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Report

Spring identification and groundwater management for potential rezoning at the Grassmere Block

Prepared for Christchurch City Council

Prepared by (Beca)

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Revision History

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1	**Mike Thorley** **Carey Lintott**	Draft for client review	28/09/2016
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Document Acceptance

Action	Name	Signed	Date
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on behalf of	Beca Ltd		

Executive Summary

Spring and seepage mapping was undertaken by Beca which identified numerous springs and seepage areas across the Grassmere Block area. Three main spring discharge areas were found around the upper reaches of Tysons Drain which ultimately drains into the Styx River. The majority of flow found in Tysons Drain west of Cranford Street appears to be fed by groundwater.

The lower lying areas of the Grassmere Block site also exhibited seepage areas where water is ponded in shallow depressions and was not flowing to the drainage network. These seepage areas were most prevalent to the south and eastern parts of the area which are adjacent to the Council owned blocks in Cranford Basin.

Options to manage springs and groundwater seepage include:

- Consider decreasing the zoning density from the north (medium density) towards the south and east of the Grassmere Block area (low density);
- Determine the appropriate land uses such as residential zoning density, blue networks, green space or reversion to wetland areas taking into account the elevation and drainage levels, presence of spring and/or seepage and ground conditions;
- Building set back from springs and protection of spring discharge areas feeding the upper Tysons Drain and No.1 and No.2 branches;
- Low lying areas and those exhibiting groundwater seepage may be better suited to wetland restoration and/or stormwater treatment;
- Ensure the drainage network is sufficient to maintain groundwater at an appropriate level;
- Filling the land surface and/or building platforms above minimum drainage levels (although there would be other consequential effects);
- Install drainage material including subsoil drains to divert groundwater to a drainage outlet (without an overall lowering of the groundwater level). This will include placing a sufficient thickness of graded crushed aggregate to act as a controlled filtered exit. The thickness of the aggregate and use of subsoil drains should be sufficient to avoid piping or heaving depending on the difference in height between the aquifer level and the finished or construction level;
- Install piped sections to allow flow from artesian springs and/or seepage points to continue if filling is required;
- Control any discharge of water by current industry practice erosion and sediment control and/or stormwater treatment measures;
- The design of excavations and piles should take account of the flowing artesian pressures and ground conditions. Water pressure may rise within excavations and around the piles and mitigation measures may be required to remove any water that might emerge at land surface; and
- Avoid interception of artesian aquifers by piling and drainage works to avoid poor pile performance and/or depressurisation of the aquifer.
- Drainage design should take into account the potential for ground settlement and/or consolidation effects due to groundwater being lowered and/or where filling is undertaken on top of compressible soils.

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1 Introduction

Christchurch City Council (CCC) has engaged Beca Ltd (Beca) to investigate and map springs and seeps across the Grassmere Block which is an area adjacent to Cranford Basin and is under consideration for rezoning by CCC to a residential zone (Figure 1). The hydrogeological conditions in the area include the presence of very shallow and flowing artesian groundwater and artesian springs and seeps, some of which are likely to be permanent or intermittent.

A number of geotechnical investigations have been commissioned by both CCC and developers to look into the feasibility of rezoning the area from rural to residential. These investigations, while concluding parts of the Cranford Basin area could be made suitable for residential rezoning, have highlighted the challenges in developing the land particularly from a hydrogeological and geotechnical perspective.

This document seeks to:

- Identify spring and seepage features in the area and existing surface/ shallow drainage connections
- Provide high level preliminary options for managing springs and groundwater to be used in the assessment of rezoning all or parts of the area to residential such as setbacks and land drainage.

