LIVING WATER

Living Water Pūkorokoro-Miranda Programme

Pūkorokoro-Miranda Catchment Inanga Spawning Site Identification, and Community/School Days

Kaiaua School students at Hauarahi Stream (photo Living Matters Ltd)

Living Matters
Biodiversity & Ecology Solutions

Living Matters
Biodiversity & Ecology Solutions

Inanga Spawning Site Identification, and Community/School Days, for Living Water at Pūkorokoro-Miranda

June 2018

Report prepared for:
Living Water Programme
Dion Patterson
Department of Conservation
Private Bag 3072
Hamilton 3240

Report prepared by:
Jason Roxburgh, M.Sc. Ecology (Hons)
Living Matters Limited
RD 5
THAMES 3757
roxatlarge@hotmail.com

Report submitted: 5 June 2018

Citation: Roxburgh, J. 2018: Pūkorokoro-Miranda catchment inanga spawning site identification, and community/school days. Report prepared for the Living Water Programme by Living Matters Ltd. 18 p. + appendices.

Living Matters
Biodiversity & Ecology Solutions

Table of Contents

1. Introduction

One of the catchments of the Firth of Thames/Tīkapa Moana, the Pūkorokoro-Miranda catchment flows into an internationally significant 8,500 hectare coastal wetland protected under the Ramsar Convention. The shorebird area and habitat at Pūkorokoro-Miranda has been significantly degraded and reduced in size, and the water quality is poor due to increased levels of suspended sediment. Much of this has been caused by various productive land uses in the catchment and the highly modified hydrology and drainage system that has been put in place to reduce inundation and flooding in the lower catchment.

Living Water is a 10 year partnership between Fonterra and the Department of Conservation (DOC), focussed on finding game-changing solutions to enable farming, freshwater and healthy ecosystems to thrive side-by-side. For the Pūkorokoro-Miranda catchment[1], Living Water's key focus is protecting and expanding the shorebird habitat, reducing sediment loads and connecting on-farm biodiversity via 'mountains to sea' blue corridors. Living Water has requested this proposal as part of a range of initiatives to involve the community in the restoration of freshwater habitats. This report focusses on the 2018 inanga spawning site identification, and School Day and Community Day started in 2017, and continued in 2018.

2 Ecological context

Inanga (*Galaxias maculatus*) is the best known of New Zealand's *Galaxias* species, found in most fresh water they can reach in their upstream migration from the sea. Their life cycle has four basic stages: migration, stream residence, spawning, and marine growth. Spawning occurs primarily from February to late May, peaking in April. When they have matured in their adult habitat inanga form into shoals and move downstream a few days before the full or new moons, or sometimes both. Two to three days after the peak height spring tides the shoals move into the bankside vegetation, and spawning usually happens within an hour of the tidal peak.

Females lay their eggs, and they are fertilised by the large quantities of sperm the males release which, if the numbers of fish are large enough, can turn the water milky. After spawning the sticky eggs adhere to the spawning site vegetation, then are washed down into the bases of vegetation and left out of the water as the tide recedes. The damp vegetation keeps the eggs hydrated, and they develop until reached by the water from the next spring tide about a month later, when they are covered with water, hatch, and are carried out to sea. If the natural vegetation has been removed, damaged, or is still developing, temporary spawning habitat can be installed, and spawning sites can be restored. The Whitebait Connection notes that plant species commonly found at spawning sites include:

Native species	Introduced species
• Tussock sedge, cutty grass (*Carex geminata*)	• Cow parsley (*Apium nodiflorum*)
• Kiokio fern (*Blechnum minus*)	• Twitch (*Agropyron repens*)
• *Carex virgata*	• Tall fescue (*Festuca arundinacea*
• Toetoe (*Cortaderia richardii*)	• Umbrella sedge (*Cyperus eragrostis*)
• Common dark green rush (*Juncus gregiflorus*)	• Yorkshire fog (*Holcus lanatus*)
	• Lotus (*Lotus major* and *Lotus pedunculatus*)
	• Mercer grass (*Paspalum distichum*)
	• Creeping buttercup (*Ranunculus repens*)
	• Jointed rush (*Juncus articulatus*)

About six months after hatching and entering the sea the fish are in the form widely known as whitebait, they make their way from the sea into freshwater streams, and swim up to their adult habitat. Here they mature into adults in the river for another six months and are ready to go back downstream to spawn.

[1] The Pūkorokoro-Miranda catchment consists of the Miranda, Pūkorokoro, Taramaire, Te Puaeharuri, and Hauarahi Stream sub-catchments

3 Project purpose and description

Engaging the wider community in biodiversity protection and restoration is an important part of Living Water. The Pūkorokoro-Miranda project aims to involve dairy (and other) farmers, the community, and local schools in identifying, protecting, and enhancing inanga spawning habitat. Community and School days are being used to involve the community to locate existing or likely inanga spawning sites, install temporary spawning habitat, and then restore spawning habitat. This report outlines that method and results of inanga spawning survey as part of the community engagement objective.

3.1 Methods

3.1.1 Inanga spawning site identification and restoration resources

There are two sets of resources for community-based education, identification, protection, and restoration of inanga spawning habitat

1. The "Care for inanga, Te Tiaki inanga" brochure (in Te Reo and English) produced from a collaboration between DOC, Te Wānanga o Raukawa and University of Canterbury. A draft of this resource, providing information for locating inanga spawning sites, was trialled during the 2017 inanga spawning site work at Pūkorokoro-Miranda. Feedback was provided to inform improvements to the resource (see Appendix 1). The brochure is a very good summary for anyone wanting to look into and work on inanga habitat restoration. This is available on the Our Estuaries Hub. https://www.doc.govt.nz/nature/habitats/estuaries/our-estuaries/straw-bales-as-temporary-inanga-spawning-habitat/
2. The Whitebait Connection© resources for community-based education, identification, protection, and restoration of inanga spawning habitat. Appendix 2 provides the hyperlinks to these resources, including their straw bale method for both surveying likely inanga spawning sites, and installing temporary spawning habitat while natural habitat is restored.

For this 2018 work we used the Whitebait Connection resources to assess the catchment's streams for inanga spawning habitat suitability and install the straw bales to survey for spawning sites. These resources have been designed by a community group for the community to use, so are directly applicable to the Community and School education days.

The Straw Bale method used in both sets of resources consists of four main stages:

- **Stage 1**: Locating the saltwater wedge during spring/king tide cycles (February-March).
- **Stage 2**: Installing temporary spawning habitat at the saltwater wedge (March-May).
- **Stage 3**: Monitoring the straw bales for inanga eggs (March-May).
- **Stage 4**: Planning and implementing spawning site restoration.

3.1.2 Field assessment of sites using the Whitebait Connection's resources

The Whitebait Connection has a wide range of freshwater assessment and management tools, including the "Inanga Spawning Habitat Assessment Sheet" used for this work (the full resource can be found at https://www.whitebaitconnection.co.nz/teaching-resources/inanga-spawning.html). This provides a range of ecological indicators that can be visually assessed by community members to score each site for its suitability as a spawning site, including:

• Fish access	• Saltwater access	• Bank angle	• Bank material
• Vegetation cover	• Vegetation height	• Vegetation type	• Root mat thickness
• Ground moisture	• Cover for fish	• Bank maintenance	• Livestock protection

Each attribute has criteria allowing the user to score Poor (0 points), OK (5 points), or Good (10 points) for each site. A score of 90-120 indicates the spawning habitat is in good condition for spawning, and a score of 55-90 indicates the spawning habitat is OK but would be better with improvements. If a site scores zero for any of the attributes then spawning is unlikely to occur as the site currently is, and the site needs work. The format and criteria are easy to use by community members, and the Kaiaua School students had a great time

doing so. Although the assessment isn't definitive, it gives a good indication of the likelihood of the site hosting spawning, and the potential of a site for restoration into a good inanga spawning site.

The Whitebait Connection resources and process seek to enable and empower communities to assess and manage their own inanga spawning sites. Appendix 2 provides links to the specific resources used for this work, and the Community Days discussed later in this report.

3.2 Predicted inanga spawning times

Figure 1 shows the peak spring tides and new and full moons at Pūkorokoro-Miranda for early 2018. The blue arrows and Figure 2 indicate the most likely inanga spawning periods.

Figure 1: The peak spring tides for the Pūkorokoro-Miranda coast for early 2018.

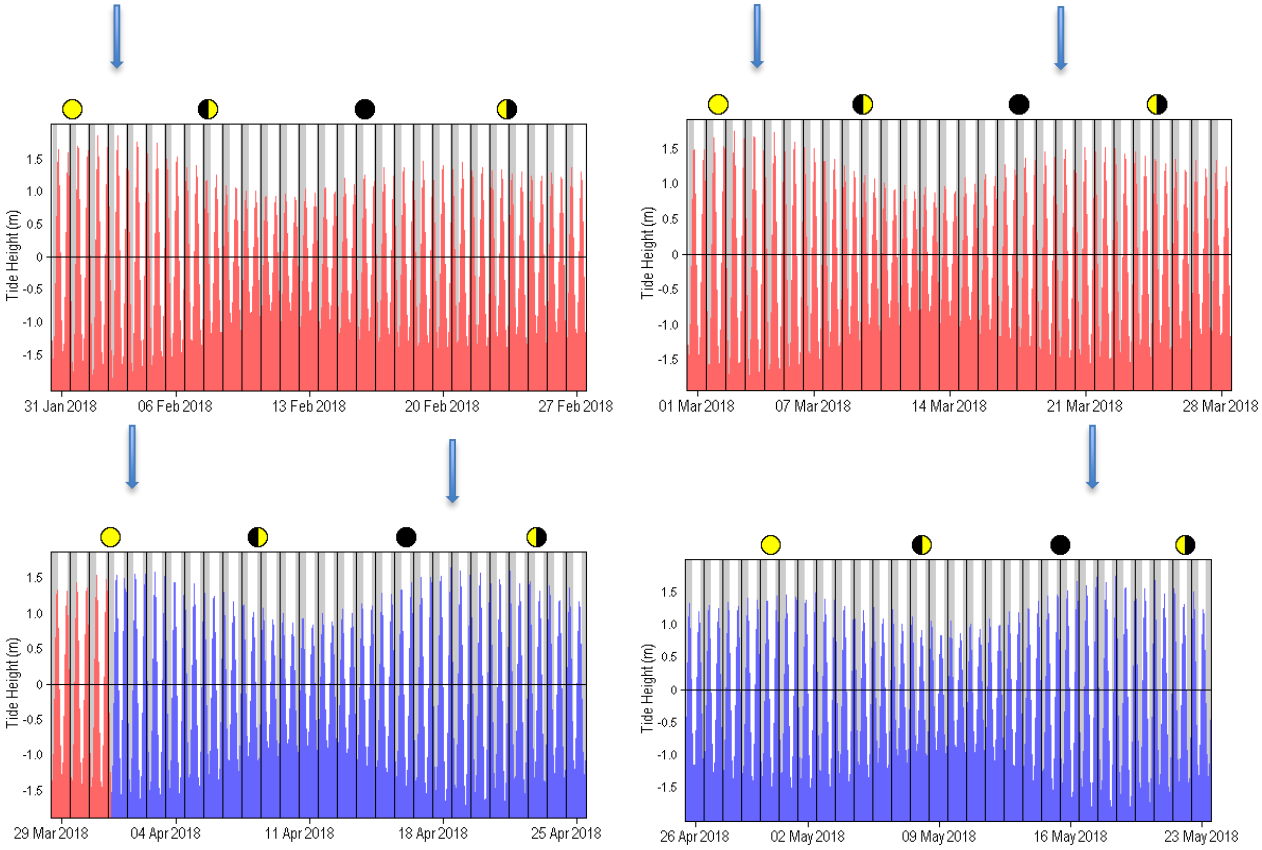


Figure 2: Timing for the most likely inanga spawning dates for Pūkorokoro-Miranda, February-May 2018

	Monday 5 February			Tuesday 6 February			Wednesday 7 February		
Tide	Low	High	Low	Low	High	Low	Low	High	Low
Time	5.42 am	11.58 am	6.13 pm	6.32 am	12.46 pm	7.03 pm	7.21 am	1.35 pm	5.52 pm
	Wednesday 7 March			Thursday 8 March			Friday 9 March		
Tide	Low	High	Low	Low	High	Low	Low	High	Low
Time	6.04 am	12.15 pm	6.30 pm	6.50 am	1.00 pm	7.15 pm	7.37 am	1.46 pm	8.02 pm
	Wednesday 4 April			Thursday 5 April			Friday 6 April		
Tide	Low	High	Low	Low	High	Low	Low	High	Low
Time	3.52 am	10 am	4.14 pm	4.36 am	10.43 am	4.56 pm	5.19 am	11.26 am	5.39 pm
	Saturday 21 April			Sunday 22 April			Monday 23 April		
Tide	Low	High	Low	Low	High	Low	Low	High	Low
Time	5.06 am	11.13 am	5.28 pm	6.00 am	12.07 pm	6.22 pm	6.57 am	1.05 pm	7.20 pm
	Saturday 19 May			Sunday 20 May			Monday 21 May		
Tide	Low	High	Low	Low	High	Low	Low	High	Low
Time	3.59 am	10.05 am	4.19 pm	5.52 am	10.58 am	4.19 pm	5.47 am	11.54 am	8.10 pm

4 Identification of potential inanga spawning sites

Google Earth's altitude function, and an altimeter were used to identify the 3-4 m above sea level (asl) area on each stream as a starting point. Each site was visited and initially assessed for its potential as an inanga spawning site, and for its suitability for use as a site for the Community Day or School Day. Botanical cues were used to identify the approximate upstream extent of the saltwater wedge. All sites (see Figure 3) were then revisited across the spring tides of 2-6 March and 30 March-3 April 2018 (see Figure 4), when a conductivity meter (supplied by DOC) was used to identify the upstream extent of the saltwater wedge (see Figure 4). These were marked with yellow and pink plastic track markers atop wooden stakes for the Miranda and Te Puaeharuri sites, which were the most suitable for the Community Days. Whitebait Connection Inanga Spawning Habitat Assessment sheets were completed for all sites, and these are included as Appendix 3.

