 days.

Groundwater mounding simulation assumptions

- For the irrigation mounding simulation, the [limestone] aquifer is unconfined and has a representative hydraulic conductivity of 1m/day and specific yield of 0.1 (derived from literature).
- The representative irrigated area is $500m^2$ (25ha) and application rate is 5mm/day for 120 days.
- Assumption that 30% of water applied to an irrigated area reaches the underlying water table in the limestone formation.

- Groundwater mounding is assumed to reach a steady state at 120 days (note: mounding peaks at about 30 days and dissipates thereafter).

Groundwater abstraction simulation assumptions

- For the irrigation bore abstraction simulation, the [gravel] aquifer has a representative hydraulic conductivity of 100m/day (transmissivity = 2,000m^2/day) and specific yield of 0.1.
- Pumping occurs from a single bore at a continuous rate of 60 L/sec (c. 5,000m^3/day) for 30 days.

3.2.2 Groundwater modelling results

The groundwater mounding model simulation results are shown in Figure 7 by showing the form of the water table along a vertical cross section through the aquifer and the irrigated area. Irrigation losses cause the water table (red line with squares) to mound over a wider area. The model shows that mounding reaches about 1.5m in the centre of the irrigated area and that it will be less than 0.1m outside a distance of about 250m from the edge of the irrigated area (the vertical dashed red lines).

