Helictite, (2022) 47: 13-19

Drainage derangement at Howitzer Hill in the Trowutta-Sumac Karst, north-west Tasmania

***Adrian Slee*[1] *and Peter McIntosh*[1]**

[1]Forest Practices Authority, 30 Patrick Street, Hobart, Tasmania 7000, Australia
Corresponding author: adrian.slee@fpa.tas.gov.au

Abstract

The Trowutta-Sumac karst is the most extensively karstified dolomite terrain in northwest Tasmania. Here, exposed surface dolomite karst covers an area of more than 140 km^2 within a triangular-shaped 380 km^2 region. In the region Precambrian dolostone units of the Black River Group crop out either as extensive hills or as karst pockets and interstratal karst lying adjacent to or beneath Cambrian and Tertiary volcanic rocks. To date studies on this karst system have been limited, except for those around well-known locations. Elsewhere hundreds of sinkholes pockmark the region; in some locations they form complex polygonal karst terrain. The subsurface hydrology of the area is unknown. Although karst stream sinks and small cave systems have been located, the abundance of sinkholes indicates that regional karst aquifers may exist, but stream resurgences are rare and those that have been documented are associated with small meander cut-off caves on large streams with clear direct surface connections between stream sinks and resurgences, notably at Julius River and Lamprey Creek. Recent field investigations by the authors have documented an intensely karstified area in the eastern Howitzer Creek catchment north of the Arthur River. Here, the informally named Howitzer Hill presents a complex polygonal karst landscape associated with karstic subsurface flow. This study describes the Howitzer Hill karst, the landforms present, dye tracing methodology and results obtained.

Introduction

The study was focused on an area covering 56 ha centred on the significantly karstified informally named Howitzer Hill rising 40-80 m above the surrounding valleys to a maximum altitude of about 140 m a.s.l., approximately 1 km north of the Arthur River-Rapid River confluence (Figure 1). The hill is underlain by Precambrian Black River Dolostone, a mixture of chert, siltstone and minor dolomite mapped as Pbdc on the Holder geological map sheet (Seymour and Everard 1999). The area forms a small subsection of the larger Trowutta-Sumac Karst which spans an area of approximately 380 km^2 between Nabageena in the north and the Horton River in the south, including the Julius River Caves, the karst sinkhole forming Lake Chisholm, the cenotes and caves at Trowutta Arch (Kiernan and others 1991; Kiernan 1995; Sharples 1997) and the Lamprey Creek Caves (Slee 2019). The Trowutta-Sumac Karst is a registered geoconservation site on the Tasmanian Geoconservation Database available on The List Tasmania website (https://maps.thelist.tas.gov.au/listmap/app/list/map).

Karst surveys

The study area (Figure 1) lies entirely in State Forest managed by Sustainable Timber Tasmania. There is evidence of past forestry operations dating around the 1960-70s over the entire study site. An old forestry road winds between sinkholes on the karstified Howitzer Hill. In 2016 work by foresters and the FPA Earth Scientist identified many large cone-shaped sinkholes up to 45 m wide and 15 m deep (Figure 2), making much of the hill unsuitable for harvest.

Further work by the senior author identified small caves and several streamsinks and resurgences in the area (Figure 2). To the northeast of Howitzer Hill is a large impenetrable streamsink with two entrances (Maryanna 1 and 2) named after the nearby forestry road, into which an intermittent class 4 stream (a stream having a catchment of <50 ha as defined in the Forest Practices Code (FPA 2020)) informally named Eastern Creek, sinks at the base of a steep backwall within a large doline. West of the Maryanna 1 and 2 streamsinks, Maryanna 3 is a small impenetrable streamsink in a bedrock bluff within a large sinkhole north of Howitzer Hill.