Figure 3: Inanga Spawning Site Assessment Site Locations

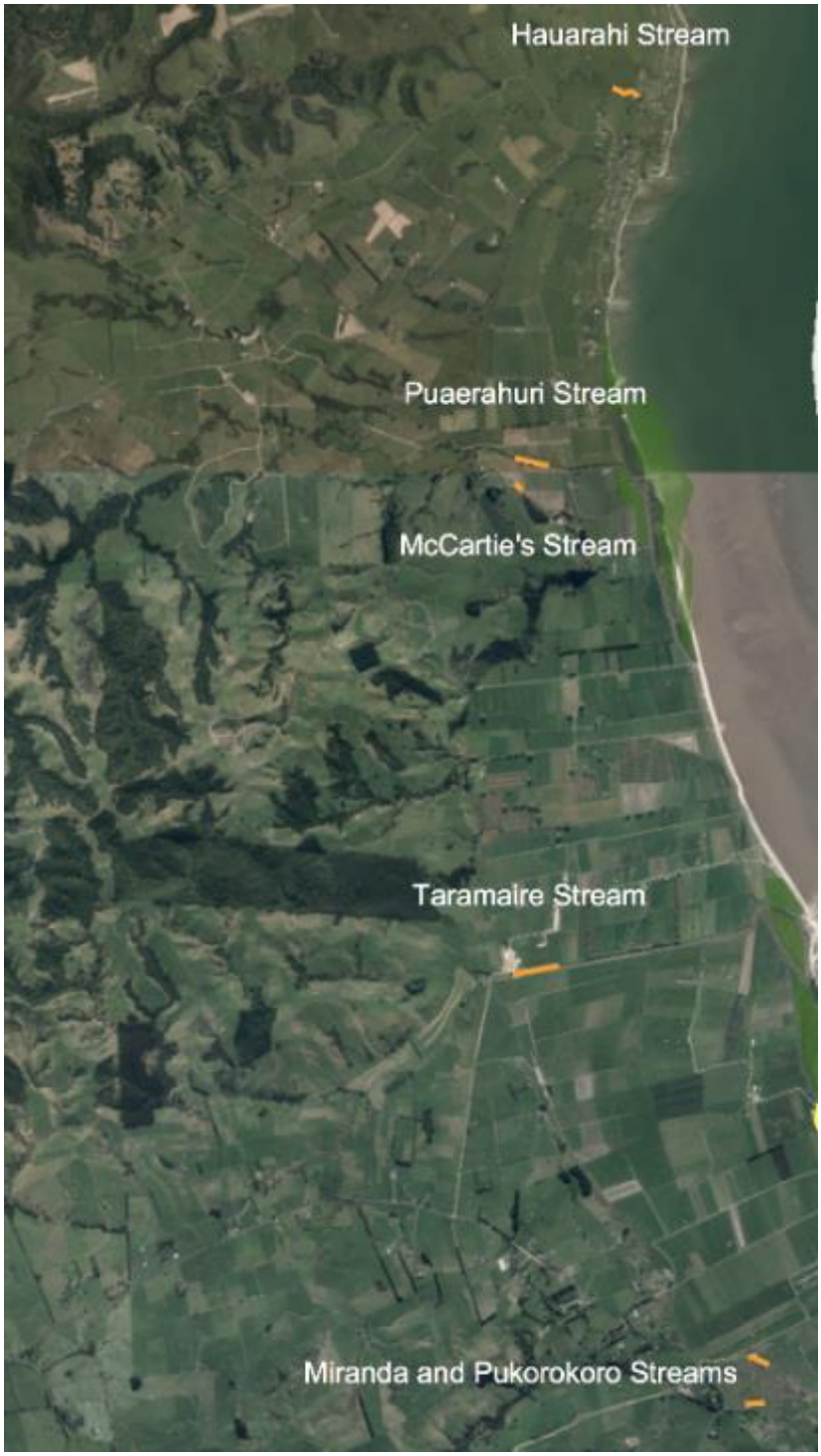


Figure 4: Using a conductivity meter to find the up and downstream extents of the saltwater wedge in Miranda Stream

4.1 Hauarahi Stream

This stream is the northern-most, largest, has the most diverse sub-catchment of the Pūkorokoro-Miranda catchments. Its largely forested headwaters sit within the Auckland Council's Auckland Water Supply Reserves. The ford on Makeawa Road may be causing a barrier to inanga and other diadromous species that are not strong climbers. The stream has an unimpeded exit to the sea, though it is highly modified through ongoing dredging to maintain boat access to the Kaiaua boat ramp and adjoining marina/mooring facilities. Due to its steep-sided banks, it has the least suitable inanga spawning site of the sub-catchments, which is reflected in its Whitebait Connection Habitat Assessment of 70.

However, it is suitable for hosting public and school events because of its proximity to Kaiaua School, easy access through the adjoining public reserve, safe access to the water for primary students, good sites for establishing straw bales, good shade from the sun, picnic tables able to be used as work sites, and good numbers of fish. For these reasons it was the focus of the **2017** Community Day, and the **2018** School Day. The upstream extent of the saltwater wedge was identified to be E1803915 N5890915, 20 m downstream from where the stream is accessed from the adjoining public reserve (see Figure 5).

4.1.1 The Whitebait Connection assessment for Hauarahi Stream

This site was assessed as scoring 70 (an "unlikely" score), and scored a zero under the Livestock Protection, Vegetation Cover, and Bank Angle criteria. Inanga were seen in this reach during the assessment, were caught in reasonable numbers during the 2017 Community Day and 2018 School Day, and were found by Roxburgh and McQueen (2015). This site is one of the lower priorities for inanga spawning investigation, but looking at sites immediately up and down stream would be worthwhile as there will probably be an inanga spawning site somewhere in the lower stream.

Attributes	Score
Fish Access	10
Saltwater Access	10
Bank Angle	0
Bank Material	10
Vegetation Cover	0
Vegetation Height	5
Vegetation Type	0
Root Mat Thickness	5
Ground Moisture	5
Cover for Fish	5
Bank Maintenance	10
Livestock Protection	10
Total Score	70

Figure 5: Potential inanga spawning reach, Hauarahi Stream

4.2 Te Puaeharuri and McCartie's Streams

4.2.1 Te Puaeharuri

Although this stream is relatively small, it runs the full length of the catchment, sandwiched between the larger Hauarahi and Taramaire catchments. As with the other catchments, it has a highly modified lower catchment, with the last 1.2km to the sea straight and channelised. The likely inanga spawning habitat identified through altitude and vegetation is as shown in Figure 6.

Figure 6: Likely inanga spawning reach, Te Puaeharuri and McCartie's Streams

4.2.1.1 The Whitebait Connection assessment for Te Puaeharuri Stream

This site was assessed as scoring 85 (an OK score) but scored a zero under the Livestock Protection criterion as stock are not excluded from the site. Because of the collapsed ford just upstream of the site potentially being a barrier to inanga passage, it was initially assessed as a "5" for Fish Access. However, given the large numbers of inanga caught in Gee Minnow traps at the site during the Community Day, it was reassessed as a 10 because inanga seem to be able to negotiate the collapsed ford to come downstream to the site. This site is one of the higher priorities for inanga spawning investigation and has good potential if the site has stock excluded.

Attributes	Score
Fish Access	5 (10)
Saltwater Access	10
Bank Angle	5
Bank Material	10
Vegetation Cover	5
Vegetation Height	5
Vegetation Type	10
Root Mat Thickness	10
Ground Moisture	10
Cover for Fish	5
Bank Maintenance	10
Livestock Protection	0
Total Score	85 (90)

4.2.1.2 Te Puaeharuri Stream potential barrier to inanga passage

There are two crossings of this lower section of the stream:

- The downstream one is a large culvert-based vehicle and stock crossing that does not pose a barrier to fish passage.
- The upstream one (seen in Figure 7) is an old collapsed culvert-based crossing, and probably limits some fish passage, though Roxburgh and McQueen (2015) found inanga above this crossing. Upstream of the ford there is a considerable build-up of sediment that has been unable to flow through or over the ford, meaning there is difference of about a metre in the bed and base flow water levels above and below the ford.

Figure 7: The collapsed ford structure in Te Puaeharuri Stream

I discussed this crossing with the landowner, and he is open to the idea of removing it. However, it is a useful crossing for stock this reach of the stream and, because it does not appear to be overly limiting fish passage (at least downstream), leaving it in place for now may be the best option. If it were to be removed, WRC's Warren Coffey sought advice from WRC's Resource Use Division, who advise a consent would "most likely"

be required, referring to Regional Plan Rule 4.2.20.2 Permitted Activity Rule – Removal or Demolition of Structures, which is shown in Appendix 4.

The upstream extent of the saltwater wedge was identified as E1803430 N5888451, 90 m downstream of this collapsed ford. The site is marked with wooden stakes with pink plastic triangle markers (shown in Figure 8). Because of the ease of access, suitability for potential inanga spawning, and the landowners keenness and interest, this site was chosen for the 2018 Community Day.

Figure 8: The Te Puaeharuri Stream inanga spawning reach, looking up (left) and downstream (right) from the marked upper extent of the saltwater wedge.

4.2.2 McCartie's Stream

This very small stream flows through the East Coast Road Scenic Reserve (which DOC is currently restoring), only extending about 500 m upstream from the Reserve before transitioning into a farm drain (Figure 6). The likely upstream extent of the saltwater wedge was identified as E1803284 N5888310. The stream exits to the sea primarily via two small flap-gated culverts into Te Puaeharuri Stream, as shown in Figure 9. In November 2010 DOC's then-Auckland Area Office caught 188 inanga in 11 Gee Minnow traps set overnight in the wetland area of this stream, though their lengths were not measured. This indicates there is some adult habitat available, though the adult inanga in this stream may spawn in Te Puaeharuri Stream.

Figure 9: McCartie's Stream looking north (left) toward the main stream outlet (right)

4.3 Taramaire Stream

The last 2.3 km of this stream, downstream from the Fairview Road crossing, is heavily modified through channelization and stop-banking. Some of the original meandering course can be seen in aerial photos, and it is tidally influenced to about 300 m downstream of the Fairview Road crossing. Roxburgh and McQueen (2015) found no inanga in the three sampling sites upstream of the crossing, although the first of these was 2.5 km further upstream and 20 m higher in altitude than the crossing. They concluded this crossing may be a barrier for inanga but does not appear to be a significant barrier to other fish species. The likely inanga spawning reach for this stream is around E1803439 N5885116 (shown Figure 10), and the Fairview Road crossing probably limits inanga passage upstream. However, it is still worth examining further for inanga spawning sites, especially if the crossing can be improved for fish passage.

4.3.1 The Whitebait Connection assessment for Taramaire Stream

This site was assessed as scoring 85 (an OK score) but scored a zero under the Livestock Protection criterion as stock are not excluded from the site. Inanga were seen in this reach during the assessment, but their numbers at this site are not known. The reach of Taramaire Stream for the 2.25 km from Fairview Road to the sea has been heavily channelised, and 1.8 km of it is now straight. This limits it's potential for inanga spawning, but does not exclude it. Roxburgh and McQueen (2015) did not find inanga upstream of the Fairview Road crossing, though they also could not sample downstream of it either, so it is possible this crossing could be limiting or preventing inanga migration upstream. This site is one of the lower priorities for inanga spawning investigation, but still has some potential.

Attributes	Score
Fish Access	10
Saltwater Access	10
Bank Angle	5
Bank Material	5
Vegetation Cover	5
Vegetation Height	5
Vegetation Type	10
Root Mat Thickness	10
Ground Moisture	10
Cover for Fish	5
Bank Maintenance	10
Livestock Protection	0
Total Score	85

Figure 10: Likely inanga spawning reach, Taramaire Stream

4.4 Miranda Stream

Miranda Stream is the southern-most of the five catchments, has the least modified outlet to the sea, no significant barriers to fish migration, and Roxburgh and McQueen (2015) found inanga throughout the catchment. For the purposes of inanga spawning, Miranda Stream has two main tributaries that join 1600 m upstream from the mouth. Both tributaries have good potential inanga spawning habitat, with the southern site shown in Figure 12. The area between these two sites is also tidal and contains potential spawning habitat, though it is currently grazed as part of the paddock it is contained within. Figure 11 shows the two

potential inanga spawning sites:

- Northern site: the upstream extent of the saltwater wedge was identified as E1804814 N5882550, 350 m downstream of the culvert crossing under Miranda Road.
- Southern site: the upstream extent of the saltwater wedge was identified as E1804868 N5882235, 100 m downstream of the Miranda Road bridge

4.4.1 The Whitebait Connection assessment for Miranda Stream

The Miranda Stream's North and South Reaches were assessed separately:

Miranda South: This site was assessed as scoring 100 (a strong score), but scored a zero under the Livestock Protection criterion as stock are not excluded from the site. It is likely the inanga spawning site for this tributary of Miranda Stream (or potentially for both tributaries) is somewhere along this reach of this stream, so installation of straw bales and searching by people on the ground would be worth pursuing. Fencing of this site should be a high priority, and the vegetation may need some management once the inanga spawning site is located.

Attributes	Score
Fish Access	10
Saltwater Access	10
Bank Angle	5
Bank Material	10
Vegetation Cover	5
Vegetation Height	10
Vegetation Type	10
Root Mat Thickness	5
Ground Moisture	10
Cover for Fish	10
Bank Maintenance	10
Livestock Protection	0
Total Score	100

Miranda North: This site was assessed as scoring 100 (a strong score), but the main difference from the Miranda South site is this site one had temporary stock exclusion fencing at the time of assessment. Otherwise this site is similar to the Miranda South site. It is likely the inanga spawning site for this tributary of Miranda Stream (or potentially both) is somewhere along this reach of this stream, so installation of straw bales and searching by people on the ground would be worth pursuing. Once the inanga spawning site is identified, permanent Fencing of this site should be a high priority, and the vegetation may need some management once the inanga spawning site is located and fenced.

Attributes	Score
Fish Access	10
Saltwater Access	10
Bank Angle	5
Bank Material	5
Vegetation Cover	10
Vegetation Height	10
Vegetation Type	10
Root Mat Thickness	10
Ground Moisture	10
Cover for Fish	5
Bank Maintenance	10
Livestock Protection	5
Total Score	100

Figure 11: Likely inanga spawning reaches, Miranda Stream

Figure 12: Looking upstream (left) and downstream (right) from the upstream extent of the saltwater wedge for the Miranda Stream South (above) and North (below) sites.

5 Kaiaua School day

Due to the timing required by Kaiaua School, the requirements of proximity to the school, and the ease of managing the pupils at the site, Hauarahi Stream was chosen for the School Day. Access to the stream is easy and safe, the water depth is low on spring tides, and the out-going tide was during the school day. However, because of this stream's eroded and near-vertical banks through much of the saltwater wedge reach, this site is probably the least likely to be a good site for inanga spawning site restoration. That said, there are still good numbers of inanga in the stream, so they are obviously spawning somewhere in this lower reach.

In order to undertake the School Day, two straw bale sets were installed on 18 March 2018, which was three days before the peak spring tide. The School Day was undertaken on 11 April 2018, shown in Figure 13. The afternoon before, Brooke Turner (DOC) had established Gee Minnow Traps in Hauarahi Stream to catch some freshwater fish for the School Day.