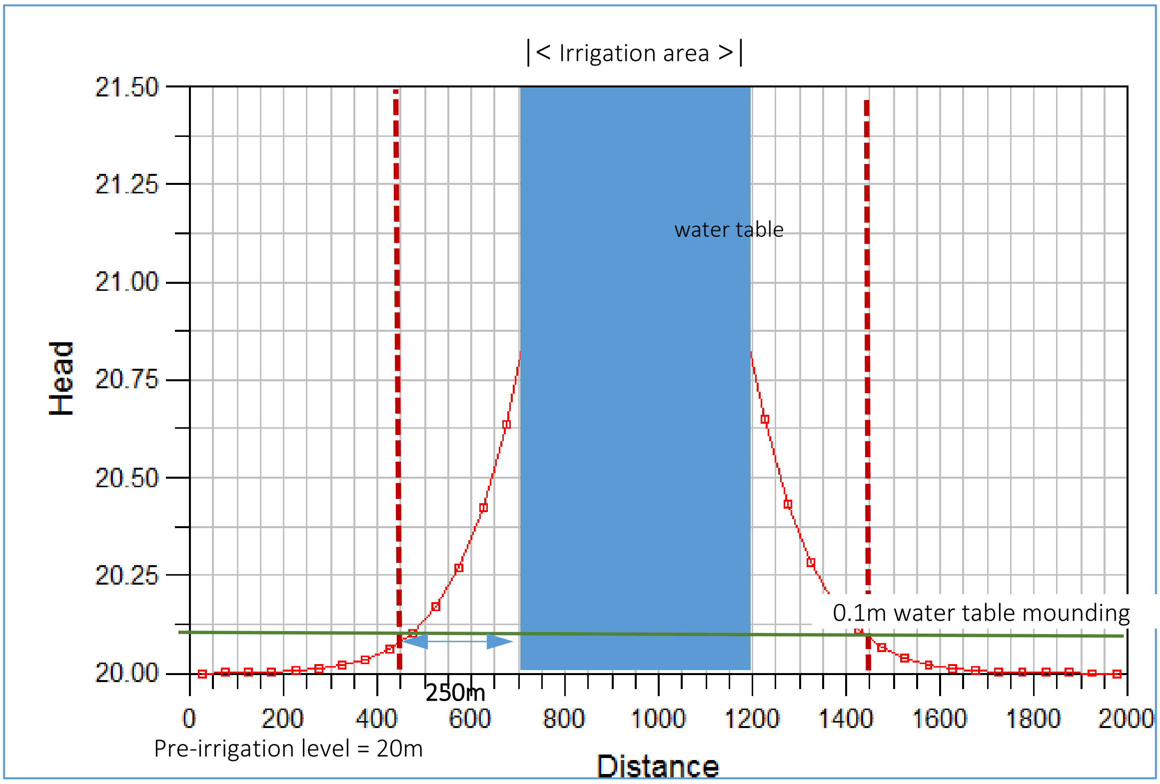


Figure 7: Irrigation mounding sensitivity zone assessment using numerical modelling. Plot showing water table mounding along an aquifer cross section through a 500m wide irrigated zone (blue shading). Irrigation losses cause the water table to mound (red line with squares) over a wider area. Mounding is shown to be more than 0.1m inside a distance of 250m from the edge of the irrigated area (the dashed red lines).

The groundwater abstraction modelling simulation results are shown in Figure 8. The simulation investigates the drawdown response of the water table when a single bore is pumping at 60 L/sec for 30 days. The plot shows that the aquifer will draw down by about 2m close to the bore and by about 0.5m at a distance of 300m from the bore (25%

drawdown). It should be noted that the constant head model boundary buffers the drawdown to some extent, the magnitude of which is not regarded to be significant.