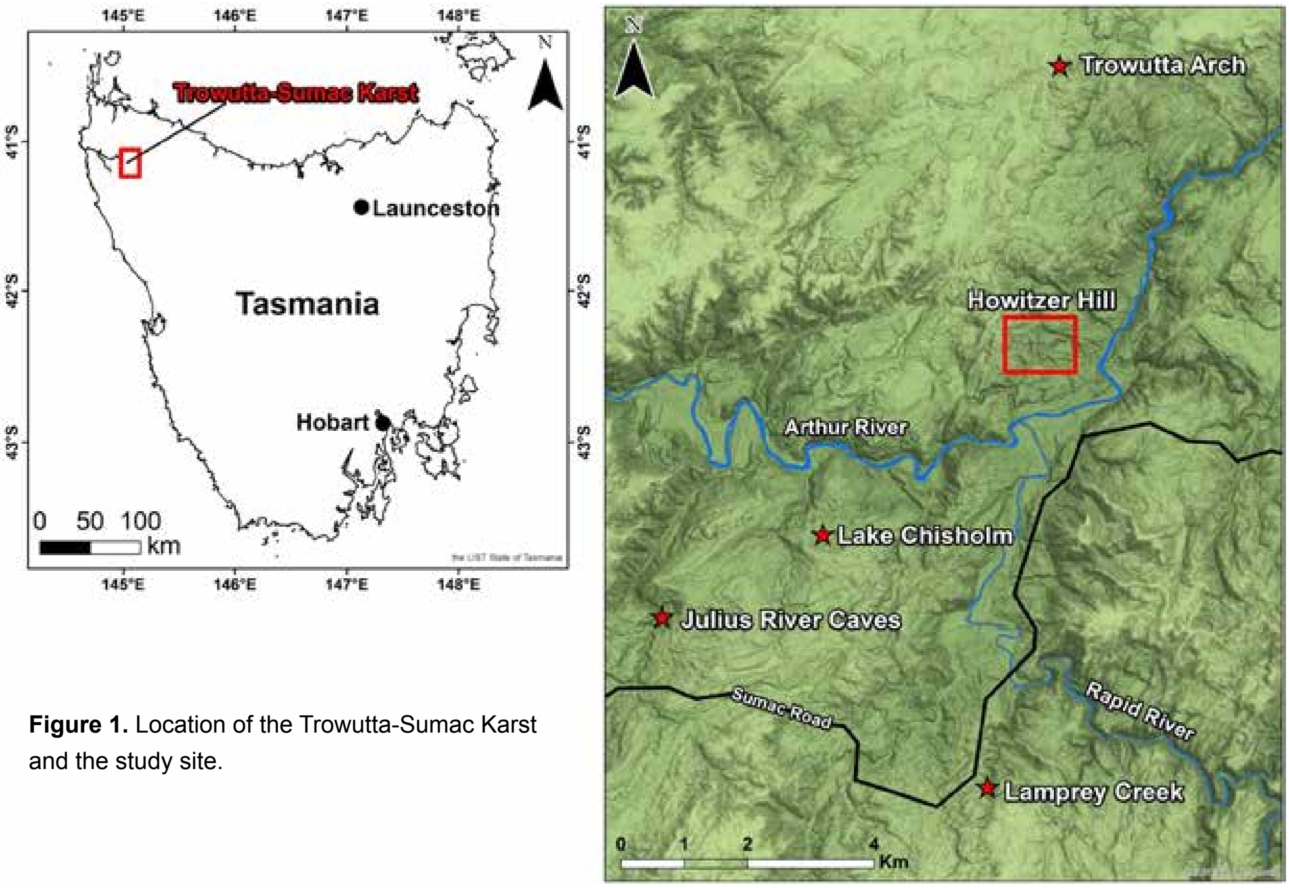

Figure 1. Location of the Trowutta-Sumac Karst and the study site.