Figure 13: Kaiaua School Day. Left: DOC's Ken Brown and Brooke Turner, Kaiaua School Principal Karlos Bosson, and the Kaiaua Primary School senior students. Right: One of the three straw bale installations at Hauarahi Stream during the Kaiaua School Day

Kaiaua School's senior students and School Principal Karlos Bosson arrived at 10 am, and were run through a safety briefing, and given an outline of what they were going to be doing. The students were split into two groups, and each ran through two exercises:

- Retrieving half the Gee Minnow Traps, and doing an exercise identifying, measuring, and recording the freshwater fish caught. This information was retained by Kaiaua School
- Using the Whitebait Connection's assessment method to assess the stream reach for its suitability for inanga spawning.

No inanga eggs were found on any of the straw bale installations, but the students had a great time carrying out the above exercises. The day was concluded with a Q&A session with the students, and they departed for the School at noon.

6 Inanga spawning community day

On 17 January 2018 Leanne Irvine and Brooke Turner (DOC) and I visited the five potential sites to assess them for their use for the Community Day. Of the five potential sites, the Te Puaeharuri Stream (Figure 6) and the southern-most of the two Miranda Stream sites (Figures 11 and 12) were the most suitable because of their:

- Good potential inanga spawning habitat
- Easy access from a close-by road
- Gently sloping stream banks
- Suitable vegetation

However, these sites were not able to be used due to farm management needs during the time the spring tides were due, so the straw bales could not be installed. Hence the Te Puaeharuri Stream site was chosen for the site of the Community Day. Three sets of straw bales were installed on 11 April 2018 (see Figure 14):

- At the upstream extent of the saltwater wedge
- 20 m up and downstream of the saltwater wedge

The Community Day was held on 28 Apr 2018, a full week after the likely inanga spawning dates of 21-23 April.

Figure 14: During and after straw bale installation at Te Puaeharuri Stream

On the afternoon of 27 April 2018, Brooke Turner (DOC) set out 6 Gee Minnow Traps along the reach, so the presence of inanga could be assessed during the Community Day. On the evening of 27 April the author (Jason Roxburgh) was interviewed by Brian Crump on his Radio NZ Nights programme about the project and inanga spawning generally. This provided an opportunity to further advertise the Community Day, and the link to this interview is https://podcast.radionz.co.nz/downloads/ngts/ngts-20180427-2007-weekend_whitebait-128.mp3.

The weather forecast for 28 April was for heavy rain and gale-force north-easterlies, and the call was made to go ahead. DOC staff (including Dion Patterson, Rose Graham, Brooke Turner, Leanne Irvine, Ken Browne, and Mailee Stanbury) organised and arranged the advertising, logistics, equipment, and information materials for the Community Day. Warren Coffey from Waikato Regional Council provided plants and materials, and his expertise in catchment management.

Although the conditions remained true to the forecast throughout the day, about twenty locals and visitors attended. DOC staff provided an introduction, health and safety briefing, and scene-setting. I provided a briefing on the inanga lifecycle, spawning sites, and the straw bale technique (see Appendix 5). The Gee Minnow traps were retrieved, and were found to contain large numbers of a range of apparently gravid adult inanga, meaning they were at least preparing to spawn. We then examined the three straw bale installations, but found no inanga eggs. Given the numbers of adult inanga found in the Gee Minnow traps on the day, it may have been that we were slightly early for the spawning event.

Once the closing presentation had been finished, the straw bale installations were removed to the Thames Refuse Transfer Station's green waste facility. During the dismantling, one bale was found to contain a nest of what were thought to be Argentine Ants (later confirmed by Rose Graham). Enquiries with the straw supplier found they had not seen Argentine Ants in their facility, and enquires with Kaiaua locals revealed that Argentine Ants are present in the area. The Thames Refuse Centre green waste facility has Argentine Ants in the vicinity, but they advise Argentine Ants are likely to be killed through the facilities hot composting process.

7 Recommendations

7.1 Hauarahi Stream

Given the numbers of inanga found in the Hauarahi Lower site by Roxburgh and McQueen (2015), and in Gee Minnow traps set during the 2017 Community Day, and the 2018 School Day, there is likely to be an inanga spawning site nearby. The section of the stream that contains the reach of the spring tides is highly eroded in most places, and it is likely any spawning site is either up or down stream from Roxburgh and McQueen's (2015) Hauarahi Lower site. An area recommended for further investigation is upstream of this site, between E1803897 N5890934 and E1803822 N5890960.

7.2 Miranda Stream

Figure 11 shows the area between the two Miranda Stream tributaries, a tidally influenced grazed area that is similarly vegetated to the main tributaries. It is possible that inanga are spawning in this area, and investigating that as part of the wider Miranda Stream would be useful.

Most of the land that both first order tributaries of Miranda Stream flow through (effectively all of that downstream of where these two stream pass under the Miranda Road) is now owned by the Dalton family. I understand that DOC hopes to purchase part of this area and manage it for biodiversity values. Given this, and the likelihood of this area containing significant inanga spawning areas, fencing stock out of these streams is recommended while the further sale to DOC is investigated and progressed.

7.3 Te Puaeharuri and McCartie's Streams

Straw bale installations and searching for inanga spawning sites should continue at Te Puaeharuri stream, as this is one of the more likely sites to have a spawning site in this reach. Inanga have been recorded in McCartie's Stream, though it isn't known if they are using this small stream as adult habitat, or coming in via the adjoining Te Puaeharuri Stream. Given it's small extent and lack of upstream adult habitat, it is less likely that inanga are spawning in significant numbers in this stream. However, it is still worth establishing if there is a spawning site here, and see what role this waterway plays for inanga.

7.4 Straw bale installation, and people on the ground during potential spawning times

Now the likely locations of inanga spawning sites have been identified for the Pūkorokoro-Miranda catchments, establishing multiple straw bale installations in all these streams should be a priority. Allied with this, when likely spawning tides occur during daylight hours, having people on the ground at these sites would be very useful to more quickly identify spawning sites by witnessing the spawning events. Given limited resources the priority order for this could be:

1. The various tributaries of Miranda Stream
2. Te Puaeharuri Stream
3. Hauarahi Stream
4. Taramaire Stream

From this and previous inanga spawning site work, Living Matters Limited has all the equipment required for the straw bale installations, mainly just requiring the purchase of barley straw bales. We would be keen to be involved in this work in the future, especially providing training to DOC staff, volunteers, and community members to provide this service across as many of the streams as possible. It would be useful to identify at least one inanga spawning site before the next Community Day is held, and use that site to host the Community Day.

7.5 Barriers to inanga passage

Roxburgh and McQueen (2015) found inanga below the Hauarahi Stream crossing on Makaewa Road (E1801182 N5889353), but not above it. Given the presence of inanga in the whole of Miranda Stream (with no apparent barriers to inanga passage) the reason for this upstream absence in Hauarahi Stream should be investigated. It would be useful to measure the presence of inanga to as far upstream as they are found below the stream crossing, as their apparent absence above the crossing may be due to something else.

Roxburgh and McQueen (2015) found no inanga above the Taramaire Stream crossing on Fairview Road (E1803104 N5885072), though they were unable to sample this stream below the crossing. Inanga were seen in the lower reach of this stream during the work for this report, so this does not necessarily mean the ford itself is a barrier to passage, or that there are no inanga above the ford, but this should be investigated too for the Taramaire Stream.

7.6 Community and School Days

Despite the poor weather conditions during the 2018 Community Day, there was a reasonable turnout of people. The DOC staff involved set the event up very well, and the resources on the day were excellent. These Community Days are well worth continuing, especially if inanga spawning sites have already been identified.

Feedback from Kaiaua School Principal Karlos Bosson on the School Day was that he saw good value for the School. On the day the students had a great time, and were engaged and interested. The School Days are also worth continuing, maybe at another site like Te Puaeharuri or Miranda Stream.

8 Acknowledgements

- Thanks to Helen Kettles (DOC Marine Technical Advisor) for contract liaison, advice, and support, and Helen and Nicki Atkinson (DOC Freshwater Technical Advisor) provided constructive comments on the drafts of this report.
- Thanks also to Dion Patterson (DOC Senior Ranger-Biodiversity) for initiating this work.
- I appreciate the support in organising and arranging the advertising, logistics, equipment, and information materials for the Community Day, and with school liaison, the from DOC's Hauraki District Office staff, particularly Brooke Turner (Ranger-Community) and Leanne Irvine (Senior Ranger-Community), and also Rose Graham, Ken Brown (Rangers), and Mailee Stanbury (Senior Ranger Biodiversity).
- Warren Coffey from Waikato Regional Council provided plants and materials, and his expertise in catchment management.
- It was great to work with the Kaiaua School's Principal Karlos Bosson, and senior students during the school day.
- Several landowners generously provided advice, experience and observations, and access to their properties - Noel Coxhead, Gary, Adrienne, and Mark Dalton, Trudy Lane, and Rob McCartie.

Appendix 1: DOC's "Care for inanga, Te Tiaki inanga" feedback form

Inanga, me tiaki tonu - trial feedback

Kia ora koutou, thank you for your interest in piloting these new resources for locating inanga spawning sites using straw bales. We hope it will be a satisfying experience for you. We are keen to get your feedback on how it went and what we might do to improve the resource so that it can be of greater value to other people with an interest in inanga, local estuaries and kaitiakitanga.

Some information about you
Name of Group:
Contact Person:
Description of group (e.g. caregroup, kura, ages, numbers):
What did you do?
When did you first visit the stream to look for a good location?
Did you receive any additional help to locate a site for positioning the straw bales?
When did you put the straw bales out?
When did you check the straw bales?
Did you observe inanga eggs?

Department of Conservation
Te Papa Atawbai

How was the information in the brochure?
Are the instruction 'steps' and the supporting material in the brochure clear and fit for purpose? Are there any amendments you would suggest and/or more information needed at any of these steps?
• Step 1 – before you went out
• Step 2 – finding the right places
• Step 3 – looking for inanga
• Step 4 – putting the straw bales out
• Step 5 – info for future planting
• What you need list
• A journey to the sea and back info
• Info given prior to the instructions pages e.g. inanga habitat is declining.

How was the experience for you?
What words would you use to describe the experience you had? e.g. fun, hard work etc
Were there any unexpected outcomes for you?
Would you recommend it to others?
Any other comments or ideas?

Thank you for your help!

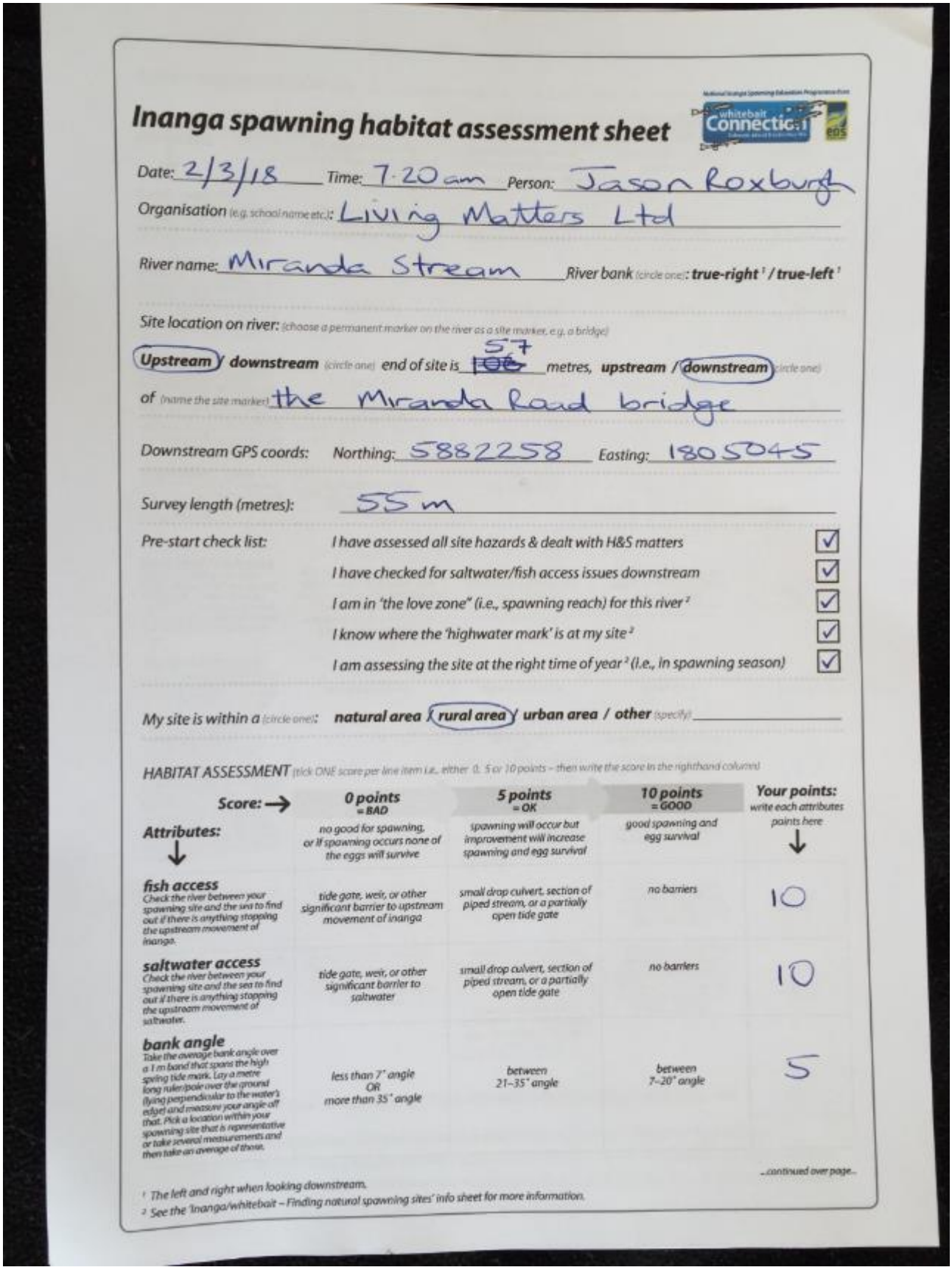
Contacts: Helen Kettles (Department of Conservation, hkettles@doc.govt.nz)
Pātaka Moore (Te Wānanga o Raukawa, patakamoore@gmail.com)
Shane Orchard (University of Canterbury, orchard.dse@gmail.com)

Appendix 2: Whitebait Connection resources for inanga spawning site identification and restoration