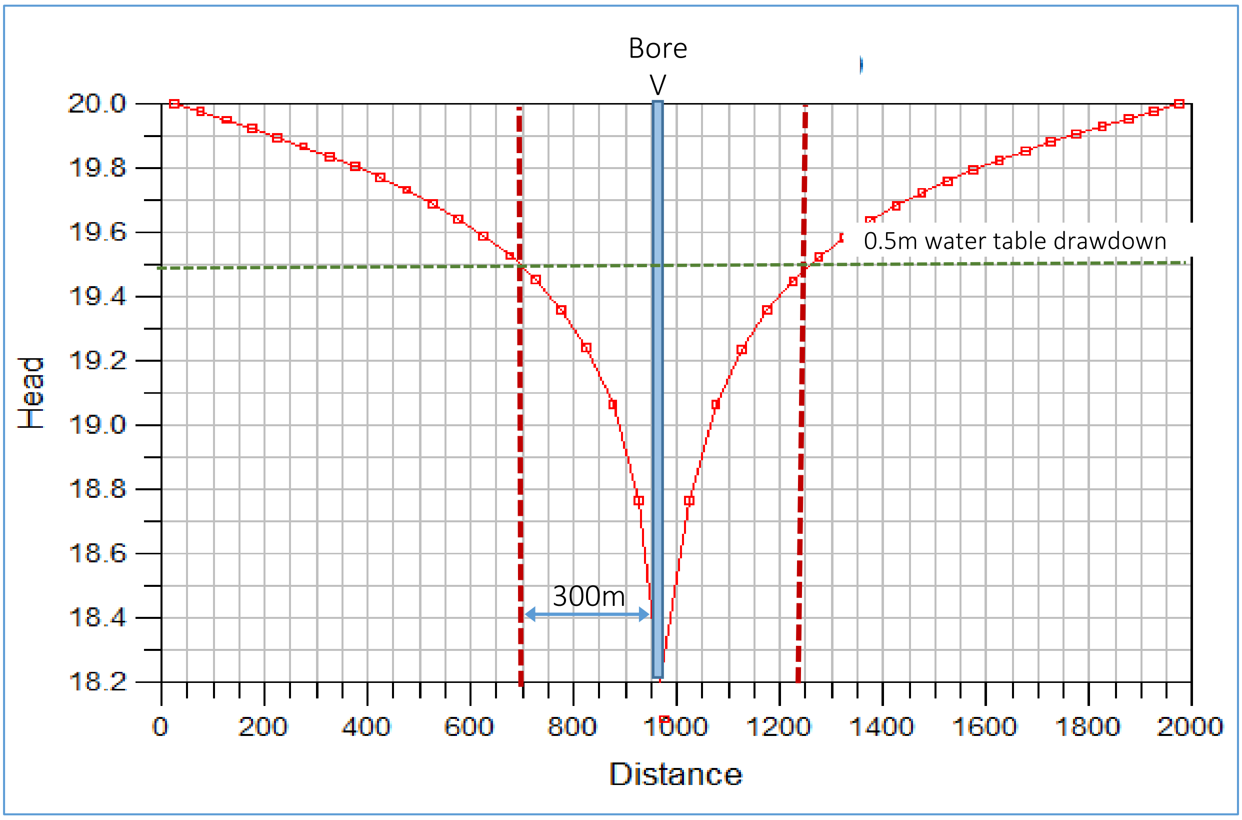


Figure 8: Modelled abstraction drawdown relating to a hypothetical irrigation bore pumping at 60 L/sec for 30 days from an unconfined aquifer (with transmissivity of 2,000m^2/day and specific yield of 0.1). A drawdown of approximately 0.5m is predicted 300m (dashed red lines) from the pumping bore

3.2.3 Recommendations for hydrological sensitivity zone size

On the basis of the model outputs illustrated in Figures 7 and 8, a rock art sensitivity zone size of 300m radius is recommended. This distance is chosen not on the basis that there will be no effects of abstraction or irrigation, but that the modelled effects will probably be small – a 0.5m decline in the water table due to irrigation abstraction, and less than a 0.1m rise due to irrigation loss. Because the rock art is more sensitive to a rise in groundwater level, this is considered to be a reasonable recommendation. The geological (limestone outcrop) sensitivity zone will also ensure that the effects of irrigation losses above a rock art shelter are taken into consideration outside the 300m hydrological sensitivity zone.

Because it is common for several rock art sites to be present in close proximity, the construction of a 300m zone around each of them results in overlapping sensitivity zones. An example of combining the geological and hydrological (300m buffers) sensitivity zones is shown in Figure 9 for an area of prolific rock art on the Opihi River.

The 300m sensitivity zone is intended to trigger the requirement for a resource consent for various activities which will require consenting authorities and applicants to consider the effects of irrigation, water abstraction and other activities on rock art sites and its associated freshwater landscape. Should an activity be proposed in the zone, then a site-specific assessment of effects should be carried out.

However, it is important to note that because a proposed activity does not fall within a rock art sensitivity zone, that discretion still needs to be exercised in some circumstances where large developments may impact known rock art sites in the vicinity.

