Flood hazard update for Selwyn District Plan review

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Kaunihera Taiao ki Waitaha

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Executive summary

Background: The Canterbury Regional Policy Statement (CRPS) provides a framework for managing natural hazards in Canterbury, and includes policies relating to flood hazards. District Councils are required to give effect to these policies through their District Plans. This report provides some background to the operative District Plan (as it relates to flood hazards) and discusses current flooding information held by Environment Canterbury. This report is intended to help Selwyn District Council give effect to the flood hazard policies of the CRPS.

The problem: The operative Selwyn District Plan does not give effect to the flood hazard policies of the CRPS.

What we did: This report provides an overview of the operative Selwyn District Plan provisions that relate to flooding, and some background to their development. It also outlines flooding information that has become available to Environment Canterbury since the operative District Plan was developed, provides some context around the usefulness of this information and identifies knowledge gaps.

What we found: There are areas of the Selwyn District that are known to be vulnerable to flooding, but are not addressed by the operative District Plan. New information (including LiDAR data, flood modelling, and flood photographs) has allowed the flood risk in certain areas of the district to be better quantified, but for many areas, Environment Canterbury does not have sufficient information to determine the likely extent or depth of flooding for specific magnitude flood events. Further research is required to gain a more comprehensive understanding of flood hazards across the Selwyn District.

What does it mean? This report will assist Selwyn District Council in giving effect to the flood hazard policies of the CRPS through their District Plan.

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1 Introduction

Selwyn District Council are currently reviewing their District Plan. The operative plan identifies some areas of the district as vulnerable to flooding, and controls certain activities within these areas.

Chapter 11 of the Canterbury Regional Policy Statement (CRPS) provides a framework for managing natural hazard risk in Canterbury, and contains policies that address flood avoidance and mitigation. District Councils are required to give effect to these policies through their district plans.

The District Plan review presents an opportunity to assess the appropriateness of the operative District Plan flood maps in light of the CRPS policies and currently available flooding information.

This report:

- Describes the current mapping and controls contained in the operative District Plan, and provides a brief history of its development.
- Outlines the CRPS policies that relate to flooding.
- Describes the flooding information that has become available to Environment Canterbury since the operative District Plan mapping was produced.
- Presents updated flooding information.
- Identifies knowledge gaps and areas where further investigation would be valuable.

2 Background

2.1 The Selwyn District

The Selwyn District covers an area of approximately 6,553 km^2, extending from the Main Divide to the East Coast (Figure 2-1). For the purposes of this report, the district can be loosely divided into four geographical areas: High Country, Foothills, Upper Plains and Lower Plains.

High Country – Over half of the district is comprised of sparsely populated, mountainous high country, which is predominantly conservation land or used for pastoral farming. The high country encompasses two large braided river catchments; the upper Waimakariri River catchment, and part of the Rakaia River catchment. The only township located within this area is Arthurs Pass, situated close to the Main Divide.

Foothills – A foothills area in the central part of the district comprises the catchment of the Selwyn River and its main tributaries, the Hororata, Waianiwaniwa and Hawkins Rivers. The area is primarily used for pastoral farming and exotic forestry, with the townships of Springfield, Sheffield, Glentunnel and Hororata (along with a number of smaller settlements) situated around the base of the foothills.

Upper Plains – The upper plains area of the district is bounded by the Waimakariri River to the north and the Rakaia River to the south-west. The upper plains consist of outwash gravels deposited by these two rivers, with the Selwyn River occupying the depression formed between the merged alluvial fans. The upper plains area is characterised by free-draining gravel soils and includes the townships of Darfield, Kirwee, West Melton, Rolleston, Burnham and Dunsandel.

Lower Plains – As the plains extend south-eastwards beyond State Highway 1, the soils generally start to become more poorly-draining and groundwater levels are closer to the surface. This is especially the case around the margins of Lake Ellesmere, and where the plains meet the base of the Port Hills. The Selwyn River flows through the lower plains area and into Lake Ellesmere, along with the Halswell and LII rivers, and several other lowland streams. Townships in the lower plains area of the district include Tai Tapu, Prebbleton, Lincoln, Springston, Doyleston, Leeston and Southbridge, along with numerous smaller settlements.

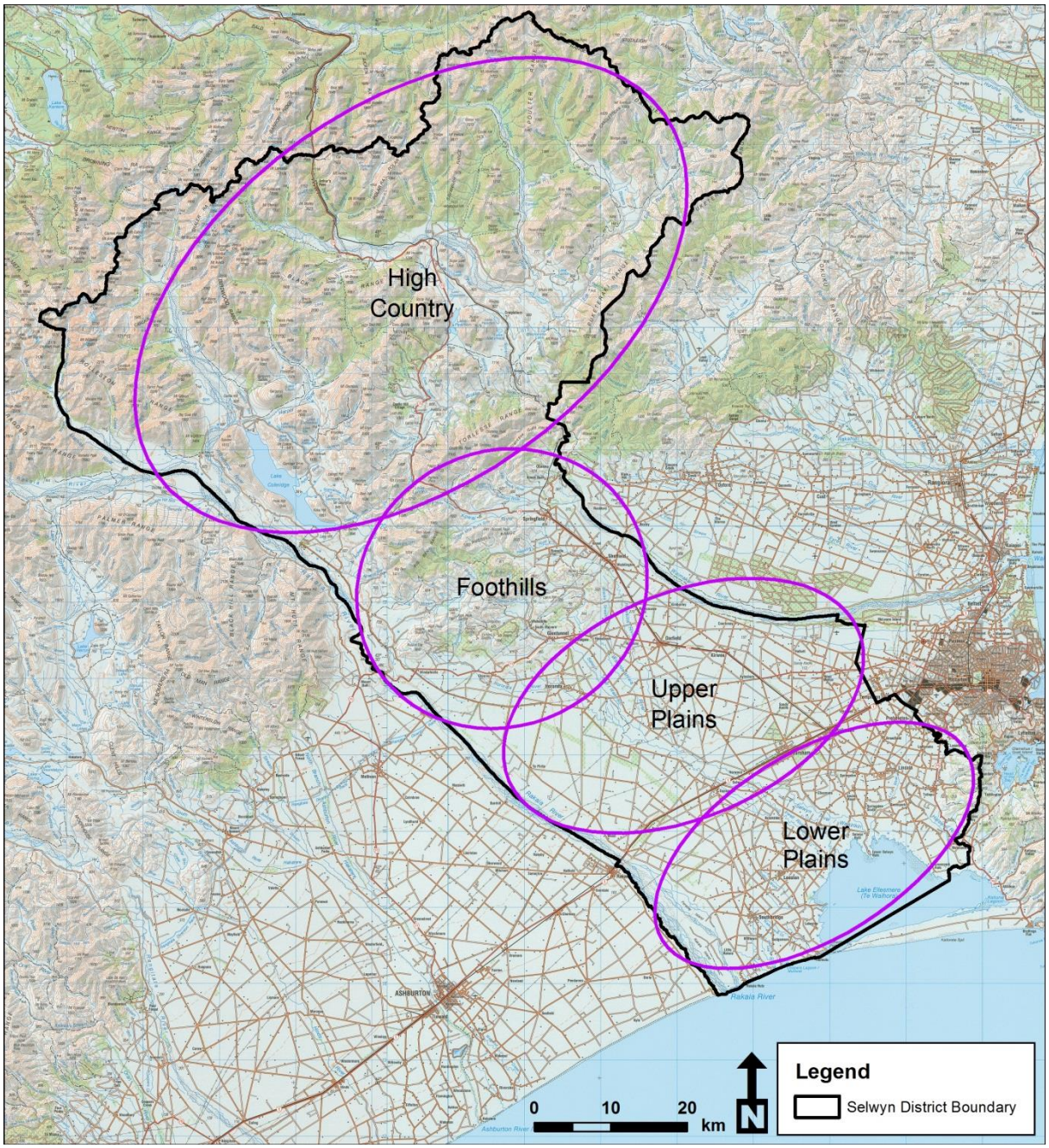


Figure 2-1: The Selwyn District divided into four geographical areas

2.2 The Operative Selwyn District Plan

The current operative Selwyn District Plan was notified as a proposed plan in two volumes; a rural volume in the year 2000 and a township volume in 2001. The proposed plan included mapped flood areas with associated rules to control certain activities within them. The maps attempted to delineate areas of the district where flooding had previously been observed and documented.