- Inanga-lifecycle-audio-part-one.m4a - 6.75 MB
- WBC-NISP_1A_Introduction_v2_18OCT.pdf - 15.72 MB
- WBC-NISP_1B_summary_v1_18OCT.pdf - 6.94 MB
- WBC-NISP_1C_ID_guide_v2_18OCT.pdf - 4.66 MB
- WBC-NISP_2A_Find_Spawning_18OCT.pdf - 1.03 MB
- WBC-NISP_2B_Salt_Wedge_v2_18OCT.pdf - 1012.76 KB
- WBC-NISP_2C_habitat_assessment_v2_18OCT.pdf - 1.29 MB
- WBC-NISP_3A_bale_installation_v2_18OCT.PDF - 1.07 MB
- WBC-NISP_3B_maintain_site_v2_18OCT.pdf - 3.44 MB
- WBC-NISP_3c_Longterm_restoration_v2_18OCT(1).pdf - 691.85 KB
- WBC-NISP_Bale_signs_6oct_HiRes.pdf - 21.3 MB

Appendix 3: Whitebait Connection inanga spawning habitat assessment sheets

Miranda Stream South Reach Page 1



Inanga spawning habitat assessment sheet

Date: 2/3/18 Time: 7.20 am Person: Jason Roxburgh

Organisation (e.g. school name etc.): Living Matters Ltd

River name: Miranda Stream River bank (circle one): **true-right**[1] / **true-left**[1]

Site location on river: (choose a permanent marker on the river as a site marker, e.g. a bridge)

(Upstream) / **downstream** (circle one) end of site is ~~100~~ 57 metres, **upstream** / (**downstream**) (circle one)

of (name the site marker) the Miranda Road bridge

Downstream GPS coords: Northing: 5882258 Easting: 1805045

Survey length (metres): 55 m

Pre-start check list:

- I have assessed all site hazards & dealt with H&S matters ☑
- I have checked for saltwater/fish access issues downstream ☑
- I am in 'the love zone" (i.e., spawning reach) for this river[2] ☑
- I know where the 'highwater mark' is at my site[2] ☑
- I am assessing the site at the right time of year[2] (i.e., in spawning season) ☑

My site is within a (circle one): **natural area** / (**rural area**) / **urban area** / **other** (specify) _____

HABITAT ASSESSMENT (tick ONE score per line item i.e., either 0, 5 or 10 points – then write the score in the righthand column)

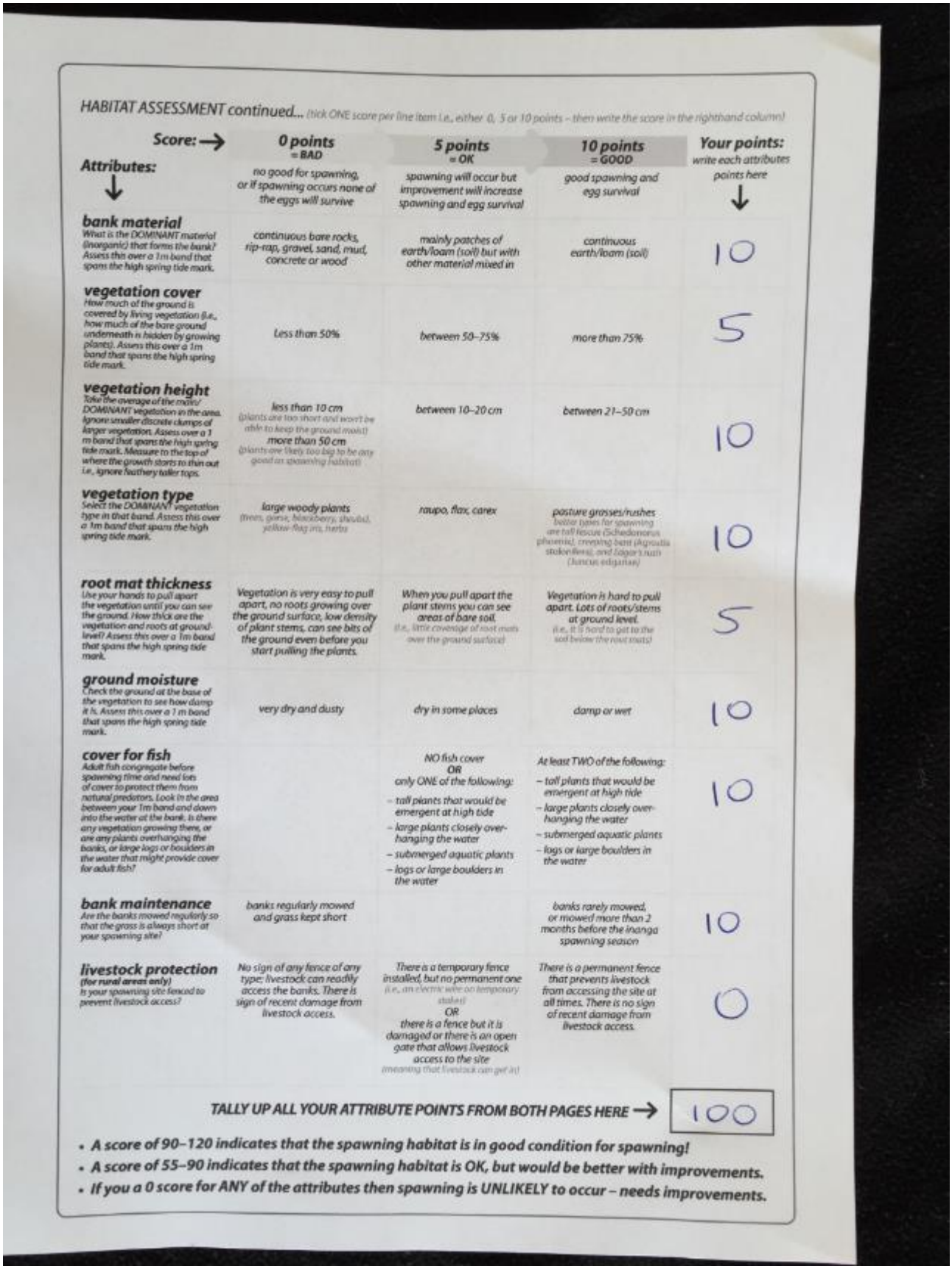
Attributes: (Score: →)	0 points = BAD	5 points = OK	10 points = GOOD	Your points: write each attributes points here ↓
fish access Check the river between your spawning site and the sea to find out if there is anything stopping the upstream movement of inanga.	tide gate, weir, or other significant barrier to upstream movement of inanga	small drop culvert, section of piped stream, or a partially open tide gate	no barriers	10
saltwater access Check the river between your spawning site and the sea to find out if there is anything stopping the upstream movement of saltwater.	tide gate, weir, or other significant barrier to saltwater	small drop culvert, section of piped stream, or a partially open tide gate	no barriers	10
bank angle Take the average bank angle over a 1 m band that spans the high spring tide mark. Lay a metre long ruler/pole over the ground (lying perpendicular to the water's edge) and measure your angle off that. Pick a location within your spawning site that is representative or take several measurements and then take an average of those.	less than 7° angle OR more than 35° angle	between 21–35° angle	between 7–20° angle	5

...continued over page...

[1] The left and right when looking downstream.

[2] See the 'Inanga/whitebait – Finding natural spawning sites' info sheet for more information.

Miranda Stream South Reach Page 2



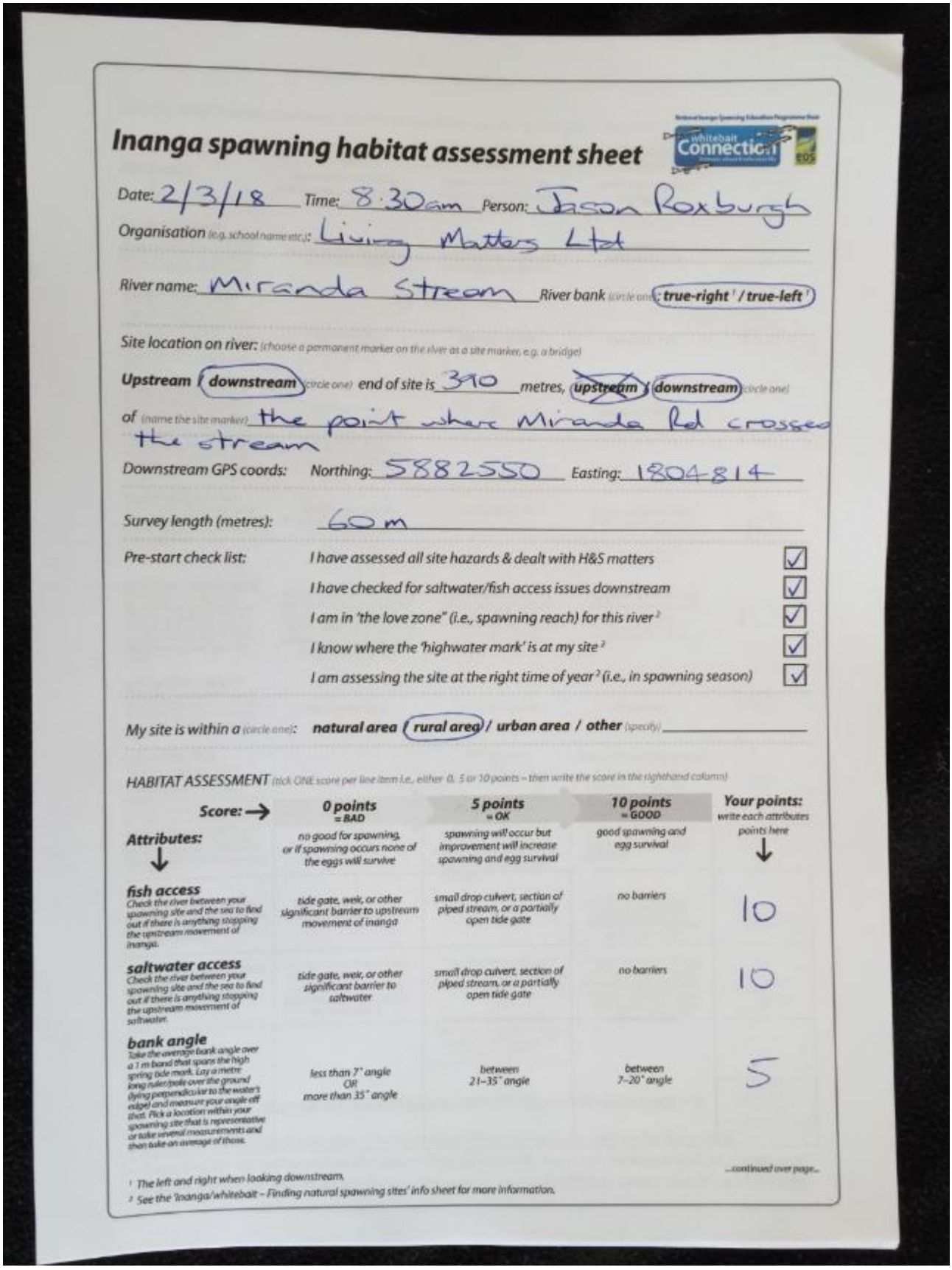
HABITAT ASSESSMENT continued... (tick ONE score per line item i.e., either 0, 5 or 10 points – then write the score in the righthand column)

Attributes:	0 points = BAD	5 points = OK	10 points = GOOD	Your points: write each attributes points here
bank material What is the DOMINANT material (inorganic) that forms the bank? Assess this over a 1m band that spans the high spring tide mark.	continuous bare rocks, rip-rap, gravel, sand, mud, concrete or wood	mainly patches of earth/loam (soil) but with other material mixed in	continuous earth/loam (soil)	10
vegetation cover How much of the ground is covered by living vegetation (i.e., how much of the bare ground underneath is hidden by growing plants). Assess this over a 1m band that spans the high spring tide mark.	Less than 50%	between 50–75%	more than 75%	5
vegetation height Take the average of the main/DOMINANT vegetation in the area. Ignore smaller discrete clumps of larger vegetation. Assess over a 1 m band that spans the high spring tide mark. Measure to the top of where the growth starts to thin out i.e., ignore feathery taller tops.	less than 10 cm (plants are too short and won't be able to keep the ground moist) more than 50 cm (plants are likely too big to be any good as spawning habitat)	between 10–20 cm	between 21–50 cm	10
vegetation type Select the DOMINANT vegetation type in that band. Assess this over a 1m band that spans the high spring tide mark.	large woody plants (trees, gorse, blackberry, shrubs), yellow-flag iris, herbs	raupo, flax, carex	pasture grasses/rushes (better types for spawning are tall fescue (Schedonorus phoenix), creeping bent (Agrostis stolonifera), and Edgar's rush (Juncus edgariae))	10
root mat thickness Use your hands to pull apart the vegetation until you can see the ground. How thick are the vegetation and roots at ground-level? Assess this over a 1m band that spans the high spring tide mark.	Vegetation is very easy to pull apart, no roots growing over the ground surface, low density of plant stems, can see bits of the ground even before you start pulling the plants.	When you pull apart the plant stems you can see areas of bare soil. (i.e., little coverage of root mats over the ground surface)	Vegetation is hard to pull apart. Lots of roots/stems at ground level. (i.e., it is hard to get to the soil below the root mats)	5
ground moisture Check the ground at the base of the vegetation to see how damp it is. Assess this over a 1 m band that spans the high spring tide mark.	very dry and dusty	dry in some places	damp or wet	10
cover for fish Adult fish congregate before spawning time and need lots of cover to protect them from natural predators. Look in the area between your 1m band and down into the water at the bank. Is there any vegetation growing there, or are any plants overhanging the banks, or large logs or boulders in the water that might provide cover for adult fish?		NO fish cover OR only ONE of the following: – tall plants that would be emergent at high tide – large plants closely over-hanging the water – submerged aquatic plants – logs or large boulders in the water	At least TWO of the following: – tall plants that would be emergent at high tide – large plants closely over-hanging the water – submerged aquatic plants – logs or large boulders in the water	10
bank maintenance Are the banks mowed regularly so that the grass is always short at your spawning site?	banks regularly mowed and grass kept short		banks rarely mowed, or mowed more than 2 months before the inanga spawning season	10
livestock protection (for rural areas only) Is your spawning site fenced to prevent livestock access?	No sign of any fence of any type; livestock can readily access the banks. There is sign of recent damage from livestock access.	There is a temporary fence installed, but no permanent one (i.e., an electric wire on temporary stakes) OR there is a fence but it is damaged or there is an open gate that allows livestock access to the site (meaning that livestock can get in)	There is a permanent fence that prevents livestock from accessing the site at all times. There is no sign of recent damage from livestock access.	0

TALLY UP ALL YOUR ATTRIBUTE POINTS FROM BOTH PAGES HERE → 100

- **A score of 90–120 indicates that the spawning habitat is in good condition for spawning!**
- **A score of 55–90 indicates that the spawning habitat is OK, but would be better with improvements.**
- **If you a 0 score for ANY of the attributes then spawning is UNLIKELY to occur – needs improvements.**