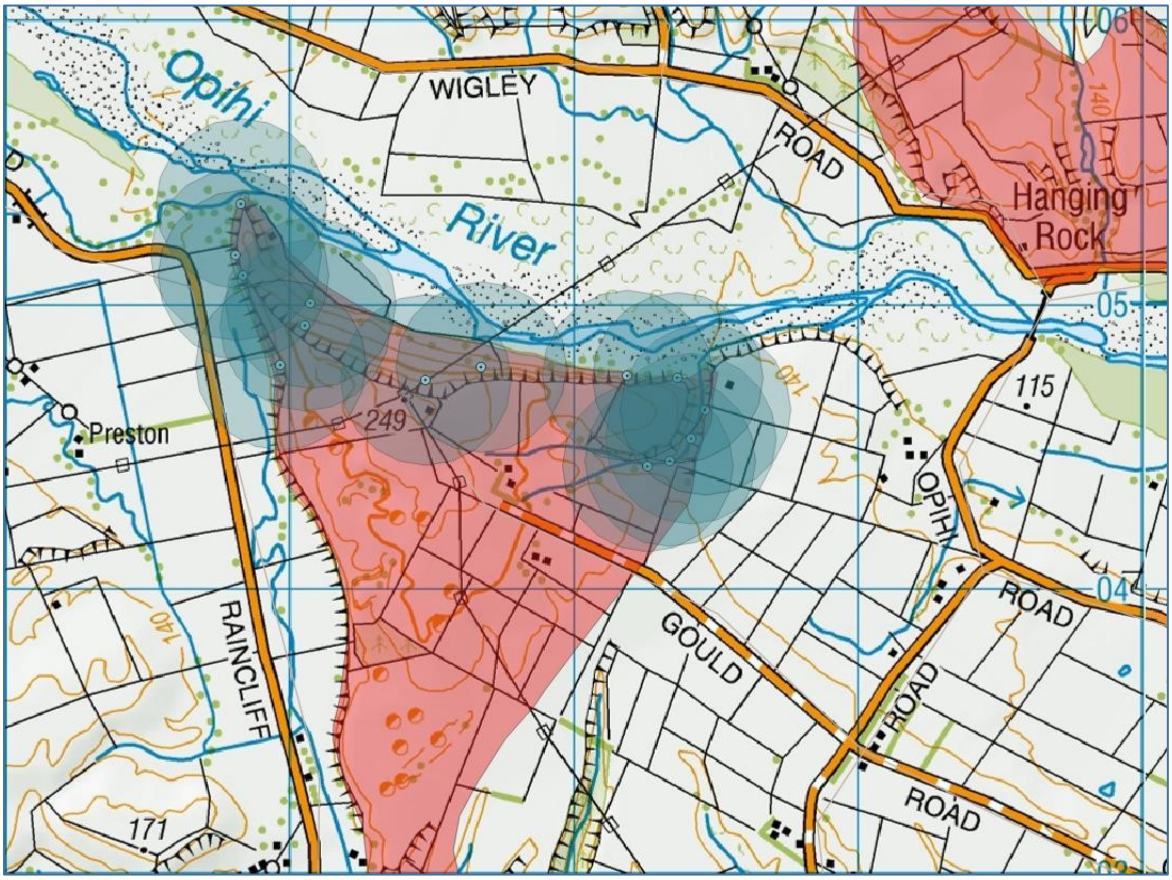


Figure 9: Example application of Geological (limestone outcrop – shown in red)) and hydrological (300m buffer – shown in blue) rock art sensitivity zones for a selected area on the Opihi River. Note: rock art site locations (small dots) are approximate only for the purposes of presenting this example. The map does not show the wāhi tūpuna zone.

3.3 The Wāhi tūpuna zone

The wāhi tūpuna zone is defined by the Heritage New Zealand Pouhere Taonga Act 2014 as a place important to Māori of ancestral significance and associated cultural and traditional values. Wāhi tūpuna mapping recognises other taonga, in addition to rock art, that contribute to the cultural landscape. Such taonga in a freshwater context may include wetlands, springs and streams. The wāhi tūpuna zone must be mapped by the mana whenua (or nominees). When a resource consent application is received, or when a planning authority requires it to inform other processes, the wāhi tūpuna zone will be defined taking into account the nature of the site and the type, location and scale of the proposed activities or other aspects related to the use of the map.

Wāhi tūpuna mapping is deliberately broad, recognise that sites do not exist in isolation but existed in 'communities of occupation and association'. It is also important to stress that

Wāhi tūpuna maps cannot be treated like conventional cartographic maps – they are intended for guidance and to facilitate continual communication between planners and iwi/hapu/whanau for clarity.

The process of wāhi tupuna mapping has been applied in Dunedin. Aukuha Limited senior planners stipulated that wāhi tūpuna mapping would be linked to objectives, policies and rules in the proposed District Plan to ensure features such as trails, mountains and battle sites were recognised. Subsequently, Ngāi Tahu have been working with the Dunedin City Council on a wāhi tūpuna mapping process on the proposed plan. Aukuha Limited explained how the wāhi tūpuna layer would work: when resource consents were lodged with the council that impinged on mapped wāhi tūpuna, provisions would be triggered that gave council planners guidance on how to consider them.