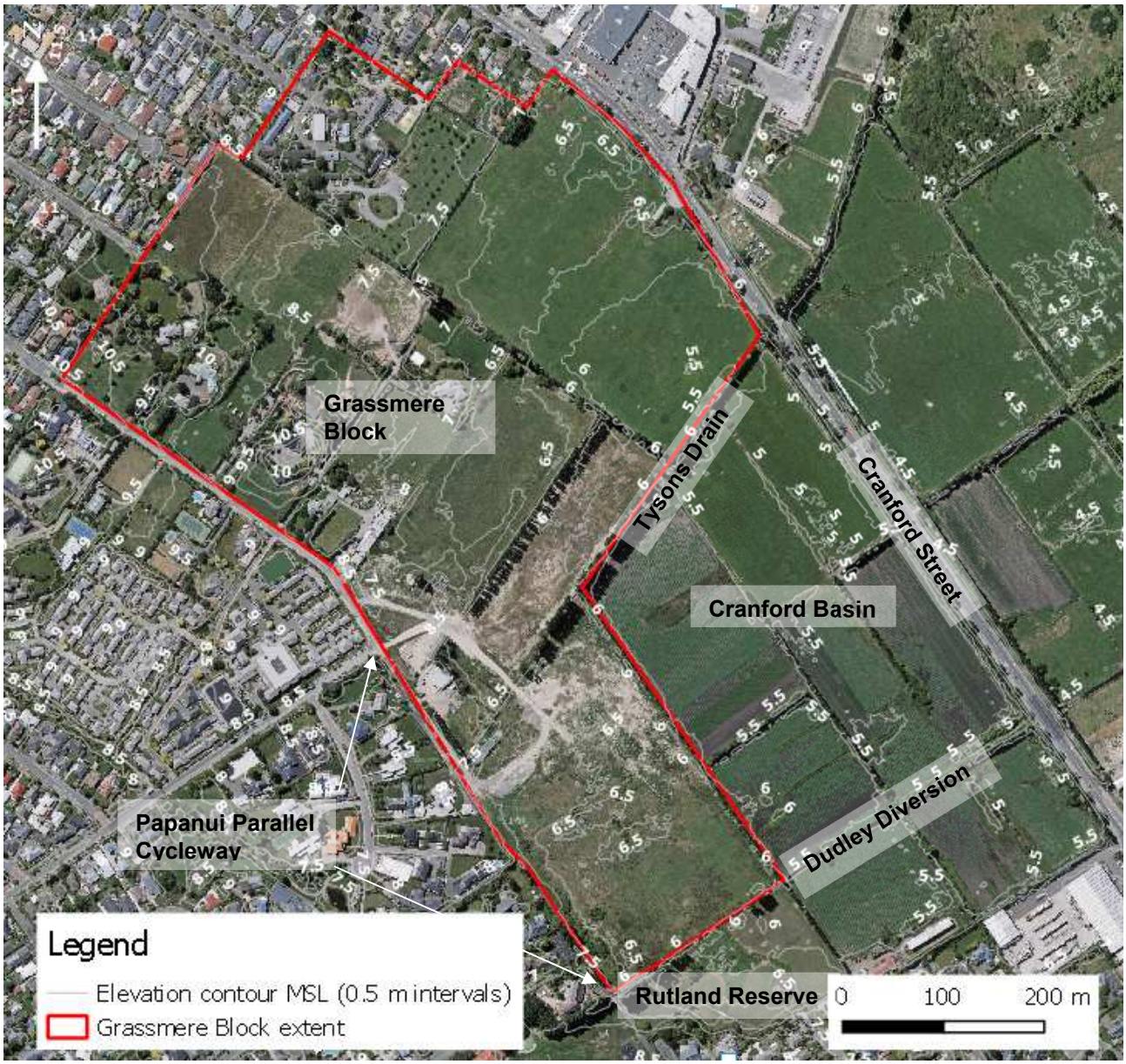


Figure 1 - Location plan Grassmere Block

2 Hydrogeology of Area

The Grassmere Block forms the western margin of Cranford Basin; parts of the Grassmere Block are effectively sitting at a similar elevation (~5 m RL) to the adjacent parts of Cranford Basin. The more northerly parts of the Grassmere Block are more elevated, ranging up to ~11 m RL. Cranford Basin has historically been drained and converted to an agricultural area. It is characterised by peaty soils which also contain

many springs and watercourses that are largely groundwater fed. Brown and Weeber (1992)[1] map the area as a peat swamp in their geology map of Christchurch.

The basin is located at a geological transitional zone where the Holocene alluvial deposits (the Springston Formation) change to marine equivalent deposits, referred to as the Christchurch Formation. The pinching out of gravel lobes such as the Springston Gravel and active drainage to a low level encourages the upward movement of groundwater. Current drainage is largely open drains with some subsurface piping of springs and groundwater seepage. The alluvial deposits of the Springston Formation comprise a mixture of peat, sand, silt and gravel whereas the Christchurch Formation comprises sand with subordinate silt, clay and organic material (including peat and shells). The underlying geological materials are variable and heterogeneous in thickness, composition, strength and water content.