Further investigations found that the eastern branch of Howitzer Creek, a large perennially-flowing class 4 stream, flows into a streamsink descending into a collapsed cave passage to the west of Howitzer Hill (Figure 2 and Figure 3). The large basin with an area of approximately 21 ha and an uneven bottom associated with this streamsink fits the definition of a *uvala*, an intermediate form of large karstic depression significantly larger than a sinkhole but smaller than flat-floored regional scale poljes (Kiernan 1995; Sauro 2019). The western face of Howitzer Hill on the eastern margin of the basin is composed of pinnacle dolomite karst and at least one tiny cave is present along the hillslope north of the Howitzer Creek streamsink and blind valley (Figure 2). Large dry valleys entrenched in bedrock are present downstream of both the Maryanna 1 and 2 streamsinks and the large depression on the eastern branch of Howitzer Creek. Subsequently three resurgences (Howitzer 1-3), one of which (Howitzer 1) forms a skylight in a continuing passage (Figures 2 and 4), were identified in a blind valley on the south-east side of the hill. These resurgences contribute water to the informally named Outflow Creek (Figures 2 and 6). A further stream rises from an impenetrable cave on the eastern margin of Howitzer Hill. We speculated that the water from the Howitzer Creek streamsink west of the hill was connected with one or more of the Howitzer 1-3 resurgences.

Experimental work

The aim of the experimental study was to establish whether a connection exists between the Howitzer streamsink and one or more of the Howitzer resurgences. On 25 May 2021, before dye injection, three activated carbon receiver bags were suspended in streams. One was suspended above the dye injection point on the eastern branch of Howitzer Creek (Figure 2) to confirm no prior presence of dye in the stream. Two were hung in the Howitzer 1 and Howitzer 3 resurgences. (We hung bags in both resurgences as they lie 50 m apart on differing valley slopes and therefore there was a need to test whether either or both these streams were connected with the Howitzer streamsink.) The Howitzer 2 resurgence was not dye-traced owing to its valley floor location 35 m downslope of the Howitzer 1 resurgence with which it is very likely to be directly connected. At 16:00 on 25 May, 425 grams of Rhodamine dye were injected (Figure 5) into the Howitzer streamsink (inflow). Over the following 24 hours, 28.8 mm of rain was recorded at the nearest weather station at Luncheon Hill (Forestry 91259), 6 km to the south-east (BOM 2021). Sample bags were picked up from all three sites on the morning of 27 May 2021. Charcoal bags were shipped to Ozark Underground Laboratory, Missouri, for dye analysis.