Miranda Stream North Reach Page 1



Inanga spawning habitat assessment sheet

Date: 2/3/18 Time: 8.30am Person: Jason Roxburgh

Organisation (e.g. school name etc.): Living Matters Ltd

River name: Miranda Stream River bank (circle one): **true-right [1] / true-left [1]**

Site location on river: (choose a permanent marker on the river as a site marker, e.g. a bridge)

Upstream / downstream (circle one) end of site is 390 metres, ~~**upstream**~~ / **downstream** (circle one)

of (name the site marker) the point where Miranda Rd crossed the stream

Downstream GPS coords: Northing: 5882550 Easting: 1804814

Survey length (metres): 60 m

Pre-start check list:

- I have assessed all site hazards & dealt with H&S matters ☑
- I have checked for saltwater/fish access issues downstream ☑
- I am in 'the love zone" (i.e., spawning reach) for this river [2] ☑
- I know where the 'highwater mark' is at my site [2] ☑
- I am assessing the site at the right time of year [2] (i.e., in spawning season) ☑

My site is within a (circle one): **natural area / rural area / urban area / other** (specify) _____

HABITAT ASSESSMENT (tick ONE score per line item i.e., either 0, 5 or 10 points – then write the score in the righthand column)

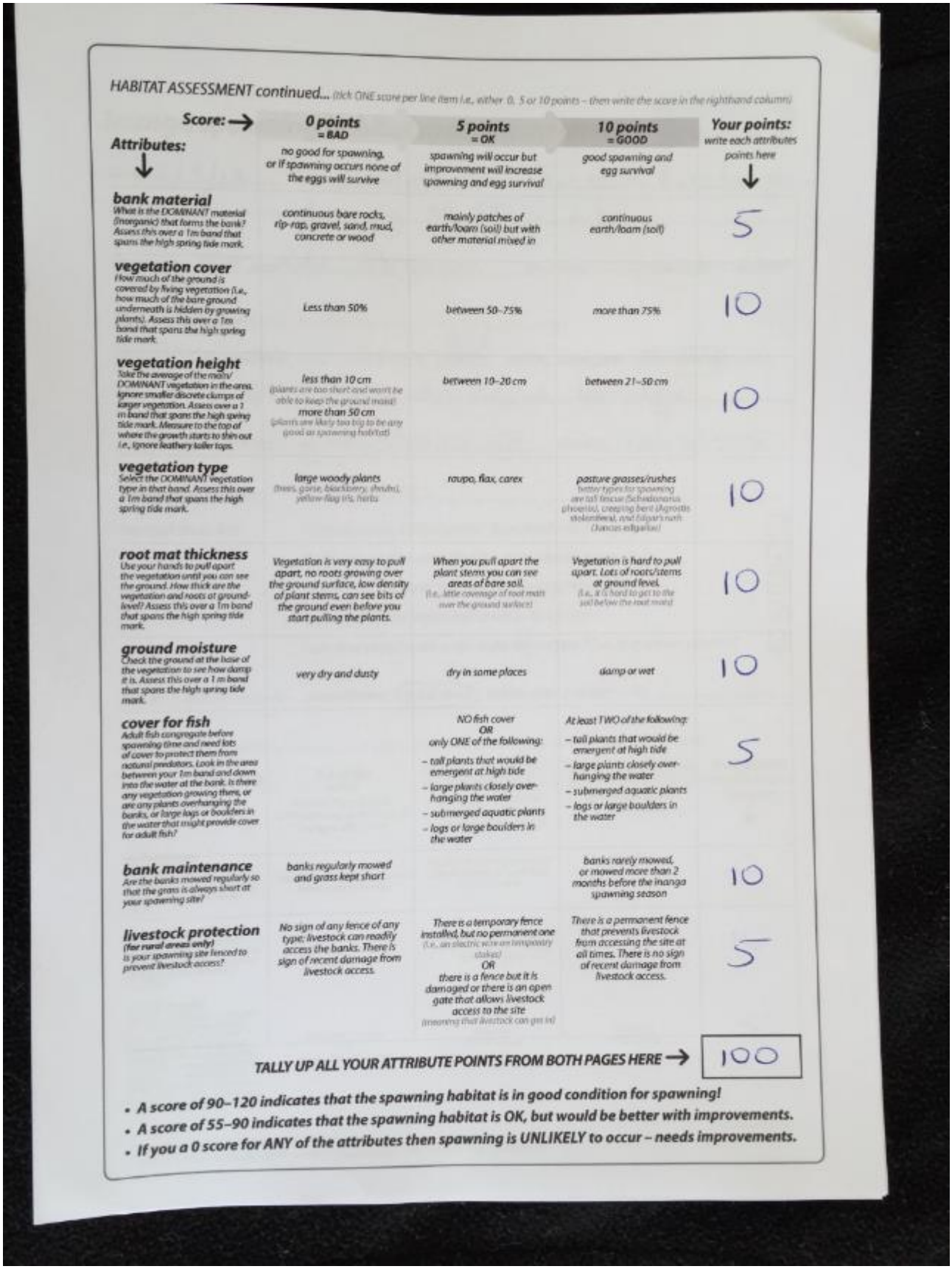
Score: → / Attributes: ↓	0 points = BAD	5 points = OK	10 points = GOOD	Your points: write each attributes points here ↓
fish access Check the river between your spawning site and the sea to find out if there is anything stopping the upstream movement of inanga.	tide gate, weir, or other significant barrier to upstream movement of inanga	small drop culvert, section of piped stream, or a partially open tide gate	no barriers	10
saltwater access Check the river between your spawning site and the sea to find out if there is anything stopping the upstream movement of saltwater.	tide gate, weir, or other significant barrier to saltwater	small drop culvert, section of piped stream, or a partially open tide gate	no barriers	10
bank angle Take the average bank angle over a 1 m band that spans the high spring tide mark. Lay a metre long ruler/pole over the ground (lying perpendicular to the water's edge) and measure your angle off that. Pick a location within your spawning site that is representative or take several measurements and then take an average of those.	less than 7° angle OR more than 35° angle	between 21–35° angle	between 7–20° angle	5

...continued over page...

[1] The left and right when looking downstream.

[2] See the 'Inanga/whitebait – Finding natural spawning sites' info sheet for more information.

Miranda Stream North Reach Page 2

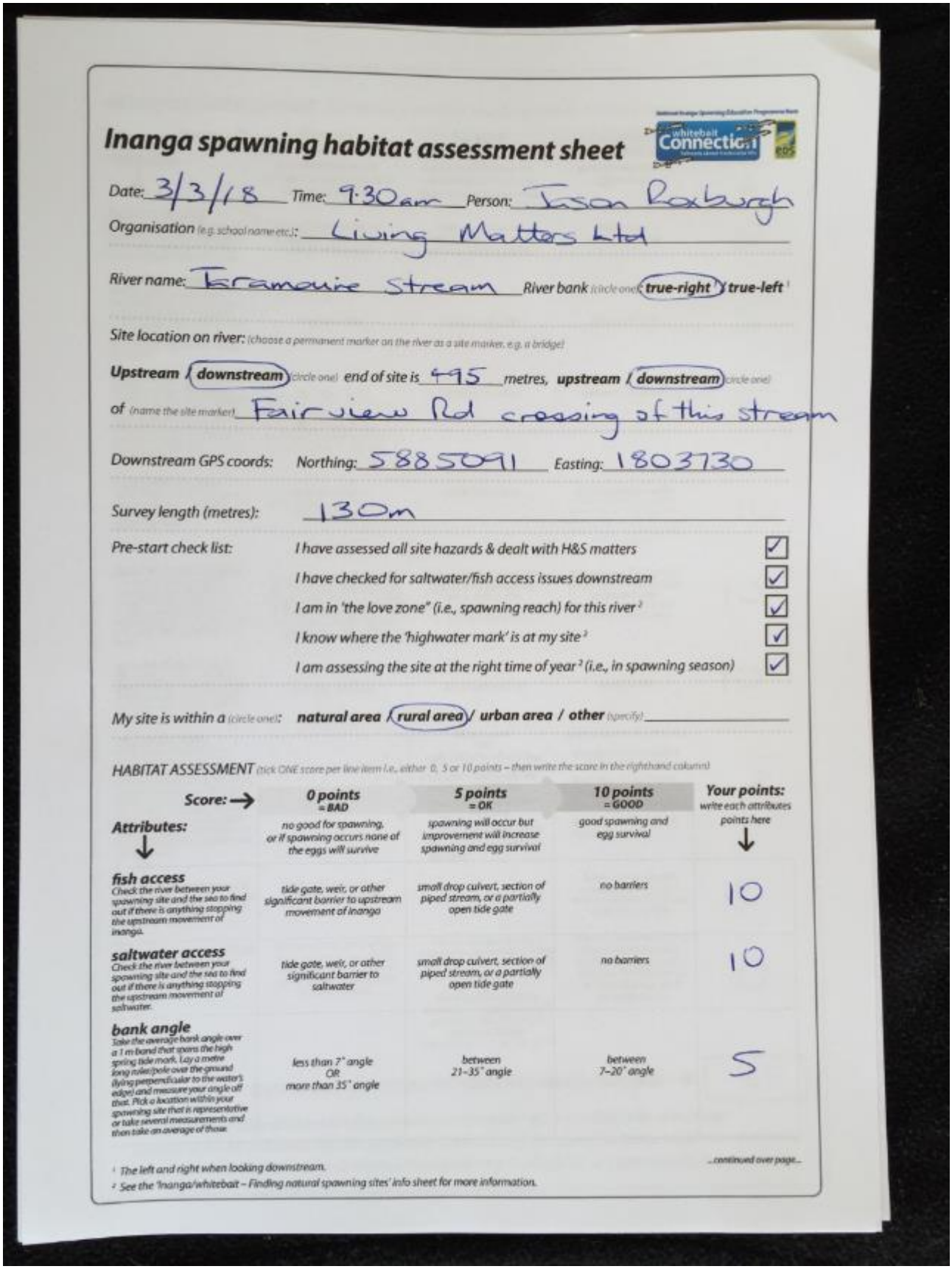


HABITAT ASSESSMENT continued... (tick ONE score per line item i.e., either 0, 5 or 10 points – then write the score in the righthand column)

Attributes:	0 points = BAD	5 points = OK	10 points = GOOD	Your points: write each attributes points here
bank material What is the DOMINANT material (inorganic) that forms the bank? Assess this over a 1m band that spans the high spring tide mark.	continuous bare rocks, rip-rap, gravel, sand, mud, concrete or wood	mainly patches of earth/loam (soil) but with other material mixed in	continuous earth/loam (soil)	5
vegetation cover How much of the ground is covered by living vegetation (i.e., how much of the bare ground underneath is hidden by growing plants). Assess this over a 1m band that spans the high spring tide mark.	Less than 50%	between 50–75%	more than 75%	10
vegetation height Take the average of the main/ DOMINANT vegetation in the area. Ignore smaller discrete clumps of larger vegetation. Assess over a 1 m band that spans the high spring tide mark. Measure to the top of where the growth starts to thin out i.e., ignore leathery taller tops.	less than 10 cm (plants are too short and won't be able to keep the ground moist) more than 50 cm (plants are likely too big to be any good as spawning habitat)	between 10–20 cm	between 21–50 cm	10
vegetation type Select the DOMINANT vegetation type in that band. Assess this over a 1m band that spans the high spring tide mark.	large woody plants (trees, gorse, blackberry, shrubs), yellow flag iris, herbs	raupo, flax, carex	pasture grasses/rushes (entry types for spawning are tall fescue (Schedonorus phoenix), creeping bent (Agrostis stolonifera), and Sharp's rush (Juncus edgariae)	10
root mat thickness Use your hands to pull apart the vegetation until you can see the ground. How thick are the vegetation and roots at ground-level? Assess this over a 1m band that spans the high spring tide mark.	Vegetation is very easy to pull apart, no roots growing over the ground surface, low density of plant stems, can see bits of the ground even before you start pulling the plants.	When you pull apart the plant stems you can see areas of bare soil. (i.e., little coverage of root mats over the ground surface)	Vegetation is hard to pull apart. Lots of roots/stems at ground level. (i.e., it is hard to get to the soil below the root mats)	10
ground moisture Check the ground at the base of the vegetation to see how damp it is. Assess this over a 1 m band that spans the high spring tide mark.	very dry and dusty	dry in some places	damp or wet	10
cover for fish Adult fish congregate before spawning time and need lots of cover to protect them from natural predators. Look in the area between your 1m band and down into the water at the bank. Is there any vegetation growing there, or are any plants overhanging the banks, or large logs or boulders in the water that might provide cover for adult fish?		NO fish cover OR only ONE of the following: – tall plants that would be emergent at high tide – large plants closely over-hanging the water – submerged aquatic plants – logs or large boulders in the water	At least TWO of the following: – tall plants that would be emergent at high tide – large plants closely over-hanging the water – submerged aquatic plants – logs or large boulders in the water	5
bank maintenance Are the banks mowed regularly so that the grass is always short at your spawning site?	banks regularly mowed and grass kept short		banks rarely mowed, or mowed more than 2 months before the inanga spawning season	10
livestock protection (for rural areas only) Is your spawning site fenced to prevent livestock access?	No sign of any fence of any type; livestock can readily access the banks. There is sign of recent damage from livestock access.	There is a temporary fence installed, but no permanent one (i.e., an electric wire on temporary stakes) OR there is a fence but it is damaged or there is an open gate that allows livestock access to the site (meaning that livestock can get in)	There is a permanent fence that prevents livestock from accessing the site at all times. There is no sign of recent damage from livestock access.	5
			TALLY UP ALL YOUR ATTRIBUTE POINTS FROM BOTH PAGES HERE →	100

- **A score of 90–120 indicates that the spawning habitat is in good condition for spawning!**
- **A score of 55–90 indicates that the spawning habitat is OK, but would be better with improvements.**
- **If you a 0 score for ANY of the attributes then spawning is UNLIKELY to occur – needs improvements.**

Taramaire Stream Page 1



Inanga spawning habitat assessment sheet

Date: 3/3/18 Time: 9.30am Person: Jason Roxburgh

Organisation (e.g. school name etc.): Living Matters Ltd

River name: Taramaire Stream River bank (circle one) **true-right** / **true-left** [1]

Site location on river: (choose a permanent marker on the river as a site marker, e.g. a bridge)

Upstream / **downstream** (circle one) end of site is 495 metres, **upstream** / **downstream** (circle one)

of (name the site marker) Fairview Rd crossing of this stream

Downstream GPS coords: Northing: 5885091 Easting: 1803730

Survey length (metres): 130m

Pre-start check list:

- I have assessed all site hazards & dealt with H&S matters ☑
- I have checked for saltwater/fish access issues downstream ☑
- I am in 'the love zone" (i.e., spawning reach) for this river [2] ☑
- I know where the 'highwater mark' is at my site [2] ☑
- I am assessing the site at the right time of year [2] (i.e., in spawning season) ☑

My site is within a (circle one): **natural area** / **rural area** / **urban area** / **other** (specify): _____

HABITAT ASSESSMENT (tick ONE score per line item i.e., either 0, 5 or 10 points – then write the score in the righthand column)

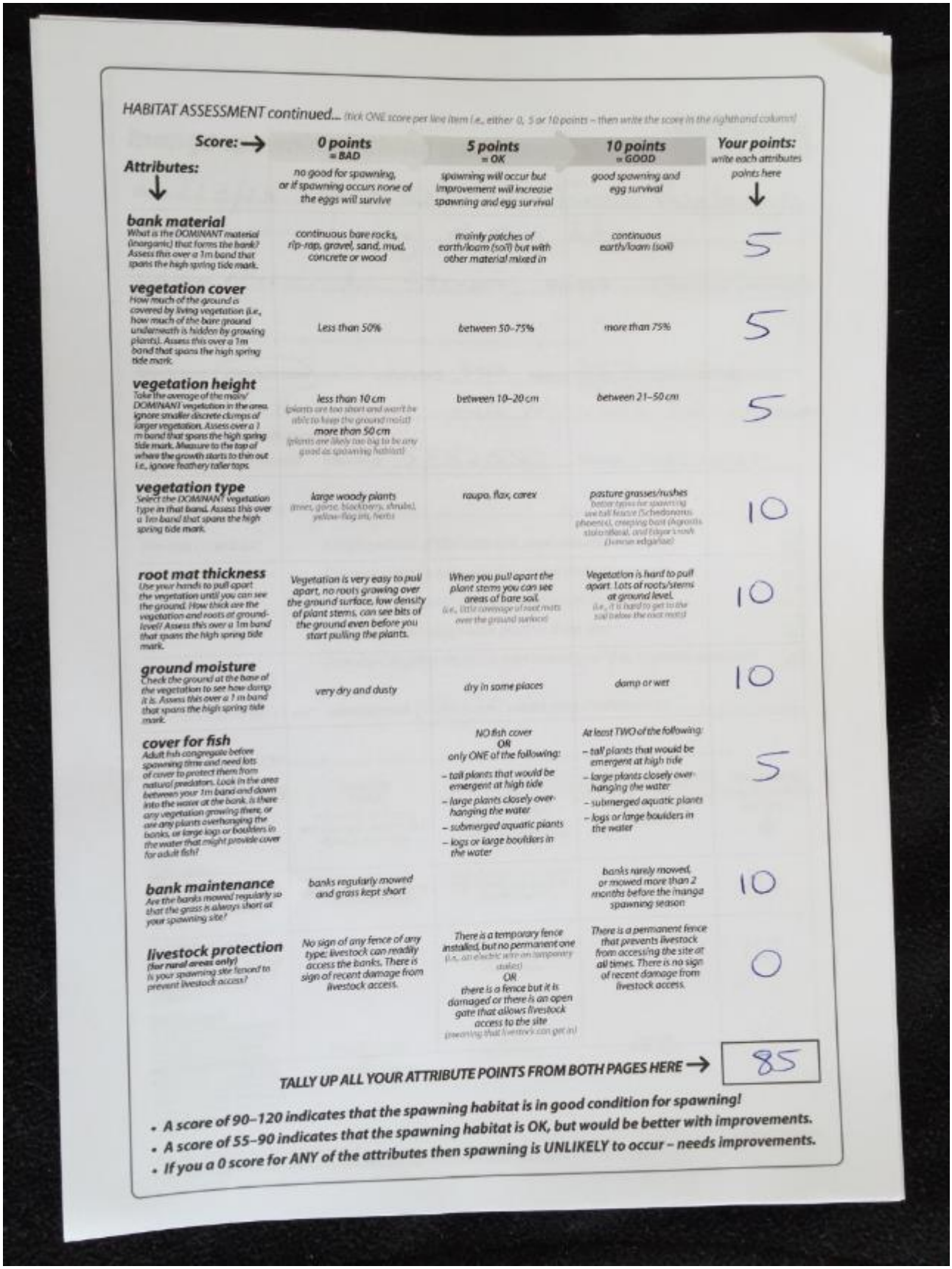
Attributes: ↓ / Score: →	0 points = BAD	5 points = OK	10 points = GOOD	Your points: write each attributes points here ↓
fish access Check the river between your spawning site and the sea to find out if there is anything stopping the upstream movement of inanga.	tide gate, weir, or other significant barrier to upstream movement of inanga	small drop culvert, section of piped stream, or a partially open tide gate	no barriers	10
saltwater access Check the river between your spawning site and the sea to find out if there is anything stopping the upstream movement of saltwater.	tide gate, weir, or other significant barrier to saltwater	small drop culvert, section of piped stream, or a partially open tide gate	no barriers	10
bank angle Take the average bank angle over a 1 m band that spans the high spring tide mark. Lay a metre long rule/pole over the ground (lying perpendicular to the water's edge) and measure your angle off that. Pick a location within your spawning site that is representative or take several measurements and then take an average of those.	less than 7° angle OR more than 35° angle	between 21–35° angle	between 7–20° angle	5

...continued over page...

[1] The left and right when looking downstream.

[2] See the 'Inanga/whitebait – Finding natural spawning sites' info sheet for more information.

Taramaire Stream Page 2



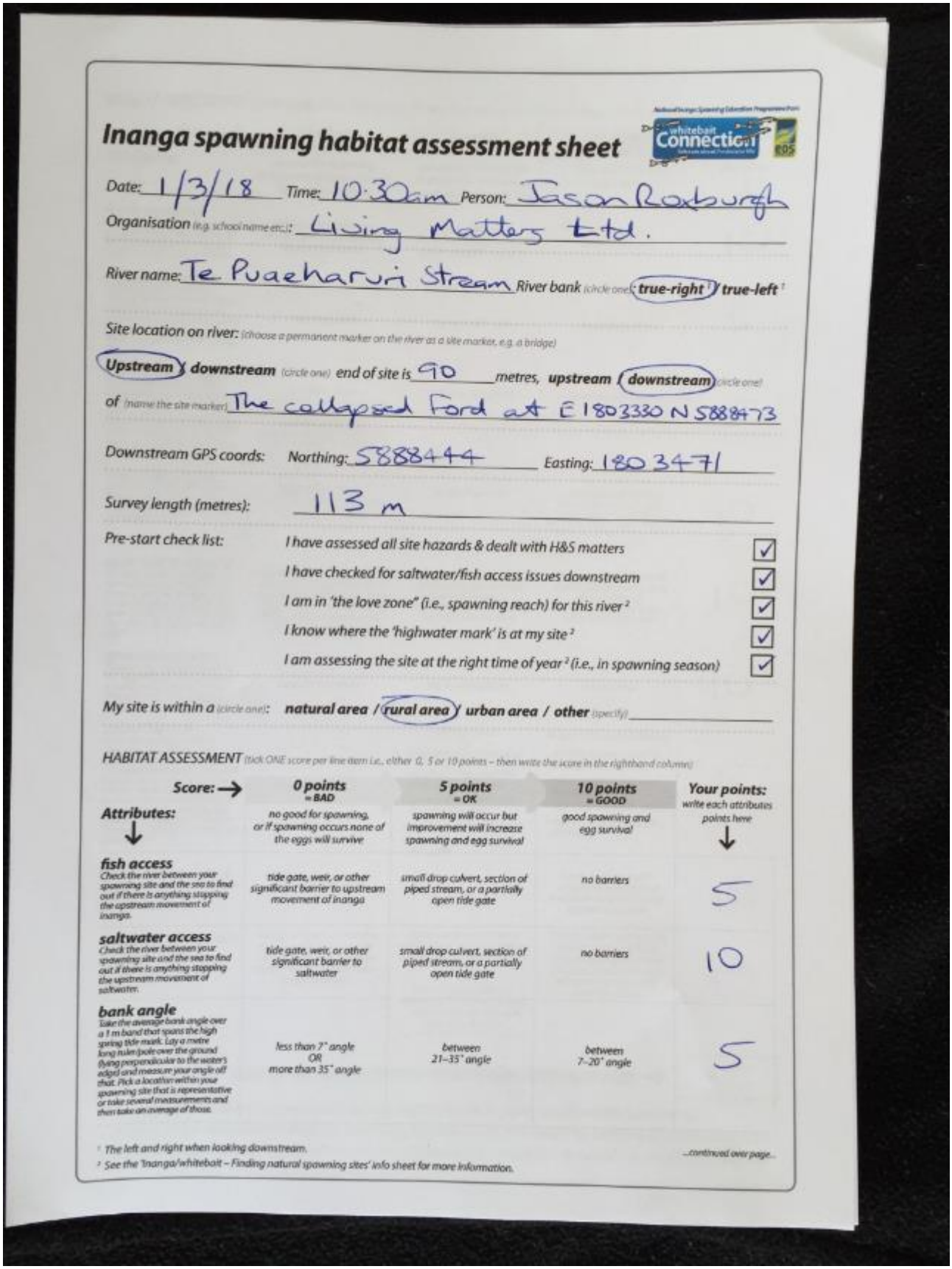
HABITAT ASSESSMENT continued... *(tick ONE score per line item i.e., either 0, 5 or 10 points – then write the score in the right-hand column)*

Attributes: ↓ / Score: →	0 points = BAD	5 points = OK	10 points = GOOD	Your points: write each attributes points here ↓
bank material *What is the DOMINANT material (inorganic) that forms the bank? Assess this over a 1m band that spans the high spring tide mark.*	no good for spawning, or if spawning occurs none of the eggs will survive	spawning will occur but improvement will increase spawning and egg survival	good spawning and egg survival	5
	continuous bare rocks, rip-rap, gravel, sand, mud, concrete or wood	mainly patches of earth/loam (soil) but with other material mixed in	continuous earth/loam (soil)	
vegetation cover *How much of the ground is covered by living vegetation (i.e., how much of the bare ground underneath is hidden by growing plants). Assess this over a 1m band that spans the high spring tide mark.*	Less than 50%	between 50–75%	more than 75%	5
vegetation height *Take the average of the main/ DOMINANT vegetation in the area, ignore smaller discrete clumps of larger vegetation. Assess over a 1 m band that spans the high spring tide mark. Measure to the top of where the growth starts to thin out i.e., ignore feathery taller tops.*	less than 10 cm *(plants are too short and won't be able to keep the ground moist)* more than 50 cm *(plants are likely too big to be any good as spawning habitat)*	between 10–20 cm	between 21–50 cm	5
vegetation type *Select the DOMINANT vegetation type in that band. Assess this over a 1m band that spans the high spring tide mark.*	large woody plants *(trees, gorse, blackberry, shrubs), yellow-flag iris, herbs*	raupo, flax, carex	pasture grasses/rushes *(better types for spawning are tall fescue (Schedonorus phoenix), creeping bent (Agrostis stolonifera), and Edgar's rush (Juncus edgariae))*	10
root mat thickness *Use your hands to pull apart the vegetation until you can see the ground. How thick are the vegetation and roots at ground-level? Assess this over a 1m band that spans the high spring tide mark.*	Vegetation is very easy to pull apart, no roots growing over the ground surface, low density of plant stems, can see bits of the ground even before you start pulling the plants.	When you pull apart the plant stems you can see areas of bare soil. *(i.e., little coverage of root mats over the ground surface)*	Vegetation is hard to pull apart. Lots of roots/stems at ground level. *(i.e., it is hard to get to the soil below the root mats)*	10
ground moisture *Check the ground at the base of the vegetation to see how damp it is. Assess this over a 1 m band that spans the high spring tide mark.*	very dry and dusty	dry in some places	damp or wet	10
cover for fish *Adult fish congregate before spawning time and need lots of cover to protect them from natural predators. Look in the area between your 1m band and down into the water at the bank. Is there any vegetation growing there, or are any plants overhanging the banks, or large logs or boulders in the water that might provide cover for adult fish?*		NO fish cover OR only ONE of the following: – tall plants that would be emergent at high tide – large plants closely over-hanging the water – submerged aquatic plants – logs or large boulders in the water	At least TWO of the following: – tall plants that would be emergent at high tide – large plants closely over-hanging the water – submerged aquatic plants – logs or large boulders in the water	5
bank maintenance *Are the banks mowed regularly so that the grass is always short at your spawning site?*	banks regularly mowed and grass kept short		banks rarely mowed, or mowed more than 2 months before the mānga spawning season	10
livestock protection *(for rural areas only) Is your spawning site fenced to prevent livestock access?*	No sign of any fence of any type; livestock can readily access the banks. There is sign of recent damage from livestock access.	There is a temporary fence installed, but no permanent one *(i.e., an electric wire on temporary stakes)* OR there is a fence but it is damaged or there is an open gate that allows livestock access to the site *(meaning that livestock can get in)*	There is a permanent fence that prevents livestock from accessing the site at all times. There is no sign of recent damage from livestock access.	0

TALLY UP ALL YOUR ATTRIBUTE POINTS FROM BOTH PAGES HERE → 85

- **A score of 90–120 indicates that the spawning habitat is in good condition for spawning!**
- **A score of 55–90 indicates that the spawning habitat is OK, but would be better with improvements.**
- **If you a 0 score for ANY of the attributes then spawning is UNLIKELY to occur – needs improvements.**

Te Puaeharuri Stream Page 1



Inanga spawning habitat assessment sheet

Date: 1/3/18 Time: 10:30am Person: Jason Roxburgh

Organisation (e.g. school name etc.): Living Matters Ltd.