Below these are located the older glacio-fluvial deposits of the Riccarton Gravel Formation, which occurs at a relatively shallow depth here (~18 m) and contains high flowing artesian groundwater (up to 4 m above ground).

The area is characterised by a shallow groundwater level that sits close to or above the ground surface depending on the proximity to Cranford Basin. The shallow groundwater levels and the relatively low land surface elevation gives rise to springs, which are found as artesian springs and depression springs or seeps. The artesian springs are usually observed bubbling and flowing from a point source and form small bowls from where a "run"[2] or drain originates. These types of spring are usually due to groundwater flowing preferentially through weaknesses in the ground or thinner cover layers. There are also a number of seeps (probably ephemeral or intermittent) found pooling in shallow depressions on lower permeability peaty soils. These differ from the springs above in that they usually do not flow to a drainage outlet and are accordingly mapped as "seeps" (see Section 3).

[1] Brown & Weeber, 1992. Geology of the Christchurch Urban area. Scale 1:25000. Institute of Geological and Nuclear Sciences geological map 1. 1 sheet +104p. Institute of Geological and Nuclear Sciences Limited, Lower Hutt, New Zealand.

[2] A stream carrying the outflow of a spring to a nearby stream is called a spring branch or run

3 Identification of springs

Spring and seepage mapping was undertaken by Beca on 15 September 2016 across the identified Grassmere Block area and the immediately adjoining area. The results of the mapping are shown on Plan 1 and described in Table 1 attached as Appendix A. This plan highlights the following features:

- Approximately 32 artesian springs flowing into the headwaters of Tysons Drain from 3 main areas:
  - Tysons Drain Branch No.1
  - Tysons Drain Branch No.2
  - Upper Tysons Drain
- Approximately 46 seeps ponding in shallow depressions most of which many may be intermittent or ephemeral in three main areas:
  - Southern half of the block adjacent to Cranford St
  - South western end of the block adjacent to the Papanui Parallel Cycleway
  - The blocks surrounding upper Tysons Drain and Tysons Drain Branch No.2

A number of springs in the area appear to form permanent water bodies with a run or the potential for good outflow with some restoration or maintenance of the channel. The majority of flow in Tysons Drain west of Cranford Street appears to be fed by groundwater. There are also a number of seeps and pools which may be ponded groundwater, given there has been low rainfall this winter.

Recent filling is understood to have occurred and was apparent across large areas of the site, particularly in the southern parts of the Grassmere Block. The fill consisted of a mixture of soil and building rubble. Aerial photographs show potential springs prior to filling which would now lie beneath these areas. During the site visit there appeared to be some possible seepage coming through the fill and a number of spring outlets and channels had either been blocked off or diverted.

It is difficult to confirm the permanence or intermittent nature of the springs and seeps without multiple site visits. The preceding 2016 summer and winter seasons have been dryer than usual with lower than average rainfall recharge to the aquifer system and groundwater levels across the western parts of Christchurch are lower than the average[3]. Therefore more springs and seeps or higher level and/or flows might be expected to follow during periods with higher rainfall recharge.

[3] http://ecan.govt.nz/news-and-notices/pages/rain-flow-drought-2016.aspx

4 Potential Groundwater Effects

Potential groundwater effects arising from residential development are likely to include the following:

- Changes to groundwater discharges (volume and location) such as springs and water bodies which support ecology and/or cultural values
- High groundwater and wet ground conditions affecting the amenity of properties (without drainage treatment)
- Blockage of drainage outlets could affect the ability of a spring or seepage area to contribute flow to a spring fed stream such as Tyson's Drain and ultimately the Styx River and may cause springs to migrate and emerge in other areas which could result in flooding elsewhere
- Earthworks (surcharge with fill with drainage) is expected to cause a re-direction, lowering and/or rise in groundwater levels and further exacerbating ground settlement or flooding respectively
- There is the possibility of interception of artesian or high groundwater flow conditions during earthworks/ piling which can lead to an ongoing drainage issue due to uncontrolled groundwater discharge and ultimately aquifer depressurisation if not resolved
- Enhanced risk of liquefaction of saturated soils subject to elevated pore water pressures in response to earthquake shaking and consequent damage to infrastructure and housing.