The mapping adjacent to the Waimakariri River was an exception, as this was derived from predictive flood extent mapping contained in the report 'Draft Waimakariri River Floodplain Management Plan' (Canterbury Regional Council 1991).

Following a submission and hearing process, alternative and additional flood mapping was incorporated into what is now the operative Selwyn District Plan. The operative plan includes three separate flood areas on the planning maps (Figure 2-2), with rules that control certain activities within each area.

The areas are:

- Lower Plains Flood Area
- Lake Ellesmere/Te Waihora Flood Area
- Waimakariri Flood Plain

The plan also includes rules relating to flood mitigation/avoidance in Tai Tapu township and parts of Rakaia Huts township; however these are not specifically identified as flood areas on the planning maps. Specific background information for each area is provided below.

Figure 2-2: Operative Selwyn District Plan flood areas

2.2.1 Lower Plains Flood Area

The proposed plan contained mapping of a 'Tai Tapu Flood/Ponding Area' and a 'Lower Selwyn/Ellesmere Flood Area'.

The 'Tai Tapu Flood/Ponding Area' is understood to have been compiled by Selwyn District Council using aerial flood photographs provided by Environment Canterbury. The maps attempted to define precise areas that were shown by the photographs to have been affected by flooding during these events. The mapping was limited to flooding within the Halswell River catchment.

The 'Lower Selwyn/Ellesmere Flood Area' is also understood to have been compiled by Selwyn District Council using aerial flood photographs provided by Environment Canterbury, as well as maps documenting the extent of flooding observed during an event in 1951. While it was still based on historically observed flooding, this mapping was more generalised than the 'Tai Tapu Flood/Ponding Area' mapping, and did not attempt to distinguish between the presence/absence of flooding at such a fine scale.

Through the submission process, alternative mapping was proposed by Environment Canterbury. For the Halswell River catchment (and parts of the LII River catchment) the mapping aimed to more broadly identify areas where there was a known flood risk, with some allowance for larger flood events than documented in the photographs. For the 'Lower Selwyn/Ellesmere Flood Area', this was based on the Selwyn River Rating District rating classification maps, which identify land deriving benefit from Selwyn River control works. The rating classification maps were modified slightly to reflect flooding observed in August 2000 (a recent event at the time) and were not dissimilar to those originally notified in the proposed plan.

The amended 'Lower Plains Water Ponding Area' and 'Lower Selwyn/Ellesmere Flood Area' maps provided by Environment Canterbury through the submission process now form the 'Lower Plains Flood Area' in the operative plan. The Lower Plains Flood Area also includes a small area around State Highway 1 adjacent to the Rakaia River. It is assumed that this area was mapped by Selwyn District Council using flood photographs taken in 1994 and included in the proposed plan, as it is not discussed in submissions made by Environment Canterbury.

2.2.2 Lake Ellesmere/Te Waihora Flood Area

The flood risk from Lake Ellesmere was not specifically addressed with mapping in the proposed plan, except where the 'Lower Selwyn/Ellesmere Flood Area' representing the Selwyn River floodplain extended to the lake margins. Through the submission process, Environment Canterbury sought to ensure that new dwellings constructed around the lake have floor levels of at least 3.0 metres above mean sea level. This was consistent with what Environment Canterbury (and previously the North Canterbury Catchment Board) had previously advocated for, and was based on mitigation against a high lake level with an allowance for wind effects.

The 2.74 metre (9 ft.) contour line (surveyed in 1958) was proposed as a suitable means of defining areas vulnerable to flooding from the lake, and this forms the boundary of the 'Lake Ellesmere/Te Waihora Flood Area' in the operative plan.

2.2.3 Waimakariri Floodplain

The proposed plan included mapping of the part of the Waimakariri floodplain that falls within the Selwyn District boundary. This was based on predictive flood extent mapping contained in the report 'Draft Waimakariri River Floodplain Management Plan' (Canterbury Regional Council, 1991).

2.2.4 Tai Tapu township

The operative plan includes minimum floor level requirements for certain buildings constructed within the Living 1A or 2A zones at Tai Tapu. The required floor level is based on flood model results contained in the report 'Further stormwater modelling for the Tai Tapu Township' (Connell Wagner - March 2003) that was commissioned by Selwyn District Council and Environment Canterbury. There appears to have been some debate around the most suitable standard of flood mitigation through the proposed plan submission process, but the level that was ultimately adopted is understood to have been acceptable to both parties.

2.2.5 Rakaia Huts township

The operative plan also controls the construction of certain buildings on land below the main river terrace at Rakaia Huts. The rule that controls building in this area was added to the district plan in response to a submission made by the Selwyn District Council acknowledging the flood risk in this area.

3 Planning context

Chapter 11 of the Canterbury Regional Policy Statement (CRPS) provides a framework for managing natural hazards in Canterbury, and sets out the responsibilities of the local authorities in the region for the control of land-use to avoid or mitigate natural hazards.

The CRPS includes two specific policies relating to flood hazard management. District Councils are required to give effect to these policies through district plans.

- Policy 11.3.1 – Avoidance of inappropriate development in high hazard areas
- Policy 11.3.2 – Avoid development in areas subject to inundation.

The 'high hazard' flood areas referred to in Policy 11.3.1 are defined as areas 'where the water depth (metres) x velocity (metres per second) is greater than or equal to 1, or where depths are greater than 1 metre in a 0.2% AEP flood event'.

A 0.2% AEP (Annual Exceedance Probability) flood event is equivalent to a 500 year ARI (Average Recurrence Interval) flood event. This is a flood event that has a 0.2% chance of occurring in any given year, or once every 500 years on average.

'Areas subject to inundation' referred to in Policy 11.3.2. are defined as areas that are not 'high hazard', but are subject to inundation by a 0.5% AEP (200 year ARI) flood event.

The CRPS requires Environment Canterbury to provide information that it holds on historical and design flood events to define high hazard areas and to assist territorial authorities in determining areas subject to inundation. This report aims to fulfil these obligations.

4 New flooding information

Since the early 2000s when the current operative Selwyn District Plan was notified as proposed, Environment Canterbury has obtained or generated additional information that will aid in assessing and quantifying flood hazard in the district.

LiDAR (Light Detection and Ranging) surveys were undertaken across varying parts of the Selwyn District in 2003, 2008, 2010, 2011, 2015 and 2016, and coverage now includes the majority of the upper and lower plains areas. LiDAR data is acquired using a laser scanner mounted on an aircraft which measures the ground level at approximately one point every square metre. This point data is used to generate very accurate and high resolution digital elevation maps which enable subtle topographic features to be identified.

The LiDAR data has enabled Environment Canterbury to model flooding in the Halswell River catchment, and on the Selwyn River floodplain. This work is documented in the reports 'Halswell River/Huritini floodplain investigation' (Environment Canterbury, 2013) and 'Draft Selwyn River floodplain investigation' (Environment Canterbury, 2017).

Also relevant to the district plan review is the draft report 'Waimakariri River floodplain management strategy – Flood hazard risk assessment' (Environment Canterbury, 2017) which assesses the likelihood of breakouts from the Waimakariri River primary stopbanking system for a range of river flows.

Notable flood events documented by Environment Canterbury since the early 2000s are limited to the following:

- A rainfall event in June 2013 caused substantial flooding in the lower plains area of the district (particularly in the Halswell and LII River catchments), and Lake Ellesmere reached its highest level since 1945. A large number of photographs were taken to document this event.
- Flooding was documented by a local resident at Rakaia Huts in September 2013, when water backed up into the township from the hāpua. This represents the most severe flooding of this type that Environment Canterbury is aware of.
- Several high flow events have occurred in the Rakaia River since the early 2000s, with overflows affecting an area around State Highway 1 in 2008. None of these events caused out of river flooding in the Selwyn District that was more severe than that previously documented.
- A rainfall event in July 2017 caused a large flood in the Selwyn River and its tributaries, with breakouts onto the floodplain in several locations. Photographs were taken to document the extent of flooding.