River name: Te Puaeharuri Stream River bank (circle one): **true-right**[1] / **true-left**[1]

Site location on river: (choose a permanent marker on the river as a site marker, e.g. a bridge)

Upstream / **downstream** (circle one) end of site is 90 metres, **upstream** / **downstream** (circle one)

of (name the site marker) The collapsed Ford at E1803330 N5888473

Downstream GPS coords: Northing: 5888444 Easting: 1803471

Survey length (metres): 113 m

Pre-start check list:

I have assessed all site hazards & dealt with H&S matters	☑
I have checked for saltwater/fish access issues downstream	☑
I am in 'the love zone" (i.e., spawning reach) for this river[2]	☑
I know where the 'highwater mark' is at my site[2]	☑
I am assessing the site at the right time of year[2] (i.e., in spawning season)	☑

My site is within a (circle one): **natural area** / **rural area** / **urban area** / **other** (specify) _____

HABITAT ASSESSMENT (tick ONE score per line item i.e., either 0, 5 or 10 points – then write the score in the right-hand column)

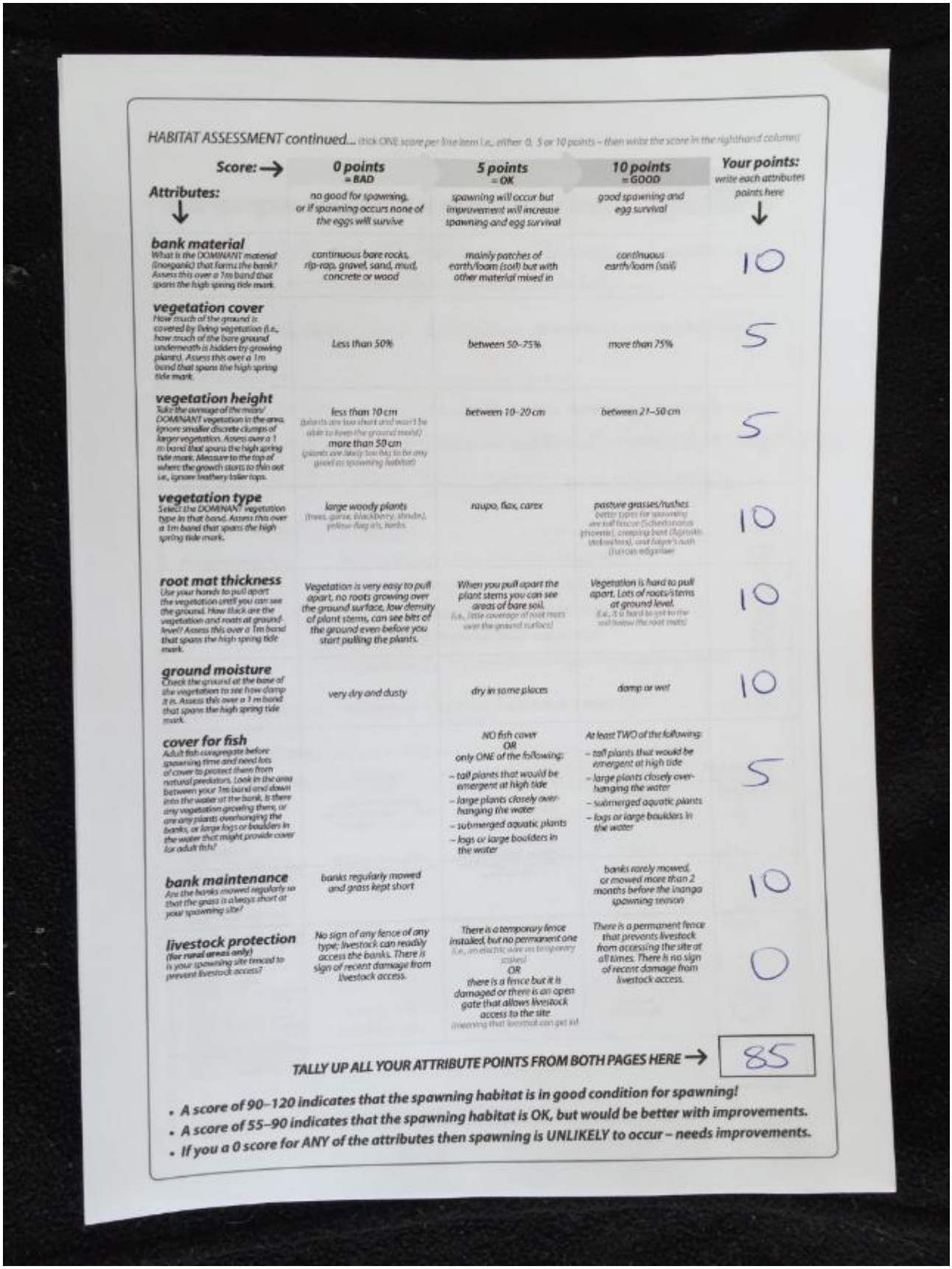
Attributes: ↓ / Score: →	0 points = BAD	5 points = OK	10 points = GOOD	Your points: write each attributes points here ↓
fish access Check the river between your spawning site and the sea to find out if there is anything stopping the upstream movement of inanga.	tide gate, weir, or other significant barrier to upstream movement of inanga	small drop culvert, section of piped stream, or a partially open tide gate	no barriers	5
saltwater access Check the river between your spawning site and the sea to find out if there is anything stopping the upstream movement of saltwater.	tide gate, weir, or other significant barrier to saltwater	small drop culvert, section of piped stream, or a partially open tide gate	no barriers	10
bank angle Take the average bank angle over a 1 m band that spans the high spring tide mark. Lay a metre long ruler/pole over the ground flying perpendicular to the water's edge) and measure your angle off that. Pick a location within your spawning site that is representative or take several measurements and then take an average of those.	less than 7° angle OR more than 35° angle	between 21–35° angle	between 7–20° angle	5

[1] The left and right when looking downstream.

[2] See the 'Inanga/whitebait – Finding natural spawning sites' info sheet for more information.

...continued over page...

Te Puaeharuri Stream Page 2



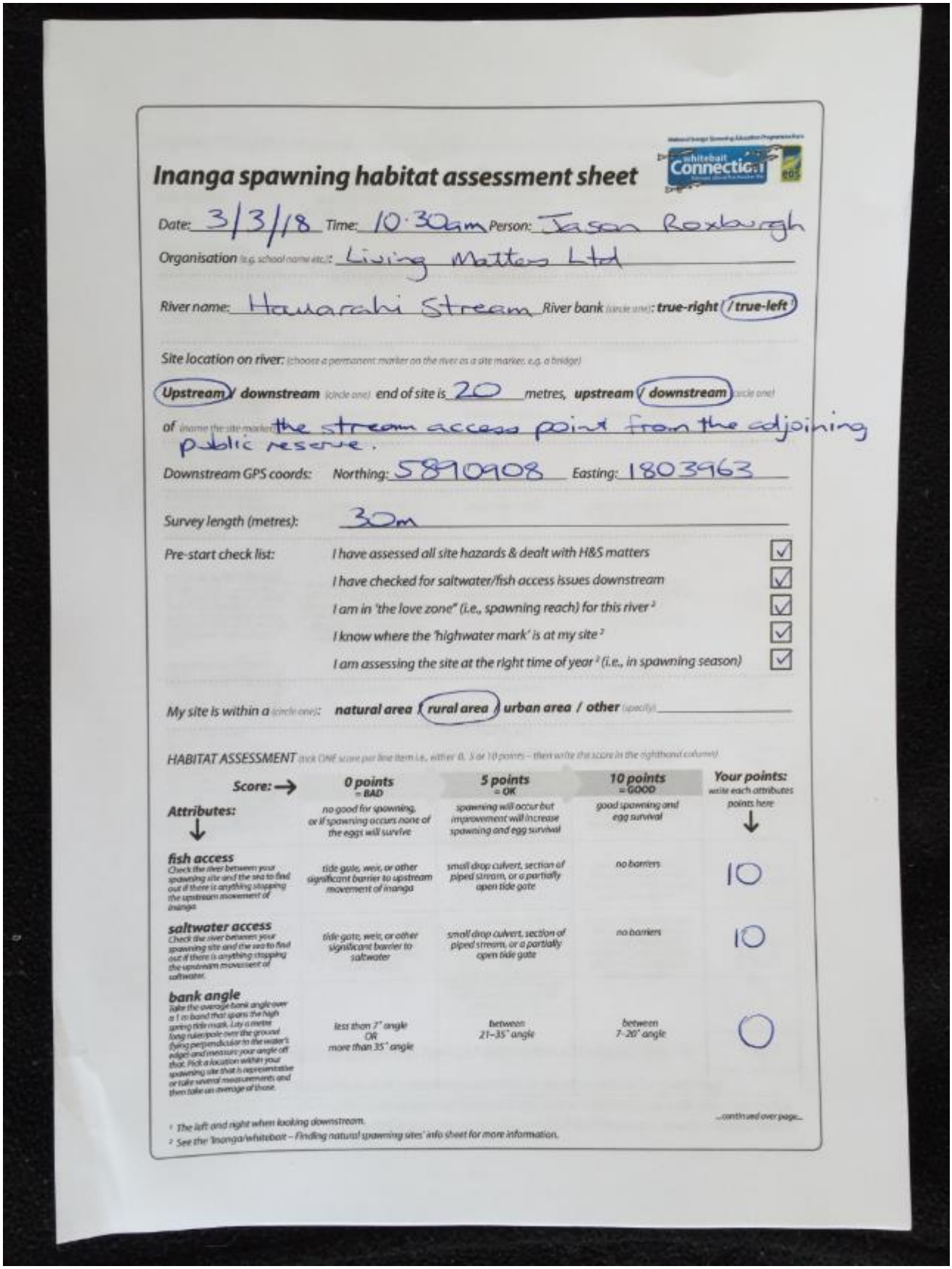
HABITAT ASSESSMENT continued... (tick ONE score per line item i.e., either 0, 5 or 10 points – then write the score in the right-hand column)

Attributes: ↓ / Score: →	0 points = BAD	5 points = OK	10 points = GOOD	Your points: write each attributes points here ↓
	no good for spawning, or if spawning occurs none of the eggs will survive	spawning will occur but improvement will increase spawning and egg survival	good spawning and egg survival	
bank material What is the DOMINANT material (inorganic) that forms the bank? Assess this over a 1m band that spans the high spring tide mark.	continuous bare rocks, rip-rap, gravel, sand, mud, concrete or wood	mainly patches of earth/loam (soil) but with other material mixed in	continuous earth/loam (soil)	10
vegetation cover How much of the ground is covered by living vegetation (i.e., how much of the bare ground underneath is hidden by growing plants). Assess this over a 1m band that spans the high spring tide mark.	Less than 50%	between 50–75%	more than 75%	5
vegetation height Take the average of the main/ DOMINANT vegetation in the area, ignore smaller discrete clumps of larger vegetation. Assess over a 1 m band that spans the high spring tide mark. Measure to the top of where the growth starts to thin out i.e., ignore feathery taller tops.	less than 10 cm (plants are too short and won't be able to keep the ground moist) / more than 50 cm (plants are likely too big to be any good as spawning habitat)	between 10–20 cm	between 21–50 cm	5
vegetation type Select the DOMINANT vegetation type in that band. Assess this over a 1m band that spans the high spring tide mark.	large woody plants (trees, gorse, blackberry, shrubs), yellow-flag iris, herbs	raupo, flax, carex	pasture grasses/rushes (better types for spawning are tall fescue (Schedonorus phoenix), creeping bent (Agrostis stolonifera), oval sedge (Carex ovalis), Baumea rubiginosa)	10
root mat thickness Use your hands to pull apart the vegetation until you can see the ground. How thick are the vegetation and roots at ground-level? Assess this over a 1m band that spans the high spring tide mark.	Vegetation is very easy to pull apart, no roots growing over the ground surface, low density of plant stems, can see bits of the ground even before you start pulling the plants.	When you pull apart the plant stems you can see areas of bare soil. (i.e., little coverage of root mats over the ground surface)	Vegetation is hard to pull apart. Lots of roots/stems at ground level. (i.e., it is hard to get to the soil below the root mats)	10
ground moisture Check the ground at the base of the vegetation to see how damp it is. Assess this over a 1 m band that spans the high spring tide mark.	very dry and dusty	dry in some places	damp or wet	10
cover for fish Adult fish congregate before spawning time and need lots of cover to protect them from natural predators. Look in the area between your 1m band and down into the water at the bank. Is there any vegetation growing there, or are any plants overhanging the banks, or large logs or boulders in the water that might provide cover for adult fish?		NO fish cover OR only ONE of the following: – tall plants that would be emergent at high tide – large plants closely over-hanging the water – submerged aquatic plants – logs or large boulders in the water	At least TWO of the following: – tall plants that would be emergent at high tide – large plants closely over-hanging the water – submerged aquatic plants – logs or large boulders in the water	5
bank maintenance Are the banks mowed regularly so that the grass is always short at your spawning site?	banks regularly mowed and grass kept short		banks rarely mowed, or mowed more than 2 months before the inanga spawning season	10
livestock protection (for rural areas only) Is your spawning site fenced to prevent livestock access?	No sign of any fence of any type; livestock can readily access the banks. There is sign of recent damage from livestock access.	There is a temporary fence installed, but no permanent one (i.e., an electric wire on temporary stakes) OR there is a fence but it is damaged or there is an open gate that allows livestock access to the site (meaning that livestock can get in)	There is a permanent fence that prevents livestock from accessing the site at all times. There is no sign of recent damage from livestock access.	0

TALLY UP ALL YOUR ATTRIBUTE POINTS FROM BOTH PAGES HERE → 85

- A score of 90–120 indicates that the spawning habitat is in good condition for spawning!
- A score of 55–90 indicates that the spawning habitat is OK, but would be better with improvements.
- If you a 0 score for ANY of the attributes then spawning is UNLIKELY to occur – needs improvements.

Hauarahi Stream Page 1



Inanga spawning habitat assessment sheet

Date: 3/3/18 Time: 10·30am Person: Jason Roxburgh

Organisation (e.g. school name etc.): Living Matters Ltd

River name: Hauarahi Stream River bank (circle one): **true-right** / **true-left**

Site location on river: (choose a permanent marker on the river as a site marker, e.g. a bridge)

Upstream / **downstream** (circle one) end of site is 20 metres, **upstream** / **downstream** (circle one)

of (name the site marker) the stream access point from the adjoining public reserve.