3.3.1 Incorporating wāhi tūpuna mapping in a management framework for rock art.

In the context of this guideline, wāhi tūpuna is a method that will enable rock art sensitivities, and in particular sensitivities to water management, to be recognised and provided for in district and regional plans. The proposed framework is represented in Figure 10.

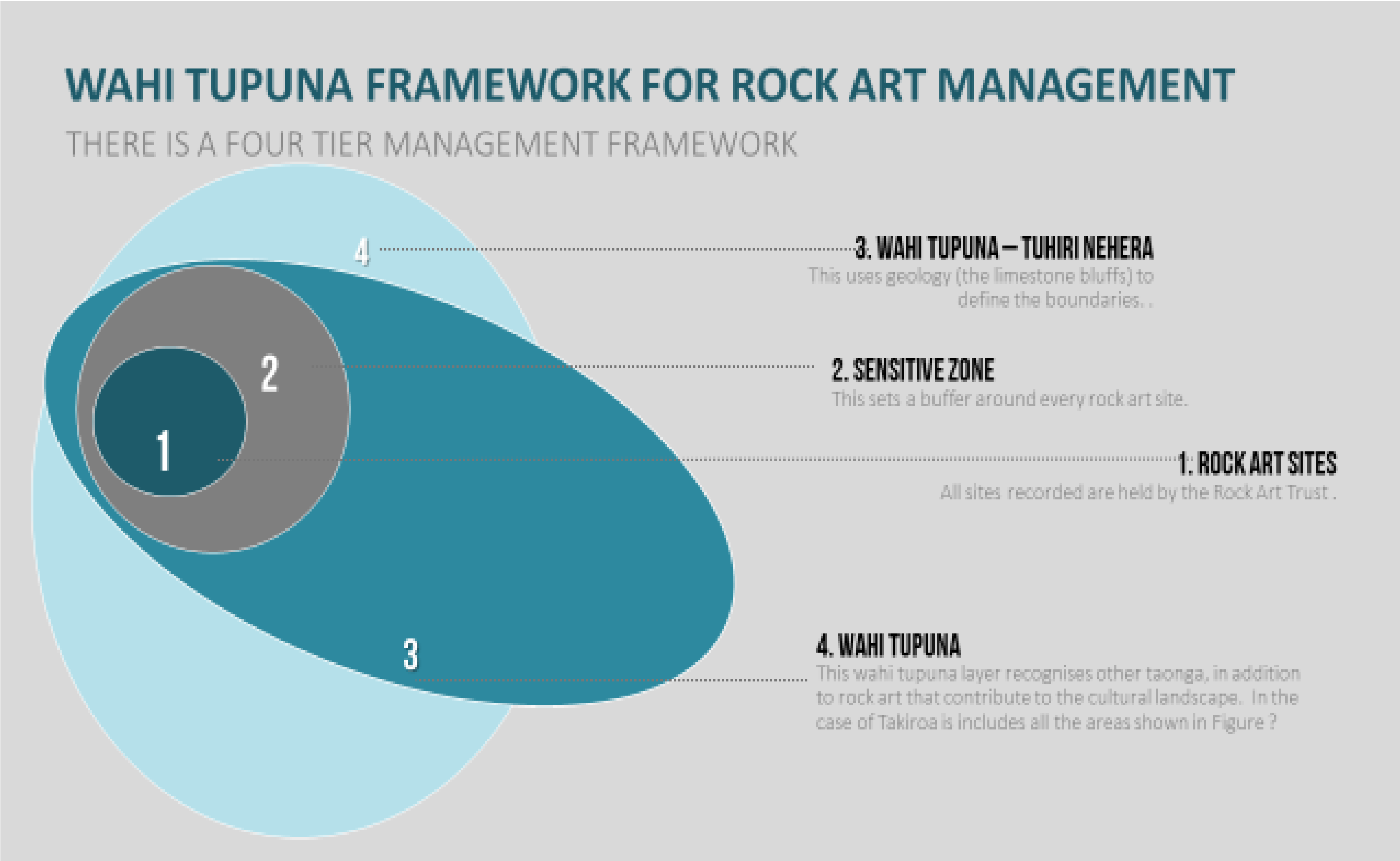


Figure 10: Wāhi tūpuna framework for rock art management and protection

As an example, at the largest scale, the limestone bluffs of North Otago and South Canterbury are mapped as a broad wāhi tūpuna (Figure 3) – or the 'geological sensitivity zone'. At a more localised scale, specific sites and associated taonga