As well as the additional documented events, Environment Canterbury now has a longer record of river flow, rainfall and lake level data at its disposal, which generally improves the accuracy of flood frequency analysis.

5 Revised flood mapping

5.1 Surface flooding

In the context of this report, surface flooding means flooding resulting from direct rainfall runoff (pluvial flooding), rather than from major river or stream overflows (fluvial flooding). An example of surface flooding is shown in Figure 5-1.

Figure 5-1: Surface flooding between Doyleston and Leeston (24 August 1986)

Surface flooding occurs when the rate of rainfall exceeds the rate at which water can infiltrate the soil, or when the soil becomes saturated, and excess water runs off. The amount of surface flooding that occurs on a given part of the plains will therefore be influenced by the soil drainage properties and antecedent soil moisture conditions. In urban areas, impermeable surfaces further reduce the ability of water to infiltrate the soil. As noted in Section 2.1, the upper plains area of the district is generally characterised by free-draining soils which become more poorly-draining with proximity to Lake Ellesmere and the Port Hills. Figure 5-2 shows that poorly drained soils are generally confined to the lower plains area of the district, with the exception of some upper plains/foothills areas around Hororata, Glentunnel and Sheffield.

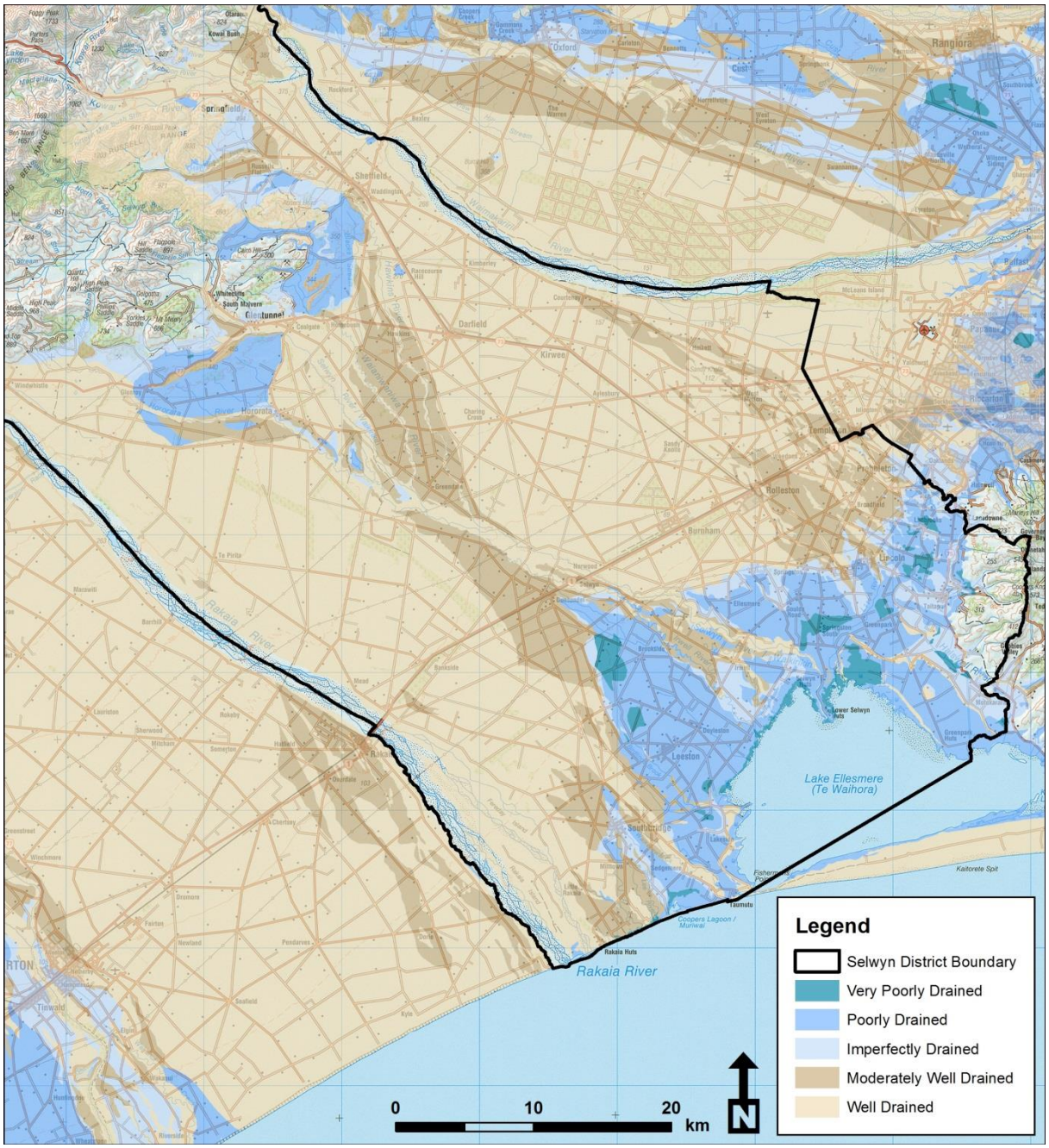


Figure 5-2: Soil drainage properties for the Selwyn District plains areas (Landcare Research)

When runoff is generated, water will flow down-plain, and pond in depressions or behind barriers to overland flow. In the lower lying parts of the Selwyn District, surface flooding can be exacerbated by runoff from the Port Hills, and high water levels in the lowland rivers inhibiting drainage.

Past monitoring of surface flooding carried out by Environment Canterbury (and previously the North Canterbury Catchment Board) has generally focussed on the lower plains areas of the district, where a large amount of rural-residential development has been occurring and where flooding can be severe. The longer duration of flooding in the lower plains areas is also more conducive to capturing aerial photographs.

Conversely, minimal monitoring of surface flooding has been carried out by Environment Canterbury in the upper plains areas. Surface water will usually drain away relatively quickly in these areas making it difficult to photograph. The absence of photographic coverage should not be interpreted to mean that

flooding does not, or could not occur, and the potential for surface flooding across any of the plains areas cannot be ruled out. Figure 5-3 shows an example of surface flooding on the plains to the east of Waddington township, where the soils are mapped as 'Well Drained' and the up-plain catchment area is relatively small.

Figure 5-3: Surface flooding to the east of Waddington township on 'Well Drained' soils

Due to the nature of surface flooding, there are no discrete boundaries between areas that are susceptible and those that are not. Instead, the degree of surface flooding will gradually transition from minor to severe in an irregular fashion across widespread geographical areas. Attempting to delimit areas that are vulnerable to surface flooding on planning maps is therefore fraught with difficulty.

As revealed through the previous Selwyn District Plan review process, it is impractical to try and define precise areas that have been affected by surface flooding in the past. Even if this could be achieved, the approach limits flood hazard management to areas known to have flooded in the past, and does not account for areas that may flood in larger events than those documented, or where flooding has not been monitored. Other limitations of this approach include the potential for misinterpretation of the maps, the fact that flood photographs may not show flooding at its peak and were taken during small to moderate sized events, and the difficulty in differentiating between degrees of flooding. Detailed delineation of areas vulnerable to surface flooding in a design rainfall event could theoretically be achieved in the future through the development of a comprehensive rainfall runoff model; however, some judgement would still need to be made about what degree, depth or severity of flooding constitutes 'surface flooding' and what is so minor as to be inconsequential.

At best, the boundary of any mapping produced using the information that Environment Canterbury currently has available will represent an arbitrary point somewhere along the continuum of minor to severe surface flooding. Maps will inevitably exclude some areas that are vulnerable to surface flooding, and include some areas that are not.

The current District Plan 'Lower Plains Flood Area' maps include some areas that are known to be susceptible to surface flooding. However, these maps do not include all known areas, or areas where surface flooding has simply not been documented. Alternative options are discussed and presented below.