5 Mitigation of Environmental effects

5.1 Setback from springs and waterways

Three main spring discharge corridors exist across the Grassmere Block area. Consideration should be given to retaining these in order to allow springs to continue to flow into the upper reaches of Tysons Drain, including branches No.1 and No.2. Plan 1 (Appendix A) shows the general spring and seepage discharge areas and those areas where filling is known to have occurred and where springs or seepage may have been covered. The mapped extents are largely based on a site visit in September 2016 and data collected by EOS Ecology[4]. Therefore spring and seepage flows and extents may vary from these one-off observations and inferences drawn.

We recommend that a "blue network" of naturalised channels and restored spring vents are established along the spring discharge areas marked in Plan 1, Appendix A. We understand this could be used as part of the Outline Development Plan process which is likely to be required for residential development. We have applied a default 10 m setback around these features although in some cases it may be appropriate to encroach within ~10 m of a spring vent or modify existing springs or channels to form an efficient drainage network. We recommend minimising any such modification. The set-back of 10 m for springs and waterways would allow conveyance paths to be 20 m wide (10 m each side), and could form stormwater drainage / flood flow corridors as well as spring flow conveyance.

Construction earthworks during subdivision should be carefully designed and closely managed to avoid filling over springs and where this cannot be avoided a protocol should be followed that enables spring or seep water to continue to flow and discharge to the drainage network. Consideration of how future stormwater and runoff may interact with the spring areas will also need to be taken into account in order to protect spring and channel water quality.

A groundwater management plan is recommended to be required as part of the subdivision consent.

5.2 Groundwater Management Options

Groundwater management and drainage is likely to be required across the area, particularly across the southern and eastern parts of the Grassmere Block area. Seepage areas will require treatment to allow the groundwater to move to a drainage outlet and maintain groundwater levels indicatively at least 0.5 m below the finished land surface. Control options include drainage blankets and a subsoil drainage network including the possibility of allowing for the connection of private subsoil drains.

The main options to manage groundwater include:

- Options for land use such as residential zoning, blue network, greens space and road layouts should take into account the land elevation and drainage levels, presence of spring and/or seepage and ground conditions;
- Ensure the drainage network is sufficient to maintain groundwater at an appropriate level;
- Filling the land surface and/or building platforms above minimum drainage levels (although there will be consequential effects);

[4] EOS Ecology, 2016. Aquatic Ecology Values of Western Cranford Basin. EOS Ecology Report No. CHR01-16129-01 prepared for Christchurch City Council.

- Install drainage material including subsoil drains to divert groundwater to a drainage outlet. This will include placing a sufficient thickness of graded crushed aggregate to act as a controlled filtered exit. The thickness of the aggregate and use of subsoil drains should be sufficient to avoid piping or heaving depending on the difference in height between the aquifer level and the finished or construction level; Sub soil drains should also be included with appropriate access for inspection and maintenance;
- Install piped sections to allow flow from artesian springs and/or seepage points to continue if filling is required;
- Control any discharge of water by established site erosion and sediment control or stormwater treatment measures;
- The design of the excavations and piles should take account of the flowing artesian groundwater conditions. Water pressure may rise around the pile and mitigation measures may be required to remove any water that might emerge at land surface; and
- Avoid interception of artesian aquifers by piling and drainage works to avoid poor pile performance and/or depressurisation of the aquifer.

Alternatively, where high groundwater and seepage is found, more appropriate uses of that land could be considered such as reverting these areas back to a wetland environment and/or utilising these areas for stormwater collection and/or treatment via planted wetlands.

Observations of springs, seepage and topography suggest that medium density residential housing is more likely to be viable in the northern part of the area (Plan 1, Appendix A). The southern and eastern parts of the site are low lying and contain numerous springs and seepage features which may be more suited to very low density housing or reverting to wetlands or stormwater treatment.

6 Conclusion

Spring and seepage mapping was undertaken by Beca on 15 September 2016. Numerous springs and seepage areas were found across the specified Grassmere Block area.

Three main spring discharge areas were found around the upper reaches of Tysons Drain which ultimately drains into the Styx River. The majority of flow in Tysons Drain west of Cranford Street appears to be fed by groundwater.