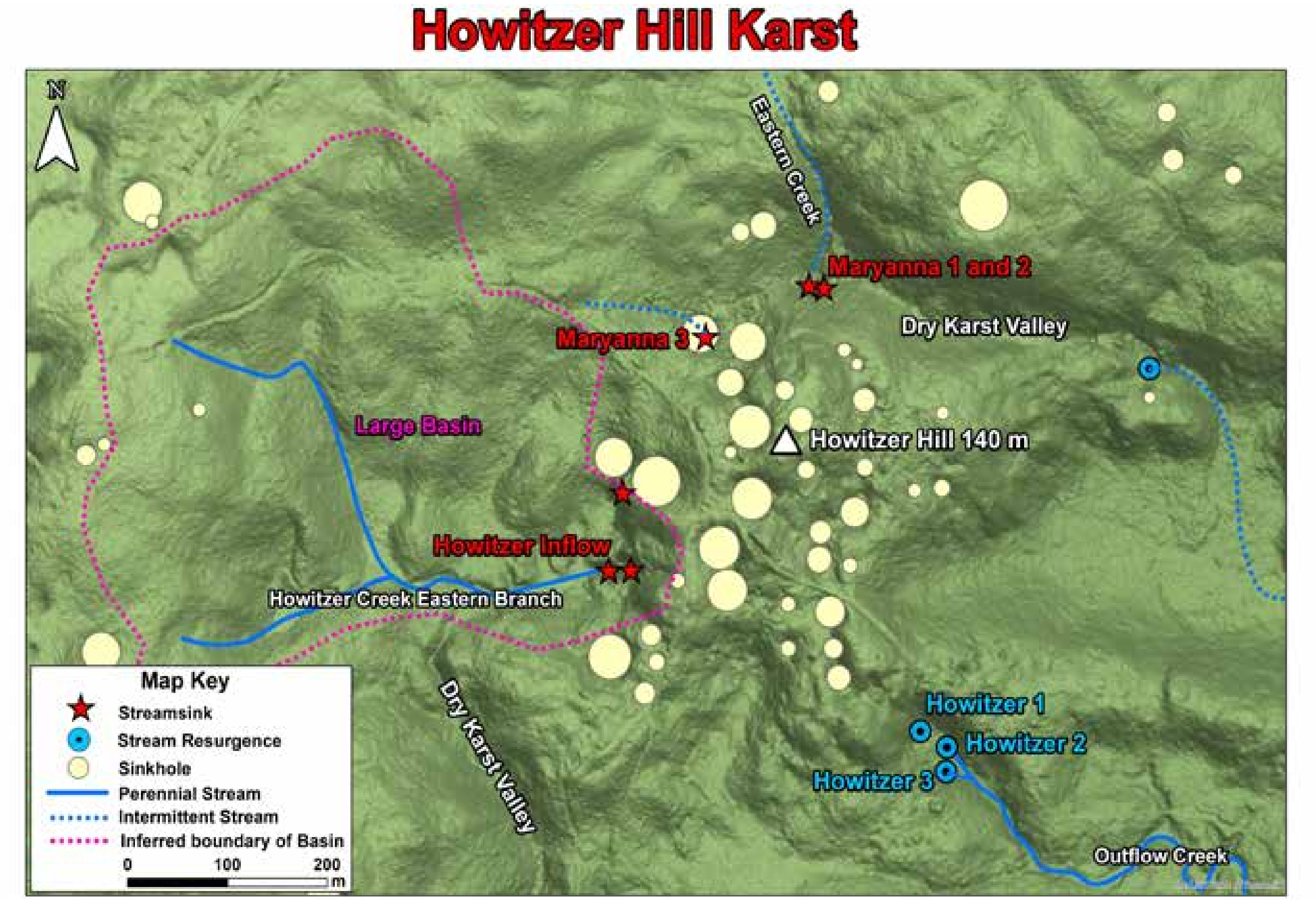

Figure 2. Major features of the Howitzer Hill Karst mapped during surveys.

Results and Discussion

The results of the Rhodamine dye-tracing experiment are summarised in Table 1. The Howitzer Creek sample above the streamsink and dye injection point showed no trace of Rhodamine dye, as expected given the remote location of the Howitzer Creek catchment. Somewhat unexpectedly, both the Howitzer 1 and 3 samples returned strong positive values at 567 nm, producing concentrations of 3800 and 3210 parts per billion for Rhodamine dye. These results indicate that water reaching both resurgences was at least partially sourced from the Howitzer streamsink (Figure 6). The lower Rhodamine concentration in the Howitzer 3 charcoal than in the Howitzer 1 charcoal may indicate that the water source of the Howitzer 3 stream is more diffuse than that of Howitzer 1.

Four named stream-sinks lie to the north of a heavily karstified hill in the upper reaches of Howitzer Creek and a neighbouring un-named valley to the east, informally named Eastern Creek. The largest streamsink is associated with karstic capture of the eastern branch of Howitzer Creek, which sinks underground in a blind valley 20 m west of a dolomite backwall with collapsed boulders and small cave entrances at its base. The proven underground drainage between the Howitzer streamsink and the Howitzer 1 resurgence (skylight) is 345 m, or 380 m if this skylight is ignored and the water at Howitzer 1 flows onwards to Howitzer 2. The traced distance to the Howitzer 3 resurgence is approximately 375 m. The fact that both resurgences contained water traced to the Howitzer streamsink but lie 50 m apart on different sides of the outflow valley implies a multi-passage anabranching cave rather than a single passage.