5.1.1 Potential surface flooding

A precautionary option is to assume that all of the plains areas of the district are potentially susceptible to surface flooding in a 200 year ARI rainfall event, unless this is known not to be true. Areas could be excluded if:

- Reliable rainfall runoff model results were available, and they showed that no (or inconsequential) flooding would occur in a 200 year ARI rainfall event; or
- An equivalent or larger rainfall event had occurred, and a given area was known not to have been affected under 'normal flood conditions' (e.g. antecedent conditions were not unusually dry, no pumping or diversion of water etc.)

Based on the current information held by Environment Canterbury, none of the plains areas of the district could be excluded.

5.1.2 Known surface flooding

A far less precautionary option is to limit mapping to areas where surface flooding has been previously documented. In this case, a judgement must still be made regarding the severity or degree of surface flooding that should be included. This approach is limited by incomplete photographic coverage, the fact that the photographs may not show flooding at its peak and that they were taken during small to moderate sized events.

A map has been produced using this approach for the lower plains area of the district, where reasonable photographic coverage is available (Figure 5-4). The map aims to include areas where surface flooding (up to a relatively minor degree) is shown. The map boundary follows road centrelines, except for around the base of the Port Hills where it follows the LINZ 1:50,000 scale topographic map (Topo50) 20 m contour line. This makes it easy to determine if a given site falls within the mapped area, and emphasises the arbitrary nature of the boundary.

Some example photographs, with corresponding maps showing the field of view for each are included in Appendix A.

The mapped area also encompasses areas that are susceptible to flooding from the Halswell and LII Rivers, and from Lake Ellesmere. Flooding in the Halswell and LII River catchments is unique, as most flooding results from high river levels preventing the drainage of surface water, rather than overflows from the rivers onto the floodplain.

Figure 5-4: General areas of known surface flooding based on aerial flood photographs

5.2 Selwyn River flooding

Environment Canterbury is currently completing a flood modelling investigation for the lower Selwyn River. A recent flood event in the Selwyn River (22 July 2017) has presented an opportunity to carry out further calibration of the model and to review the flood frequency and design flows. However, this will delay the model results and associated technical report being finalised. Preliminary model results (produced pre-22 July) are available, and the modelled flood extent for a 200 year ARI event is shown in Figure 5-5. Most of the modelled flood extent falls within the area of 'known surface flooding' presented in Figure 5-4.

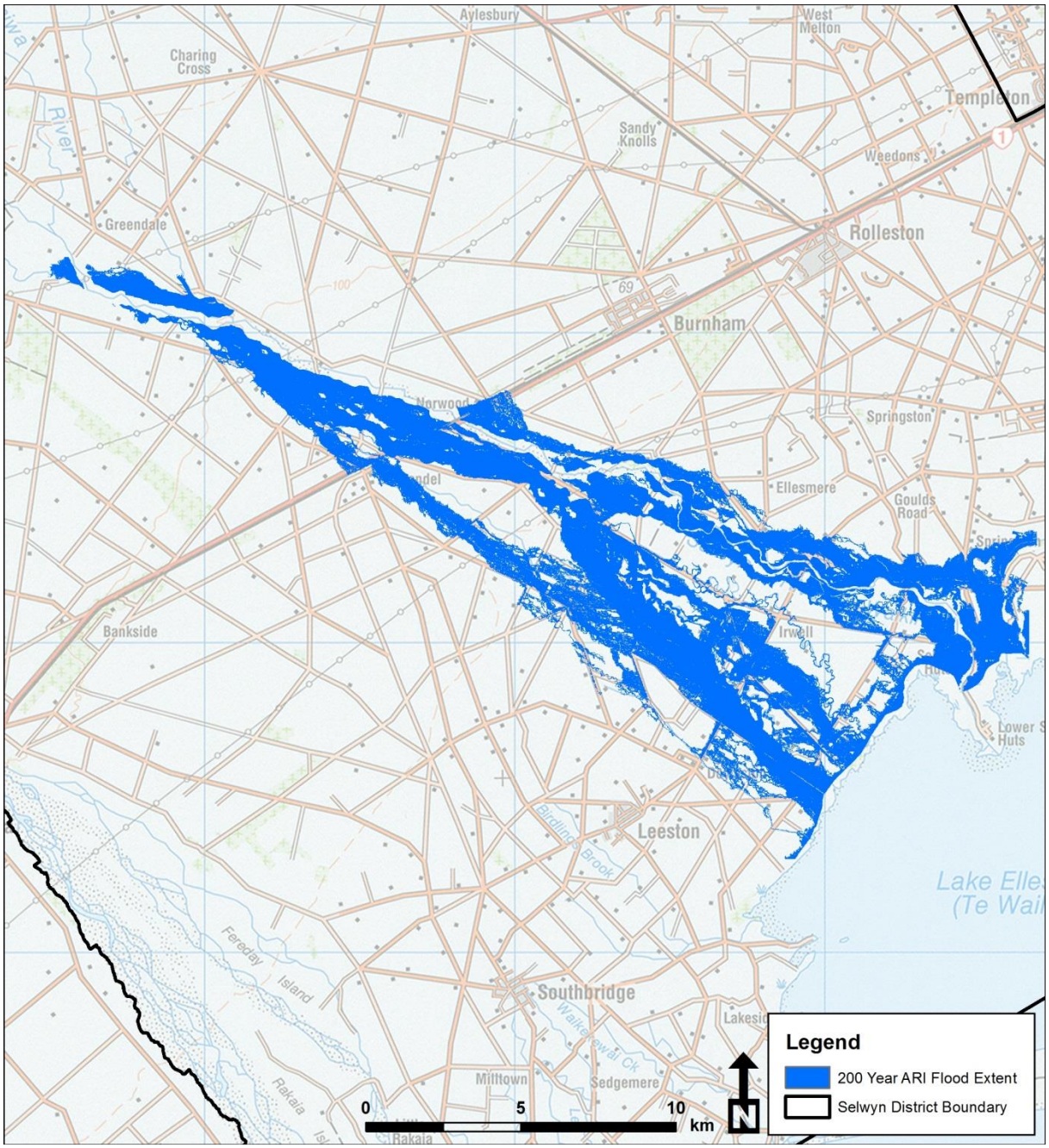


Figure 5-5: 200 year ARI modelled flood extent

Once complete, the flood frequency review will likely show that design flows (i.e. 200 and 500 year ARI flows) are smaller than originally estimated, but it is not yet known what effect this will have on the extent of predicted flooding. Whilst information obtained during the 22 July flood event is likely to result in a

reduced flood extent, it highlights the fact that new information can become available at any time, and this can significantly alter Environment Canterbury's understanding of flood events and their likely effects. Because of this, and the many other uncertainties and limitations associated with flood modelling, the raw model results are best used as a tool for conducting site specific assessments rather than for direct translation into planning maps. A more generalised map to incorporate the wider lower Selwyn River floodplain could be produced if required, using the model results as a guide. As well as helping to reinforce the uncertain nature of where floodwaters may extend to in an actual 200 year ARI flood, this would allow a 'buffer' for potential increases in the flood extent that could result from future model updates, and could account for areas that may also be flooded in larger events.

5.3 Lake Ellesmere/Te Waihora flooding

Aside from an increased length of lake level records, Environment Canterbury has not acquired any notable information to better quantify the flood risk from Lake Ellesmere since the early 2000s when the Proposed Selwyn District Plan was notified. No further attempts have been made to assess the likely frequency of flooding associated with high lake levels and/or wind effect, and constructing building floor levels to at least 3.0 metres above mean sea level around the lake margins (as required by the current district plan) is likely to achieve a standard of mitigation consistent with the CRPS requirements with respect to lake flooding.

However, areas that are directly susceptible to flooding from Lake Ellesmere are also susceptible to surface flooding, and fall within the area of 'known surface flooding' presented in Figure 5-4. Some areas are also susceptible to flooding from the Selwyn River, and fall within the 200 year ARI modelled flood extent presented in Figure 5-5.

The way that Lake Ellesmere flooding is designated and controlled in the current district plan does not allow other potential sources of flooding to be accounted for. In some instances, constructing building floor levels to 3.0 metres above mean sea level in the current 'Lake Ellesmere Flood Area' will be adequate to mitigate against flooding from the lake, but will be too low to adequately mitigate against surface flooding, or flooding from the Selwyn River.