Downstream GPS coords: Northing: 5890908 Easting: 1803963

Survey length (metres): 30m

Pre-start check list:

- I have assessed all site hazards & dealt with H&S matters ☑
- I have checked for saltwater/fish access issues downstream ☑
- I am in 'the love zone" (i.e., spawning reach) for this river [2] ☑
- I know where the 'highwater mark' is at my site [2] ☑
- I am assessing the site at the right time of year [2] (i.e., in spawning season) ☑

My site is within a (circle one): **natural area** / **rural area** / **urban area** / **other** (specify) _____

HABITAT ASSESSMENT (tick ONE score per line item i.e., either 0, 5 or 10 points – then write the score in the right-hand column)

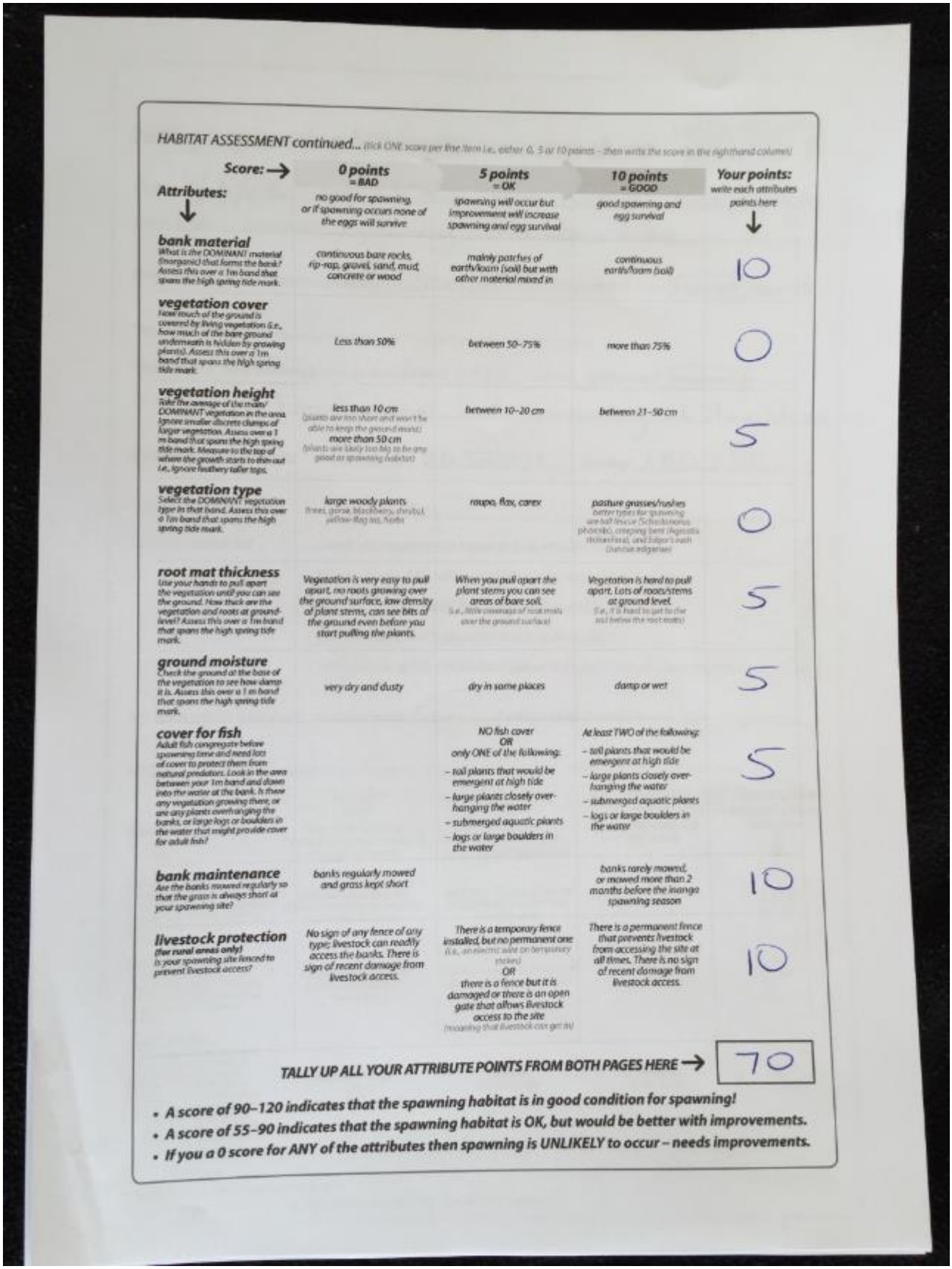
Attributes: ↓ / Score: →	0 points = BAD	5 points = OK	10 points = GOOD	Your points: write each attributes points here ↓
	no good for spawning, or if spawning occurs none of the eggs will survive	spawning will occur but improvement will increase spawning and egg survival	good spawning and egg survival	
fish access Check the river between your spawning site and the sea to find out if there is anything stopping the upstream movement of inanga	tide gate, weir, or other significant barrier to upstream movement of inanga	small drop culvert, section of piped stream, or a partially open tide gate	no barriers	10
saltwater access Check the river between your spawning site and the sea to find out if there is anything stopping the upstream movement of saltwater.	tide gate, weir, or other significant barrier to saltwater	small drop culvert, section of piped stream, or a partially open tide gate	no barriers	10
bank angle Take the average bank angle over a 1 m band that spans the high spring tide mark. Lay a metre long rule/pole over the ground (lying perpendicular to the water's edge) and measure your angle off that. Pick a location within your spawning site that is representative or take several measurements and then take an average of those.	less than 7° angle OR more than 35° angle	between 21–35° angle	between 7–20° angle	0

[1] The left and right when looking downstream.

[2] See the 'Inanga/whitebait – Finding natural spawning sites' info sheet for more information.

...continued over page...

Hauarahi Stream Page 2



HABITAT ASSESSMENT continued... (tick ONE score per line item i.e. either 0, 5 or 10 points - then write the score in the right hand column)

Attributes: ↓ / Score: →	0 points = BAD	5 points = OK	10 points = GOOD	Your points: write each attributes points here ↓
	no good for spawning, or if spawning occurs none of the eggs will survive	spawning will occur but improvement will increase spawning and egg survival	good spawning and egg survival	
bank material What is the DOMINANT material (inorganic) that forms the bank? Assess this over a 1m band that spans the high spring tide mark.	continuous bare rocks, rip-rap, gravel, sand, mud, concrete or wood	mainly patches of earth/loam (soil) but with other material mixed in	continuous earth/loam (soil)	10
vegetation cover How much of the ground is covered by living vegetation (i.e., how much of the bare ground underneath is hidden by growing plants). Assess this over a 1m band that spans the high spring tide mark.	Less than 50%	between 50–75%	more than 75%	0
vegetation height Take the average of the main/ DOMINANT vegetation in the area. Ignore smaller discrete clumps of longer vegetation. Assess over a 1 m band that spans the high spring tide mark. Measure to the top of where the growth starts to thin out i.e., ignore feathery taller tops.	less than 10 cm (plants are too short and won't be able to keep the ground moist) / more than 50 cm (plants are likely too big to be any good as spawning habitat)	between 10–20 cm	between 21–50 cm	5
vegetation type Select the DOMINANT vegetation type in that band. Assess this over a 1m band that spans the high spring tide mark.	large woody plants (trees, gorse, blackberry, shrubs), yellow-flag iris, Nassella	raupo, flax, carex	pasture grasses/rushes (better types for spawning are tall fescue (Schedonorus phoenix), creeping bent (Agrostis stolonifera), and Esker's rush (Juncus edgariae))	0
root mat thickness Use your hands to pull apart the vegetation until you can see the ground. How thick are the vegetation and roots at ground-level? Assess this over a 1m band that spans the high spring tide mark.	Vegetation is very easy to pull apart, no roots growing over the ground surface, low density of plant stems, can see bits of the ground even before you start pulling the plants.	When you pull apart the plant stems you can see areas of bare soil. (i.e., little coverage of root mats over the ground surface)	Vegetation is hard to pull apart. Lots of roots/stems at ground level. (i.e., it is hard to get to the soil below the root mats)	5
ground moisture Check the ground at the base of the vegetation to see how damp it is. Assess this over a 1 m band that spans the high spring tide mark.	very dry and dusty	dry in some places	damp or wet	5
cover for fish Adult fish congregate before spawning time and need lots of cover to protect them from natural predators. Look in the area between your 1m band and down into the water at the bank. Is there any vegetation growing there, or are any plants overhanging the banks, or large logs or boulders in the water that might provide cover for adult fish?		NO fish cover OR only ONE of the following: – tall plants that would be emergent at high tide – large plants closely over-hanging the water – submerged aquatic plants – logs or large boulders in the water	At least TWO of the following: – tall plants that would be emergent at high tide – large plants closely over-hanging the water – submerged aquatic plants – logs or large boulders in the water	5
bank maintenance Are the banks mowed regularly so that the grass is always short at your spawning site?	banks regularly mowed and grass kept short		banks rarely mowed, or mowed more than 2 months before the inanga spawning season	10
livestock protection (for rural areas only) Is your spawning site fenced to prevent livestock access?	No sign of any fence of any type; livestock can readily access the banks. There is sign of recent damage from livestock access.	There is a temporary fence installed, but no permanent one (i.e., an electric wire on temporary stakes) OR there is a fence but it is damaged or there is an open gate that allows livestock access to the site (meaning that livestock can get in)	There is a permanent fence that prevents livestock from accessing the site at all times. There is no sign of recent damage from livestock access.	10

TALLY UP ALL YOUR ATTRIBUTE POINTS FROM BOTH PAGES HERE → 70

- **A score of 90–120 indicates that the spawning habitat is in good condition for spawning!**
- **A score of 55–90 indicates that the spawning habitat is OK, but would be better with improvements.**
- **If you a 0 score for ANY of the attributes then spawning is UNLIKELY to occur – needs improvements.**

Appendix 4: Regional Plan Permitted Activity Rule 4.2.20.2 Permitted activity rule – removal or demolition of structures

Exception
This Rule does not apply to:
Plantation forestry activities as from 1 May 2018 these activities are regulated under the National Environmental Standards for Plantation Forestry Regulations 2017 (external link).

1. The removal or demolition of any structure or part of any structure, and associated bed disturbance, in, on, under or over the bed of a river or lake, and
2. Any discharge of sediment associated with removal or demolition;

are **permitted activities** subject to the following conditions:

a. There shall be no use of explosives in the water except by a person who holds a current certificate of competence as a construction blaster, (issued by Occupational Safety and Health, under the Health and Safety Regulations 1995) that would allow demolition of a structure in, on, under or over the bed of a river or lake where the Waikato Regional Council is notified at least 10 days prior to the activity commencing and 24 hours in the case of an emergency.
b. The structure, or part thereof, being removed or demolished shall be removed from the river or lake bed, and/or any material or temporary structures required to undertake the activity shall be removed.
c. The activity shall not result in the removal of, or damage to, any lawfully established flood protection or erosion control structures, or linear bank protection structures or plantings undertaken for flood or erosion control.
d. The activity shall not reduce the ability of the channel to convey flood flows or floating debris.
e. The removal or demolition works shall comply with the suspended solids discharge standards as set out in Section 4.2.21.
f. This Rule shall not apply to any structure records on the Historic Places register (in accordance with s22 of the Historic Places Act 1993).
g. No submerged piles or parts of structures shall be left in the river or lake bed which might catch debris or obstruct navigation.
h. The Waikato Regional Council shall be notified in writing of the removal or demolition at least 10 working days prior to commencement of the activity.
i. The activity shall not disturb any archaeological site or waahi tapu as identified at the date of notification of this Plan, in any district plan, in the NZ Archaeological Association's Site Recording Scheme, or by the Historic Places Trust except where Historic Places Trust approval has been obtained.
j. In the event of any waahi tapu that is not subject to condition i) being identified by the Waikato Regional Council to the person undertaking the removal or demolition, the activity shall cease insofar as it may affect the waahi tapu. The activity shall not be recommenced without the approval of the Waikato Regional Council.
k. This rule shall not apply to activities located in, on, under or over the bed of a river or lake that is a Significant Geothermal Feature.

Advisory Notes:

- The demolition or removal of any structure, or part of any structure, in, on, under or over the bed of a river or lake that does not comply with any of the conditions in Rule 4.2.20.2 is a controlled activity in accordance with Rule 4.2.20.3.
- Where a waahi tapu site is identified whilst undertaking the activity, the process that Waikato Regional Council will follow in order to implement condition j) is set out in Section 2.3.4.22 of this Plan.
- Where a structure or activity is to be located in, on, under or over the bed of a water body that is Significant Geothermal Feature, Rules 7.6.6.1 to 7.6.6.3 shall apply. Significant Geothermal Features are defined in the Glossary, and in Development and Limited Development Geothermal Systems, identified on maps in Section 7.10 of this Plan.

Appendix 5: Presentation notes for inanga spawning community day

What Are Inanga?

- Inanga are the most common, and smallest, of the six native fish species that make up the 'whitebait catch'. They reach around 100 mm long as adults
- The other five are kōaro, giant kōkopu, banded kōkopu, and shortjaw kōkopu (all *Galaxias* species). Young common smelt are also sometimes called whitebait.
- All six spend part of their lifecycle at sea.
- When they are returning to freshwater habitats as juveniles, they are collectively known as whitebait.

Where are they found?

- They don't travel far inland, as they can't swim through swift-flowing rapids, and can't climb waterfalls.
- The other whitebait fish species can get past these obstacles, so are found much further inland.
- Inanga swim in shoals during the day, where adults of the other whitebait fish species tend to live alone, and are mostly out at night
- Although native to New Zealand, inanga are also found in Chile, Argentina, the Falklands Islands and parts of Australia.

Inanga Lifecycle

- Between February and April inanga migrate to the tidal reaches of rivers, and wait for the very high 'spring' tides that occur around full and new moons.
- On these tides they push their way into the flooded dense river bank vegetation, and spawn.
- Their eggs are around 1 mm long, and are laid near the base of plants like native and introduced grasses, herbs, rushes and harakeke/flax.
- These plants protect the eggs from changing temperatures, drying out, and UV light
- A month later the next spring tide floods the eggs, and most hatch into larvae
- The larvae are about 7 mm long, and the out-going tide carries them into estuaries and coastal waters, where they spend six months growing to around 55 mm long.
- In spring they migrate back to lowland rivers, streams, wetlands and coastal lakes, as the whitebait that most people know.
- They live there for 1-2 years, then the adult inanga begin their lifecycle again

Threats

- The main threat to inanga is disturbing or modifying their habitat. These threats affect all aspects of their life so understanding the inanga lifecycle is key to helping protect this species.
- **Barriers to fish passage:** Inanga need unrestricted access to the sea and then back to freshwater to complete their lifecycle.
- **Poor water quality:** Polluted waterways affect inanga
- **Spawning habitat disturbance:** Grazing along lowland waterway edges can disturb and destroy spawning habitat.
- **Waterway modification:** Channelisation of waterways can reduce their feeding habitat
- **Habitat modification:** Draining and modifying lowland wetland and river habitats can reduce inanga habitat
- **Invasive weeds and fish:** Invasive weeds can clog streams and rivers, and take over inanga spawning vegetation. Invasive fish species can compete with inanga for habitat and food
- **Removal of native vegetation:** When native forests are removed, rain runs off the land quicker, and can cause floods that cover spawning habitat in sediment

Why have we put these straw bales in the creek?

- In streams where the bank vegetation has been modified or removed, this method using straw bales is a great way to find where inanga spawn, and to provide temporary spawning habitat while a spawning habitat is being restored

You can help

- If you're interested in using this method to start an inanga habitat restoration project, talk to the DOC staff here today
- Protect inanga spawning habitat by planting and fencing stream edges.
- Report blockages or fish passage barriers such as dams or overhanging culverts to your local DOC or Regional Council office.
- Follow the whitebait fishing regulations.
- Keep streams free of invasive weeds and fish.
- Get involved in a community project to fence and plant local streams.
- Visit the Whitebait Connection website to find out what programmes they have regionally.