The lower lying areas of Grassmere Block contain water ponded in shallow depressions that did not appear to be flowing into the drainage network. These seepage areas were most prevalent in the southern and eastern parts of the area which are adjacent to the Council owned blocks in Cranford Basin.

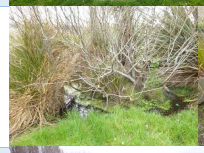
Options to manage springs and groundwater seepage include:

- Decrease the zoning density from the north (medium density) towards the south and east of the Grassmere Block area (low density);
- Determine the appropriate land uses such as residential zoning density, blue networks, green space or reversion to wetland areas taking into account the elevation and drainage levels, presence of spring and/or seepage and ground conditions;
- Building set back from springs and protection of spring discharge areas feeding the upper Tysons Drain and No.1 and No.2 branches;
- Low lying areas and those exhibiting groundwater seepage may be better suited to wetland restoration and/or stormwater treatment;
- Ensure the drainage network is sufficient to maintain groundwater at an appropriate level;
- Filling the land surface and/or building platforms above minimum drainage levels (although there will be consequential effects);
- Install drainage material and include subsoil drains to divert groundwater to a drainage outlet;
- Install piped sections to allow flow from artesian springs and/or seepage points to continue if filling is required;
- Control any discharge of water by established site erosion and sediment control or stormwater treatment measures;
- The design of the excavations and piles should take account of the flowing artesian groundwater conditions. Water pressure may rise around the pile and mitigation measures may be required to remove any water that might emerge at land surface; and
- Avoid interception of artesian aquifers by piling and drainage works to avoid poor pile performance and/or depressurisation of the aquifer.
- Drainage design should take into account the potential for ground settlement and/or consolidation effects due to groundwater being lowered and/or where filling is undertaken on top of compressible soils.

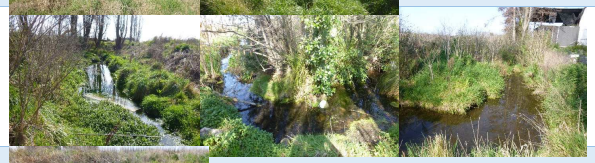
Appendix A

Map and table of springs & seepage across the western Cranford Basin area

Plan 1: Grassmere Block Spring Mapping September 2016

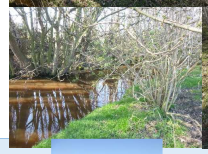
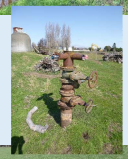
ID	Type	Morphology	Permanence	Easting	Northing	Description	Approx Width (m)	Approx Length (m)	Approx Depth (cm)	Photo
1	Spring	Depression	Permanent	1569606	5183711	Boggy, shallow pool in area planted with flax etc. Head of drain. Outflows into man-made drain cut towards Dudley drain.	1	8	9	
2	Spring	Depression	Permanent	1569596	5183745	Spring head next to playground. Rocks placed in spring, ponded water. Outflows N toward man-made channel.	2	2	10	
3	Seep	Depression	Intermittent?	1569596	5183745	Small damp spot , lacks spring vent, no flow.	1	3	3	
4	Seep	Depression	Intermittent?	1569548	5183752	Spring head amongst large boggy area.	1	2	5	
5	Spring	Artesian	Permanent	1569531	5183706	Spring head under wooden bridge, flows towards Spring 2, and joins before outletting to drain .Obvious flow.	3	3	10	
6	Spring	Depression	Permanent	1569495	5183733	Planted area around springs with ponded water. Surrounding planted area all boggy. Outlets to diversion drain (slight flow visible).	5	10	2	 
7	Seep	Depression	Intermittent?	1569567	5183776	Ponded water in rounded depression. No obvious flow.	8	8	5	
8	Seep	Depression	Intermittent?	1569578	5183818	Ponded water in elongated depression. No obvious flow.	4	13	6	