There is therefore little value in defining areas that are susceptible to flooding from Lake Ellesmere, as they fall within areas that have already been identified as susceptible to flooding from other sources.

5.4 Waimakariri River flooding

The Waimakariri River forms the northern boundary of the Selwyn District. The upper reaches of the river are bounded by natural terraces, but the river becomes less entrenched toward the coast. Where the river is not naturally constrained, it is constrained by stopbanks managed by Environment Canterbury.

The draft report, 'Waimakariri River floodplain management strategy – Flood hazard risk assessment' (Environment Canterbury, 2017) assesses the likelihood of breakouts from the primary stopbanking system. The risk assessment divides the stopbanking into several zones, and quantifies the likelihood of a breakout occurring in each zone for a range of river flows. For flooding from the Waimakariri River to affect the Selwyn District, a breakout would have to occur along the Halkett Zone (between Courtenay and Chattertons Road).

This reach of the river is designed to contain a flow of 5,100 m^3/sec with 900 mm freeboard. This flow is estimated to have an ARI of 400 years. Hydraulic modelling conducted as part of the report shows that a 500 year ARI flow (5,400 m^3/sec) would be carried with a minimum freeboard of approximately 700 mm. The stopbank is therefore unlikely to be overtopped in either a 200 year ARI flow (4,500 m^3/sec) or 500 year ARI flow, but the report also considers the likelihood of failure through lateral erosion.

The likelihood of bank failure occurring along the Halkett zone in a 200 year ARI flow is assessed to be 0% (or so unlikely that 0% has been adopted). The likelihood of failure in a 500 year ARI flow is assessed to be approximately 5%.

Because bank failure in a 200 or 500 year ARI flow is so unlikely, there are no areas of the Selwyn District that are considered to be susceptible to flooding from the Waimakariri River in a 200 year ARI event, or that would meet the CRPS definition of High Hazard areas as a result of Waimakariri River flooding. A secondary stopbank (due to be completed in 2019) will further reduce the flood risk to the parts of the district that lie beyond it.

Note that the findings of the risk assessment exercise are based on current flood frequency estimates and the current state of the river and stopbanking scheme. The findings are based on a 'snapshot in time' and there are many ever changing variables that could lead to different conclusions being reached if a similar exercise is repeated in the future.

5.5 Tai Tapu township flooding

Tai Tapu township is located within the Halswell River catchment, and falls within the area of 'known surface flooding' presented in Figure 5-4. As with many areas in the catchment, the township is subject to surface water ponding, and high water levels in the Halswell River can prevent this water from draining.

Rule 4.1.1 of the operative district plan effectively requires new buildings in the township to have floor levels built to at least 6.93 metres above mean sea level. As outlined in Section 2.2.4, this level is based on stormwater modelling completed in 2003. Modelling carried out for the wider Halswell River catchment by Environment Canterbury demonstrates that building to a level of 6.93 metres above mean sea level may not provide a standard of mitigation consistent with CRPS Policy 11.3.2. (which requires new buildings to have 'an appropriate floor level above the 0.5% AEP (200 year ARI) flood level')

5.6 Rakaia Huts township flooding

The Rakaia Huts township is located near the mouth of the Rakaia River, and most properties sit above a natural river terrace. However, some properties include land that sits both above and below the terrace. Land below the terrace is potentially vulnerable to flooding directly from the river, and also as a result of water backing up from the hāpua.

Rule 4.1.3 of the operative district plan makes the construction of dwellings or principal buildings on the parts of the properties below the terrace a non-complying activity. This area falls within the area of 'known surface flooding' presented in Figure 5-4.

5.7 High hazard areas

High hazard areas (as defined in the CRPS) are areas 'where the water depth (metres) x velocity (metres per second) is greater than or equal to 1, or where depths are greater than 1 metre in a 0.2% AEP (500 year ARI) flood event'.

Due to the quantitative nature of this definition, it is difficult to determine if a given location is likely to be 'high hazard' unless detailed flood modelling has been completed, or a site-specific flood assessment is carried out. In the Selwyn district, flood modelling has only been completed for the Halswell River catchment and lower Selwyn River floodplain.

Where available, the model results allow areas that meet the definition of 'high hazard' to be easily calculated, however the inherent uncertainty involved in flood modelling means that high hazard areas calculated from the model results will have a margin of error. Due to limitations in modelling methodology, not all high hazard areas within a given study area will necessarily be identified, and some areas may be incorrectly identified as high hazard.

High hazard areas based on the Halswell catchment model results (clipped to the district boundary) are presented in Figure 5-6, with high hazard areas based on the lower Selwyn River model results presented in Figure 5-7. The identified high hazard areas could be edited to remove isolated pixels, fill in isolated 'islands', or to smooth area boundaries, if there were a need to do so. However, this inevitably involves removing some areas which are predicted to be high hazard and adding some areas which are predicted not to be high hazard.

In the Halswell catchment, all of the identified high hazard areas are due to flood depths being greater than 1 metre (as opposed to depth x velocity being greater than 1). The time that it takes for water to pond to this depth will be highly variable from one location to another, and would also vary depending on the nature of the rainfall event.