Table 1: Rhodamine tracer results

OUL Number	Station Name	Date / Time Placed	Date / Time Collected	Rhodamine WT Results	
				Peak (nm)	Conc. (ppb)
F2684	**Howitzer 1**	25/05/21 13:15	27/05/21 9:15	567.2	3,800
F2685	**Howitzer 3**	25/05/21 13:30	27/05/21 9:40	567	3,210
F2686	**Howitzer Inflow**	25/05/21 16:00	27/05/21 10:30	ND	

Figure 3. Top: View looking east down the blind valley towards the Howitzer streamsink lying under the log to the left of the image (circled), Yellow arrow indicates location of the caves in lower image.

Bottom: East of the streamsink is a steep valley backwall approximately 15 m tall featuring dolomite bluffs, collapse boulders and two or more small cave entrances only one of which is penetrable for a short distance.

Figure 4. View of the two small cave passages extending from the downstream edge of the Howitzer 1 skylight. Passage dimensions around 0.5-1 m across.

Figure 5. Injecting the tracer into the east branch of Howitzer Creek on day 1 during heavy rain.

The streams entering Maryanna 1-3 streamsinks on the north-eastern slopes of Howitzer Hill were not dye traced due to their low flows but are assumed to be associated with the Howitzer 1-3 resurgences (Figure 6). This assumption is supported by the absence of other resurgences in the area and by the chain of large sinkholes running approximately north to south across Howitzer Hill towards the Howitzer 1 resurgence (Figure 2). If the assumed flowpaths are correct, they imply further karstic drainage extending underground for ~445 m (Figure 6). However, the minor stream resurgence associated with the small cave at the eastern extremity of Howitzer Hill (Figure 2) could conceivably relate to one of more of the Maryanna streamsinks.

The Howitzer karst is of limited significance in the Tasmanian context owing to the caves present being impenetrable and small, and the presence of caves and karst of more impressive dimensions that occur in dolomite karst landscapes elsewhere in Tasmania, notably at Hastings (Houshold and Bradley 1994) and Mt Anne (Kiernan 1995) in the state's south. However, Howitzer Hill is the third site in the Trowutta-Sumac karst in which