will also be mapped as a wāhi tūpuna - Figures 11 and 12 show an example from the Takiroa site on the Waitaki River.

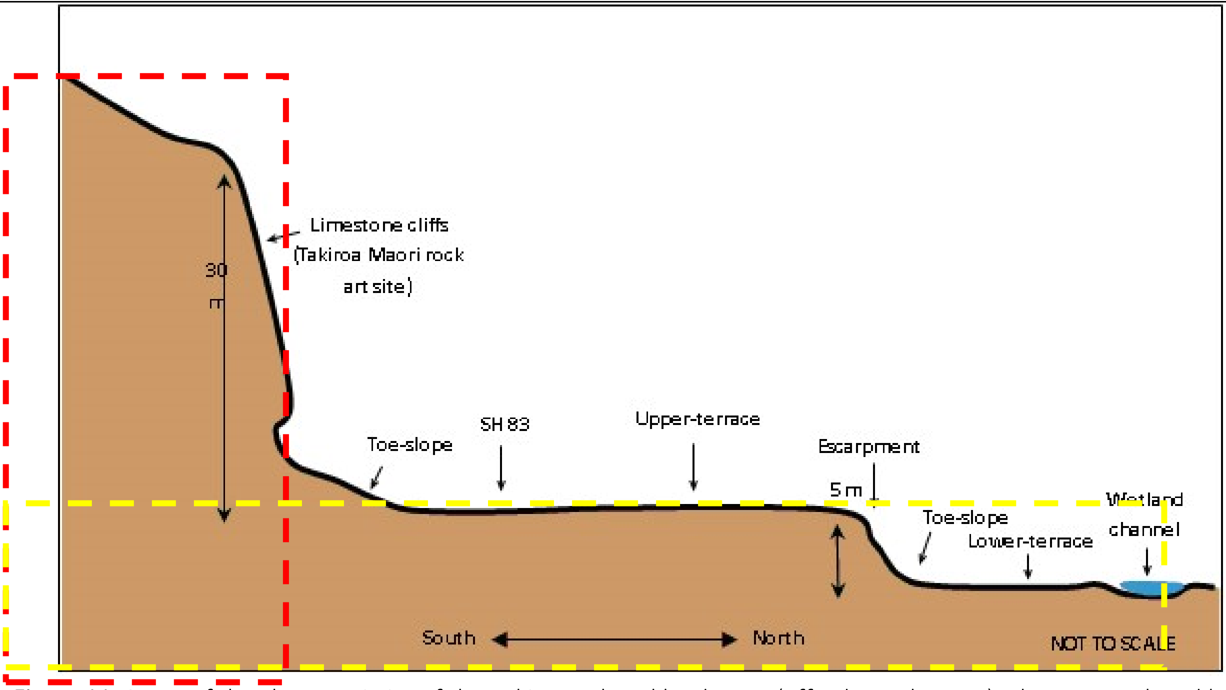


Figure 11: Some of the characteristics of the Takiroa cultural landscape (Efford, J. Bylsma, R). The area enclosed by the red dashed lines is the wāhi tūpuna defined by the rock art bluffs. The area to the right enclosed by the yellow dashed lines encompasses other taonga found at Takiroa

Figure 12: An aerial of the lower Waitaki looking downstream. Enclosed in the box is part of the Takiroa cultural landscape (photo from New Zealand Aerial Archaeology). Included with the box is limestone bluff, stream, wetland, native vegetation and springs.