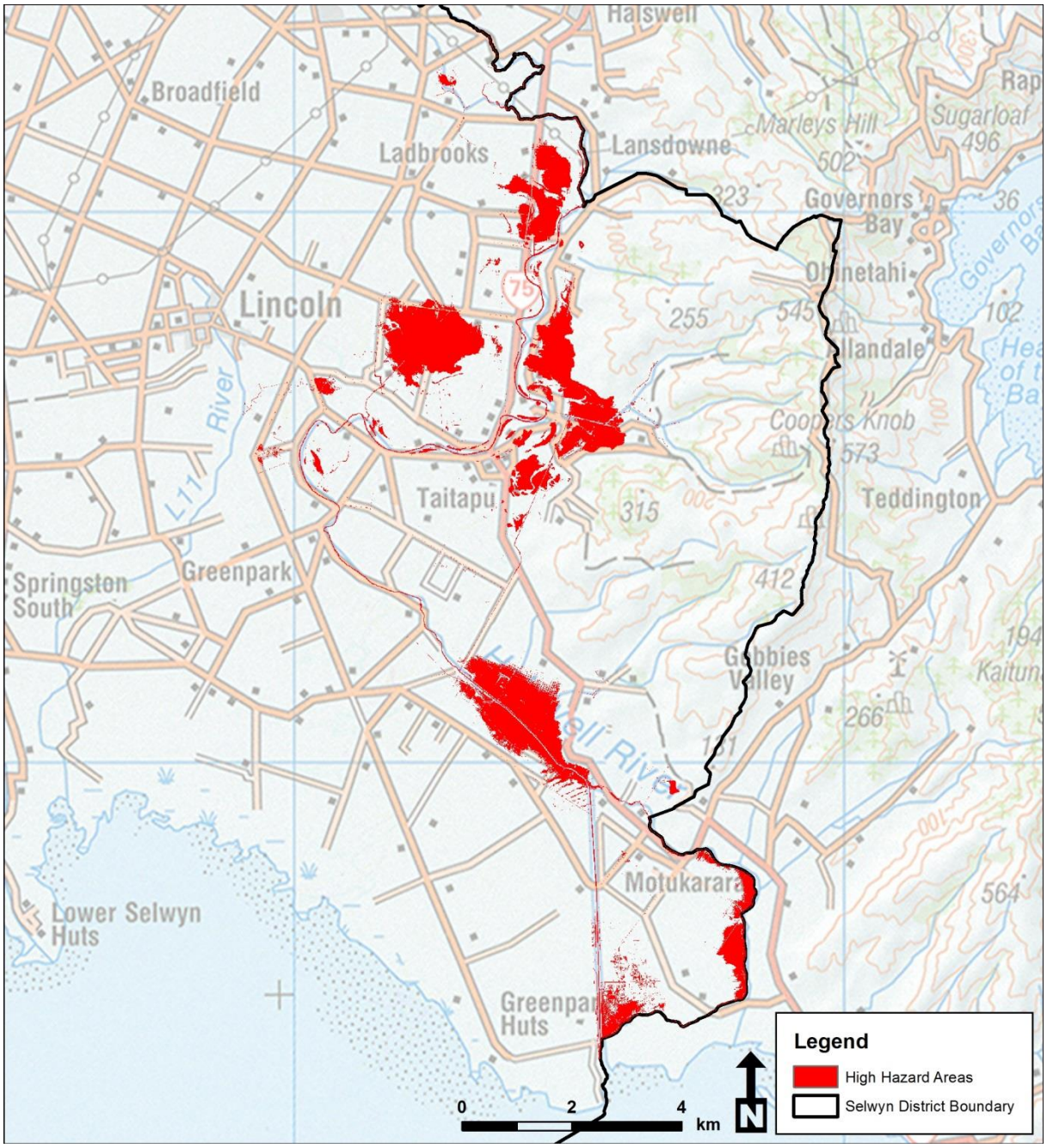


Figure 5-6: Modelled high hazard areas in the Halswell River catchment

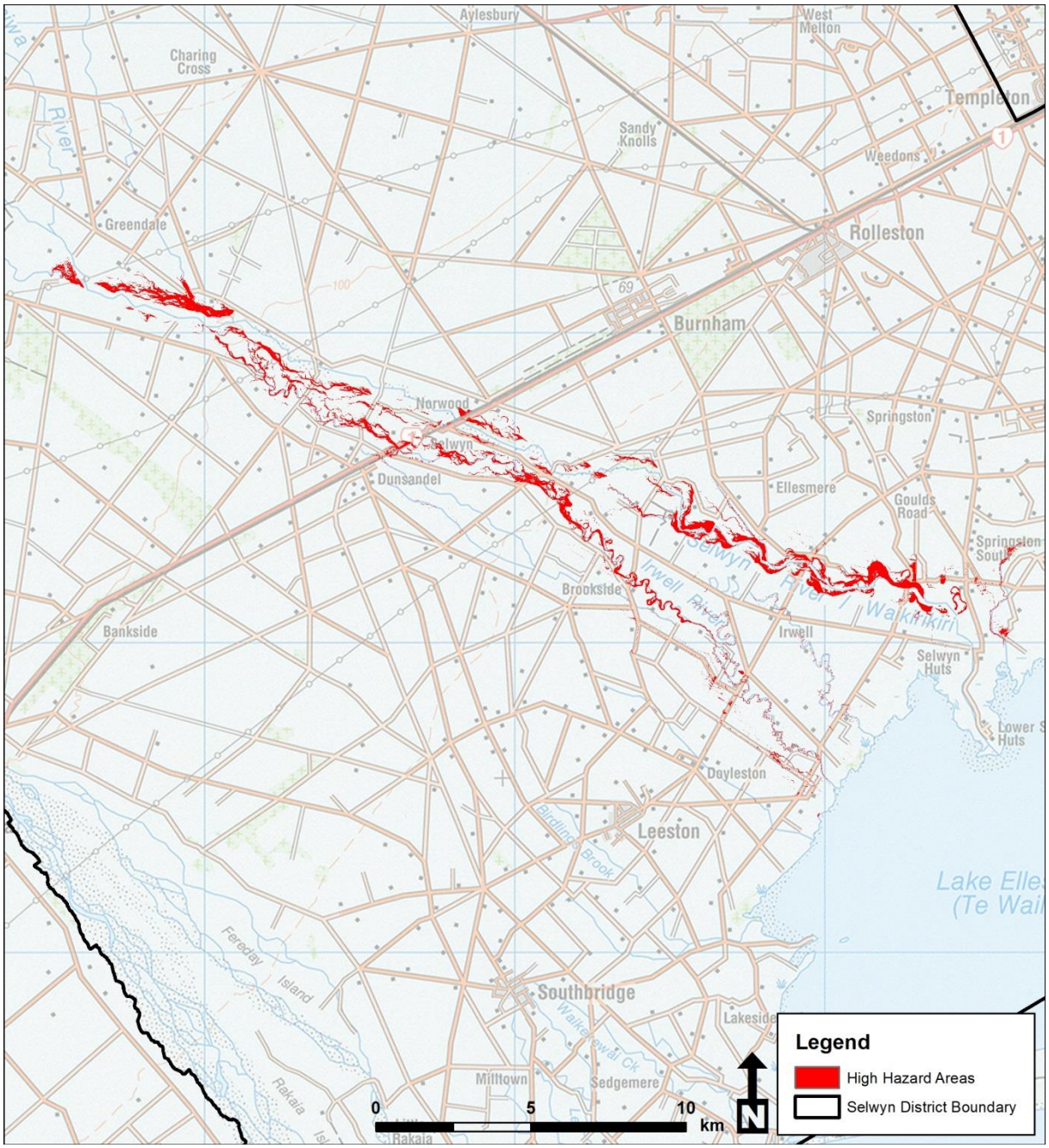


Figure 5-7: Modelled high hazard areas on the Selwyn River floodplain

6 Stopbank setback

The only formal stopbanks managed by Environment Canterbury in the Selwyn District are adjacent to the Selwyn and Waimakariri Rivers, however there are likely to be short lengths of stopbanking adjacent to other rivers and streams.

Amongst other things, Policy B3.1.2 of the operative District Plan advocates avoiding 'locating dwellings, buildings or other assets of high value in proximity to a stopbank where there is a high risk of damage and loss of life from inundation due to the potential depth and velocity of floodwater'. This policy is not specifically supported by District Plan rules.

Some parts of the Selwyn River floodplain adjacent to stopbanks are already identified as high hazard areas as they are predicted to overtop with water of sufficient depth and/or velocity in a 500 year ARI flood event to meet the CRPS definition. In other reaches of the Selwyn River, and along the Waimakariri River, the stopbanks are predicted to contain a 500 year ARI flood flow. While the likelihood of bank overtopping or failure in these locations may be low, the consequences of a bank failure can be high. This is due to the potential for lack of warning time and debris entrained in the flow, as well as the high water depths and velocities. Therefore in some locations adjacent to stopbanks, the overall flood 'risk' may be similar to, or even greater than other high hazard areas identified through flood modelling.

7 Information gaps

Flooding information for the Selwyn District is far from comprehensive. For some areas, good historic and predictive flooding information is available, but in many areas there is little or none. Areas where further investigation would be valuable include:

- Rainfall runoff modelling across the plains areas of the district would help to quantify the extent and depth of surface flooding that could occur in 200 and 500 year ARI rainfall events.
- Modelling to determine areas susceptible to flooding from the upper Selwyn, Hawkins, Waianiwaniwa and Hororata Rivers in 200 and 500 year ARI flood events.
- Modelling to determine areas that are susceptible to flooding from Rakaia River breakouts in 200 and 500 year ARI flood flows.
- Refinement of existing flood modelling for the Halswell River catchment.
- Further investigation into flooding from Lake Ellesmere, and an assessment of the flood frequency.

It is important to recognise that Environment Canterbury's knowledge of flooding in the Selwyn District will never be complete. Flood models can always be refined, and observations of future flood events and extended flow and rainfall records will continue to improve our understanding of flooding and the frequency that it occurs.

8 Key discussion points

This report raises some issues that will require further consideration when reviewing the flood hazard provisions of the Selwyn District Plan. These include:

- How to manage adverse effects from the potential for surface flooding on the use, subdivision and development of land in the plains areas of the district.
- How to best utilise flood modelling results produced for the Selwyn River floodplain and Halswell River catchment when considering a flood risk management regime for the use, subdivision and development of land likely to be adversely affected by flooding from these sources.
- The mechanisms for managing the flood risk associated with Lake Ellesmere on the use, subdivision and development of land.
- The current understanding of the flood risk from the Waimakariri River.
- The mechanisms for managing flood risk in the Tai Tapu and Rakaia Huts townships.
- The management of the use, subdivision and development of land within identified high hazard flood areas.
- The management of severe consequence flooding associated with stopbank breaches on the use, subdivision and development of land.
- How to fill or account for information gaps.

9 Peer Review

This report has been externally peer reviewed by Michael Rachlin (Principal Policy Planner at Porirua District Council – and former Planner at both Environment Canterbury and Selwyn District Council). His peer review comments have been incorporated into the report. In addition he noted 'The report provides a good issues identification document and is best used to inform commissioning further technical work and furthering the evidence base. In summary the report is sound as an issues identification document'.