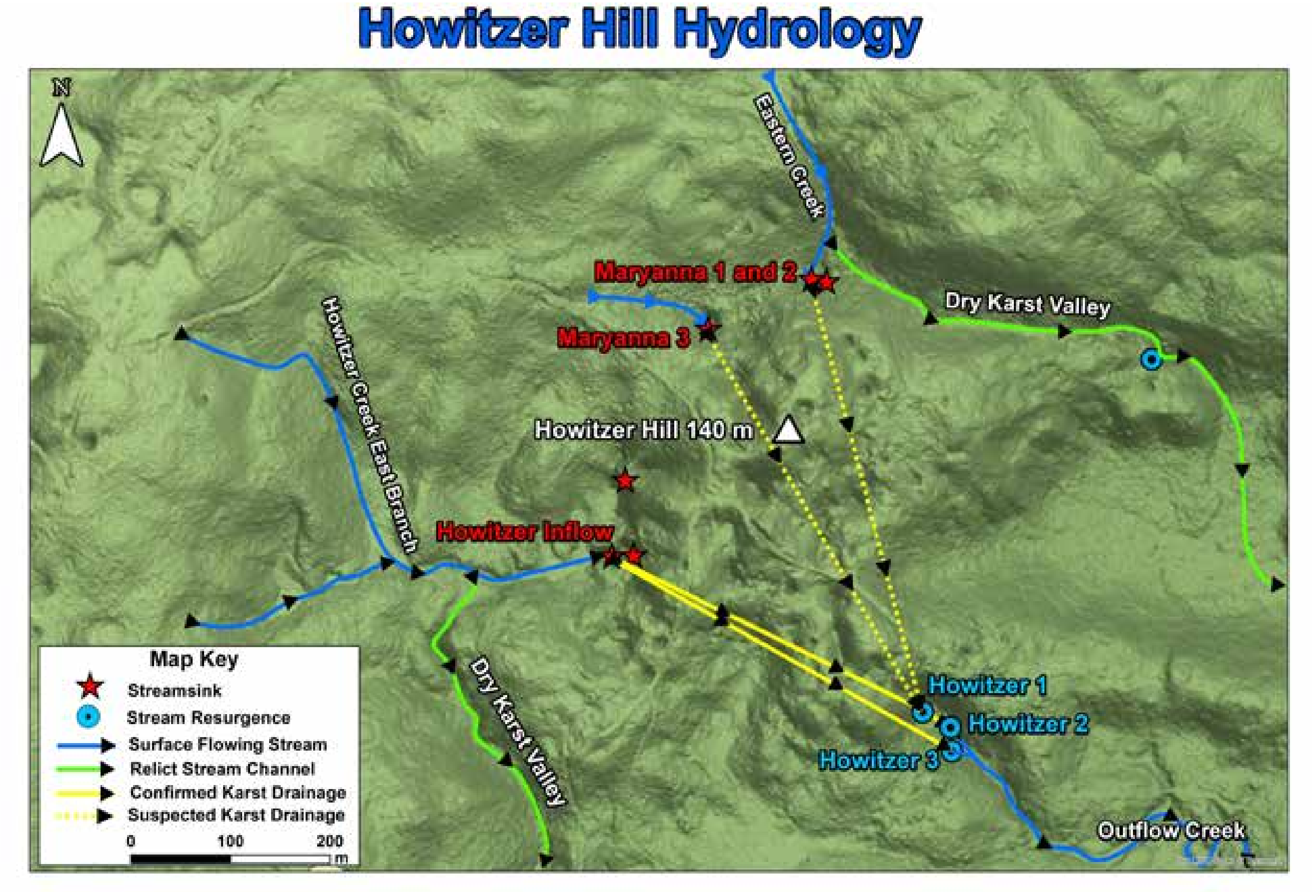

Figure 6. Hydrology at Howitzer Hill showing relict stream channels and underground flow paths.

underground drainage has been confirmed from streamsink to resurgence. The other sites are Julius River cave and Lamprey Creek cave, which have subterranean flow paths of ~150 m and ~50 m respectively, in contrast to the 345 m and 375 m recorded in this study. Of interest is that both the eastern branch of Howitzer Creek and Eastern Creek sink underground into blind valleys leaving dry deeply entrenched karst valleys downslope of the streamsinks. In the case of the eastern branch of Howitzer Creek the stream flow has been captured and entrenched into its new drainage pathway prior to sinking at the Howitzer streamsink, leaving a dry south-trending relict karst valley perched above the channel of Howitzer Creek in a clear example of stream capture by a karst system, forming a large, enclosed basin (Figures 2 and 6). When capture occurred is unknown, however the deep and narrow nature of the dry karst valley suggests thousands of years of fluvial incision prior to capture.

The area in the vicinity of Howitzer Hill presents significant karst management issues relating to the numerous sinkholes and proven subsurface drainage. These present challenges for forestry operations and prescriptions in line with the Forest Practices Code (2020) and Forest Sinkhole Guidelines (McIntosh 2014) will need to be implemented. The results of this study will help define the future harvest boundary and highlight the careful management required for both the Howitzer Creek and Eastern Creek catchments. Given the relatively undocumented nature of large extents of the karst at Trowutta-Sumac, further examples of complex karst development and underground drainage can be expected, although the likelihood of finding large undocumented caves appears to be limited given the scarcity of massive and contiguous, relatively pure non-silicified dolomite lenses in the area.

Acknowledgements

This project was undertaken with support by the Board of the Forest Practices Authority (FPA). We wish to thank Sustainable Timbers Tasmania (STT) for access to this area of State Forest. Foresters Toni Ogilvie and Ian Brumby of STT assisted in documentation of karst landforms in the area. We thank Dean Tuson (STT) for constructive comments on a draft of the paper. The dye tracing was undertaken by Ozark Underground Laboratory, Missouri, United States of America.

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