Many taonga are present at Takiroa in addition to the rock art. Taonga include a mix of spring-fed channels and swampy land. The spring, wetland and stream complex sustain large stands of harakeke (uncommon in valley) and purei are common. Water cress and other macrophytes are abundant in channels. Birds present include mallard, paradise shelduck, pukeko, and scaup. Shortfin eel and longfin eel are abundant and dominate the species composition.

The wāhi tūpuna framework can be applied in two planning contexts:

- A resource consent application that can be evaluated at the pre-notification stage; and
- In advance of a limit setting process where a scenario could impact rock art and/or the associated freshwater taonga .

The intent of the framework is to ensure that Manawhenua (with assistance from nominees such as the Ngāi Tahu Rock Art Trust) are able to assess the actions of an activity on rock art. For example, if an applicant sought to irrigate an area in close proximity to the rock art, by looking at the hydrological sensitivity zone GIS layer in a plan, it will highlight that there are rock art interests in the area and the plan will include rules for the activities that are a threat. This will trigger the person who is assessing that application to consider Ngāi Tahu values, which in this instance includes rock art. The onus is then on the applicant to identify how their activity is not going to the threaten the rock art.

4 Implementation of rock art sensitivity zones

The preceding chapters have described the three rock art sensitivity zones - geological, hydrological and cultural (wāhi tūpuna).

This section describes how Mana wheuna working with a planning authority could implement the rock art sensitivity zones in a planning framework to enable rock art sites and their associated freshwater taonga to be recognised and protected.

4.1 Planning provisions

The Resource Management Act 1991 includes as matters of national importance provisions to recognise and provide for the relationship of Māori and their traditions with their ancestral lands, water, sites, wāhi tāpu and other taonga (s6(e)) and to recognise and protect historic heritage (s6(f)) when managing the use, development, and protection of natural and physical resources. Resource management planning provisions will need to be included in planning documents including regional policy statements, regional plans and district plans to ensure rock art sites and their associated freshwater taonga are identified and protected.

The planning authority will need to work with Mana whenua (or nominees) to determine what activities are likely to threaten rock art if they were to occur within the vicinity of rock art sites. The hydrological sensitivity zone provides the appropriate specificity to be referenced in planning rules. A resource consenting pathway will enable an assessment of the effects of the proposed activity on a rock art site and the identification of methods to protect the rock art. In the Opihi and Pareora catchments in South Canterbury, Papatipu Rūnanga, the Ngāi Tahu Māori Rock Art Trust and Canterbury Regional Council are currently developing sub-regional policies and rules for the protection of rock art sites in a regional land and water plan.

As well as for use in planning rules, the maps are also valuable in terms of informing planning authorities during the design of freshwater management policy of the need to consider rock art in particular areas.

4.2 Provision of rock art sensitivity zones to planning authorities

Although the specific rock art locations will not be made publicly available to ensure the security of the sites. GIS layers for the geological and hydrological rock sensitivity zones will be provided to planning authorities. The maps will only be provided to the planning authorities once all necessary permissions and conditions for map use by Mana whenua are in place.

4.3 Wāhi tūpuna mapping

The wāhi tūpuna zone will be mapped only on an 'as needed' basis. When a resource consent application is received, the nature of the site and nature and scale of the proposed activity will be taken into consideration.

possible that some Rūnanga will establish a wāhi tūpuna mapping team) and liaise as necessary with the consenting authority and applicant.

5 Future work – A guidance framework for undertaking a rock art and wāhi tūpuna hydrological risk assessment

A recommended process for implementing a rock art and wāhi tūpuna effects assessment process is currently in development. This process will provide a stepped process to be followed when a planning authority is required to make a policy decision or receives consent application which has potential to effect rock art and associated freshwater environments (groundwater and surface water including wetlands, springs, small streams and large rivers).