10 References

Canterbury Regional Council (1991): *Draft Waimakariri River Floodplain Management Plan.* Report No. R91 (9)

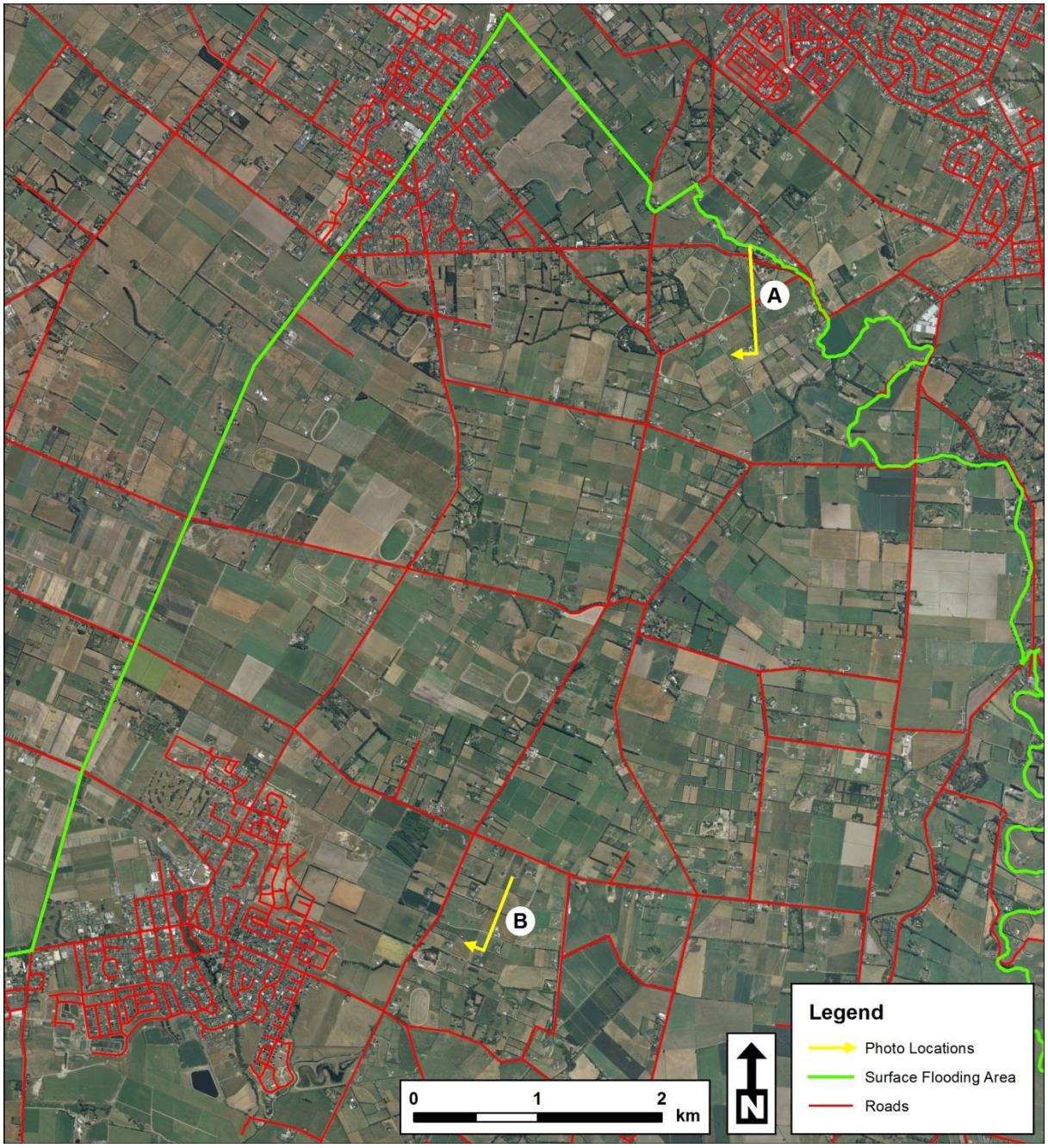
Canterbury Regional Council (2013): *Halswell River/Huritini floodplain investigation.* Report No. R12/68

Canterbury Regional Council (2017): *Draft Waimakariri River floodplain management strategy – Flood hazard risk assessment.* Report No. R17/21

Canterbury Regional Council (2017): *Draft Selwyn River/Waikirikiri floodplain investigation.* Report No. R17/31

Connell Wagner (2003): *Further stormwater modelling for the Tai Tapu Township.*

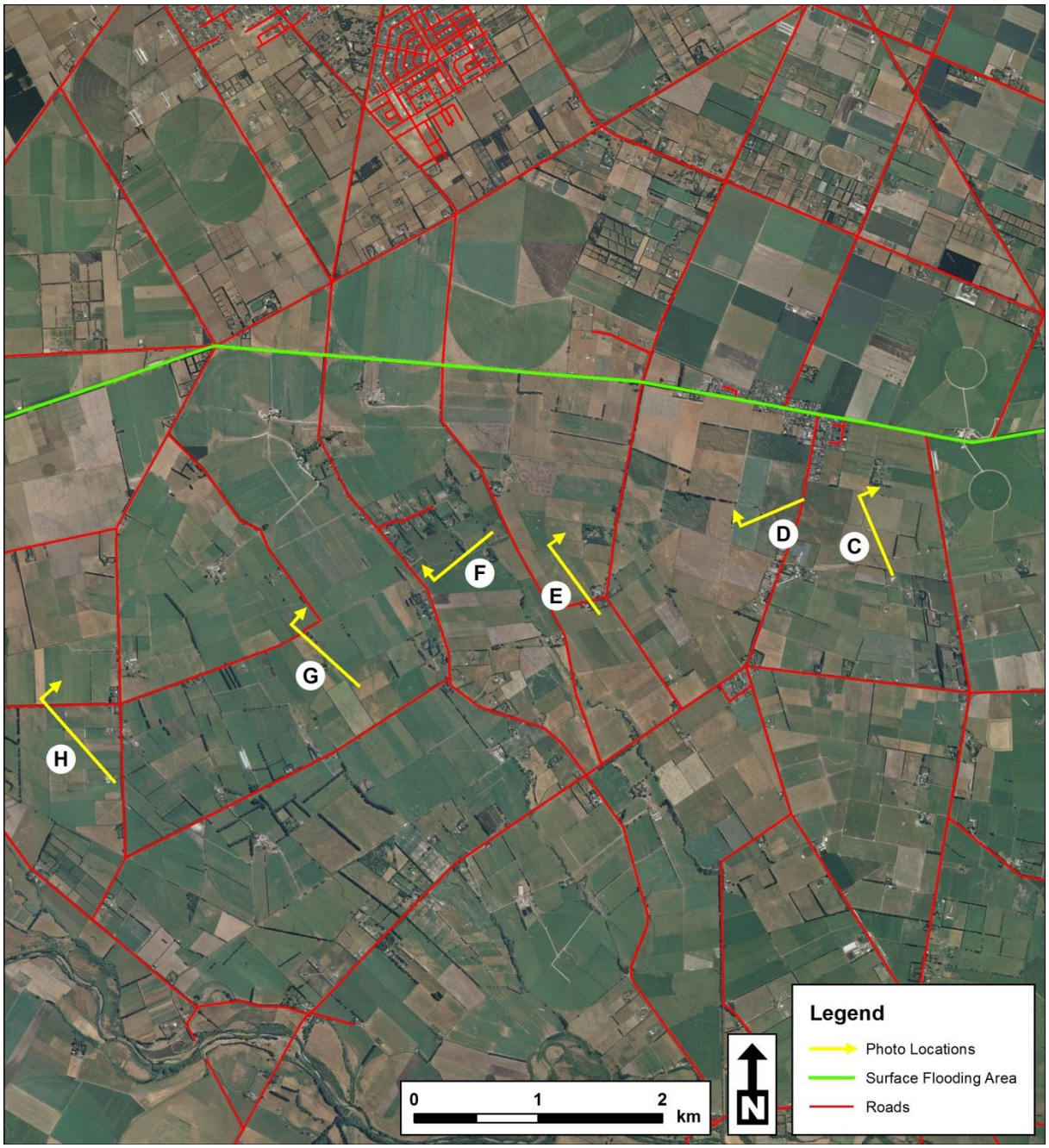
Appendix A: Example photos and location maps



Locations of Photos A & B

Photo A – 24 August 1986

Photo B – 23 June 2013



Locations of Photos C, D, E, F, G & H

Photo C – 24 August 1986

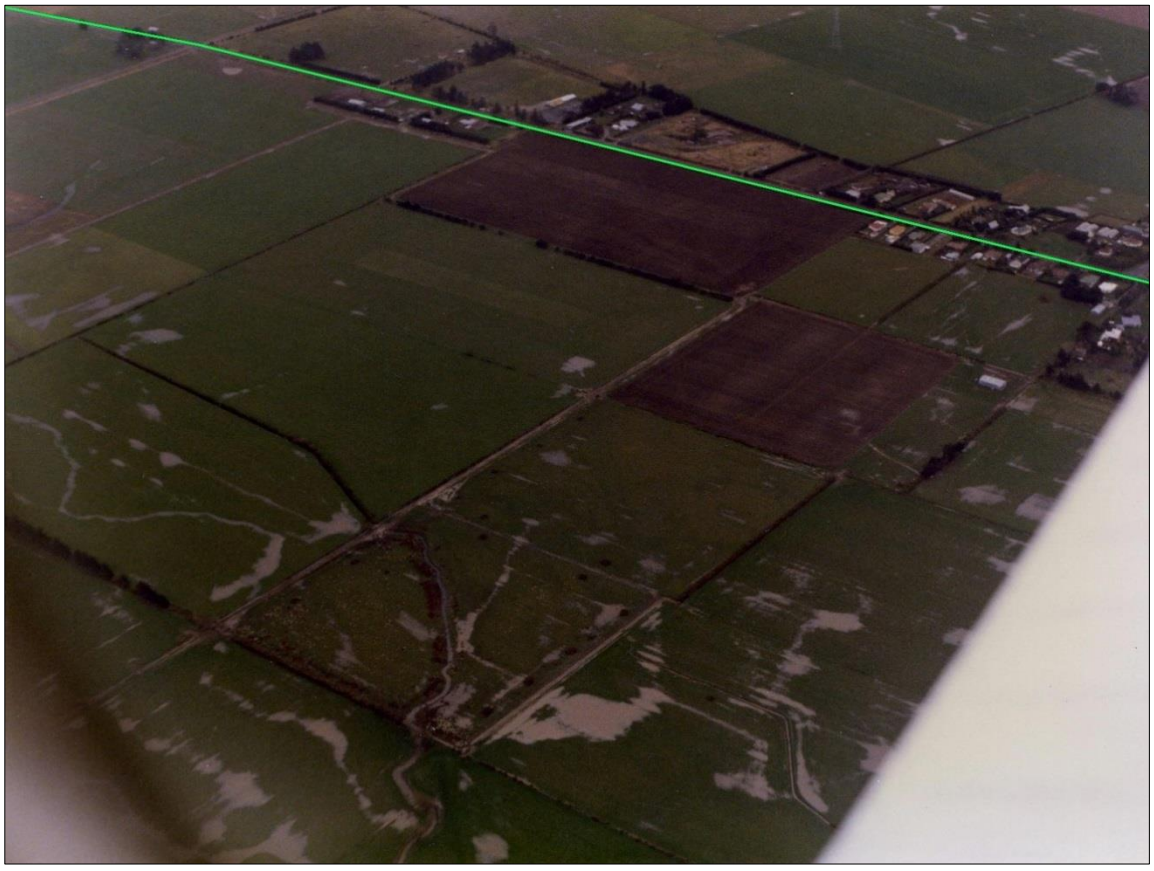


Photo D – 24 August 1986

Photo E – 24 August 1986

Photo F – 24 August 1986

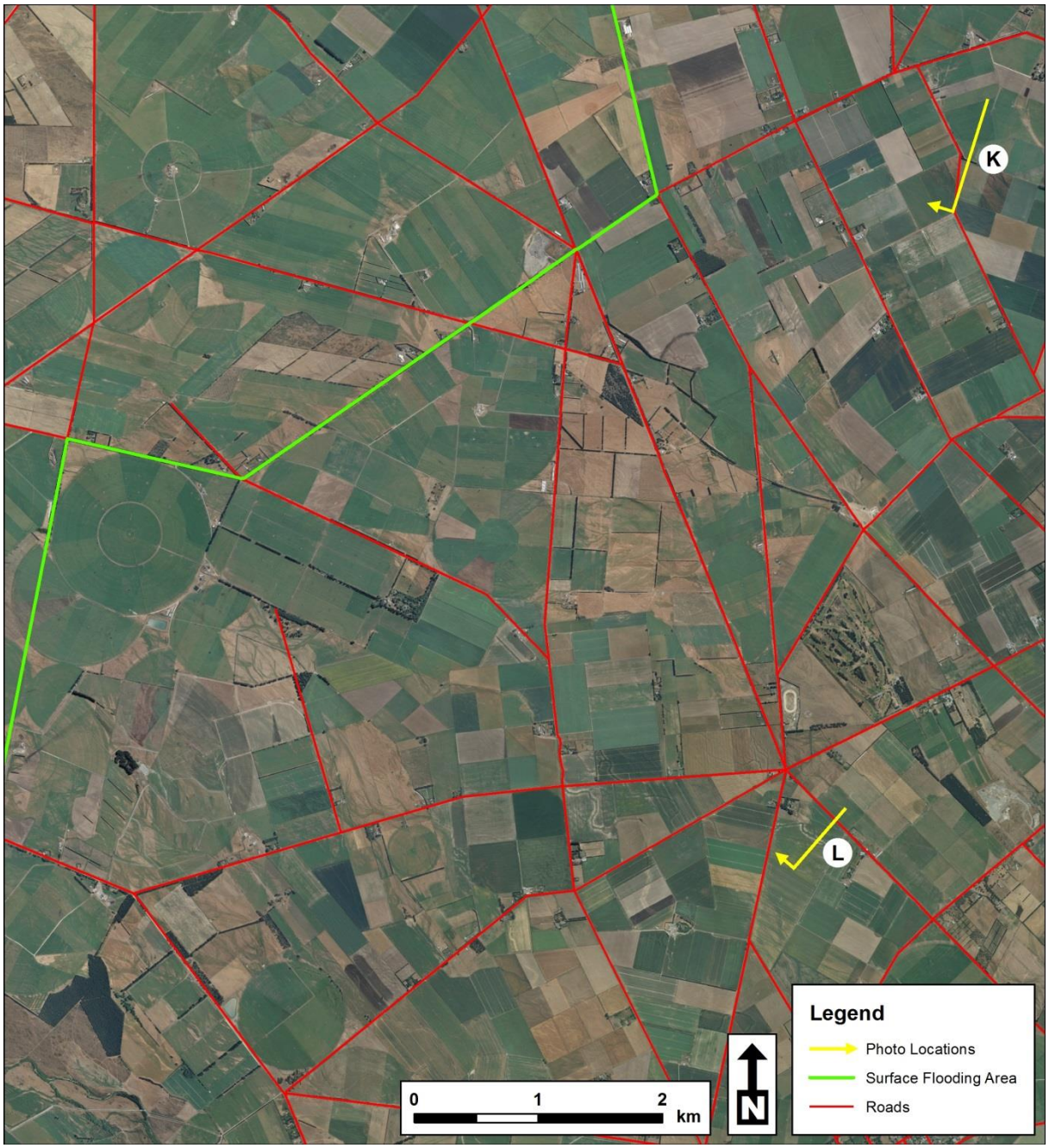
Photo G – 24 August 1986

Photo H – 24 August 1986

Locations of Photos I & J

Photo I – 24 August 1986

Photo J – 24 August 1986



Locations of Photos K & L

Photo K – 23 June 2013

Photo L – 23 June 2013