9	Spring	Linear/Channel	Permanent	1569337	5183973	SW end of manmade drain against embankment (on E side). Head of drain spring fed. Intersects with another small channel then connects into Tyson drain system 30m from head. Very slight flow only. Surrounded by boggy overgrown area 20m E and 50m to W. Shed with infilled yard to NW, filled area with vehicle access through a lot of area to SE. Stopbanks have been built up on SE of stream.	1.2	30	12		
10	Spring	Linear/Channel	Permanent	1569287	5183941	Head of another small drain that feeds into the start of Tysons Drain. Intersects perpendicular with the drain from spring 9. Very slight flow only.	0.8	15	15	 	
11	Spring	Linear/Channel	Permanent	1569456	5183948	Spring with very slight flow showing. Channel meanders back toward fill, outlets to Dudley drain.	1	1	10	 	
12	Spring	Linear/Channel	Permanent	1569352	5183934	Small depression with ponded water, no outflow. Boggy channel with reeds leads away from depression. Cut off by fill, no obvious flow.	2	5	10	  	
13	Seep	Depression	Intermittent?	1569336	5183871	Spring - ponded water and boggy area. Reeds, no obvious outflow.	10	15	10	 	
14	Seep	Depression	Intermittent?	1569391	5183837	Possible ephemeral spring area	30	30	0		628
15	Seep	Depression	Intermittent?	1569387	5183796	Head of spring area. All area vegetated, flow along side of cycleway 20m from edge of seal. No outflow present	2	5	4	 	
16	Seep	Linear/Channel	Intermittent?	1569410	5183775	Spring 15 water starts again	1.5	10	10		
17	Spring	Linear/Channel	Permanent	1569438	5183941	Spring, bubbling evident where fill diverts channel paths	0.5	4	40		

18	Spring	Linear/Channel	Permanent	1569480	5183931	Spring, some ponded water with larger 10x10m boggy area, no outflow	5	5	5	
19	Spring	Linear/Channel	Permanent	1569272	5183959	Source of Tyson's Drain (connects with several other small spring fed chaneels). Next to shed on infilled land. Some flow coming from PVC culvert. Good flow evident.	1.5	2	20	
20	Spring	Linear/Channel	Permanent	1539260	5183986	Another small drain feeding into the start of the Tysons Drain system.	1.2			
21	Spring	Artesian	Permanent	1569288	5184001	Whole area boggy, with a large spring pond. Slow moving flow evident, feeds into Tysons Drain	30	30	30	
22	Spring	Linear/Channel	Permanent	1569295	5184021	Boggy area with springs around S and E margins of compound. Flow moves from shed around a bend and then S along embankment and into Tysons drain system.	15	15	80	
23	Spring	Depression	Permanent	1569294	5184011	Boggy springy area	5	8	5	
24	Seep	Depression	Intermittent?	1569392	5184080	Depression with ponding water (stagnant). No obvious flow.	8	6	15	
25	Seep	Depression	Intermittent?	1569354	5184046	Ponding water in muddy depression in infilled area. Possible filled over spring. No obvious flow.	3	2	5	
26	Seep	Depression	Intermittent?	1569343	5184027	Ponding water in muddy depression in infilled area. Possible filled over spring. No obvious flow.	6	2	10	

27	Seep	Depression	Intermittent?	1569358	5184006	Ponding water in muddy depression in infilled area. Possible filled over spring. No obvious flow.	6	3	5	
28	Seep	Depression	Intermittent?	1569360	5184007	2 small areas of ponding water in muddy depression in infill area. Possible filled over spring. No obvious flow.	2	2	5	 
29	Seep	Depression	Intermittent?	1569375	5184015	Ponding water in muddy depression in infilled area. Possible filled over spring. No obvious flow.	1	1	3	
30	Seep	Depression	Intermittent?	1569373	5183969	Ponding water in muddy depression in infilled area. Possible filled over spring. No obvious flow.	2	4	6	
31	Seep	Depression	Intermittent?	1569571	5183878	Large area of standing water. Some bubbles in middle of pond, no outflow.	20	30	5	
32	Spring	Depression	Permanent	1569555	5183913	Large spring area. Very slight flow to man-made outlet channel.	20	20	5	  
33	Spring	Depression	Permanent	1569588	5183923	Small culvert (black plastic pipe) cuts across a small side junction to Dudley Drain - pipe broken, flow can be heard into pipe.	0.6	2	8	
34	Spring	Artesian	Permanent	1569651	5183957	Spring bubbling up in small pool, man-made cut leads to drain Dudley Drain	1	1	6	 
35	Spring	Artesian	Permanent	1569587	5183966	L shaped spring (artesian - bubbling up), flows into manmade drain Dr_C5, outletting to Dudley Drain	1	0.8	6	

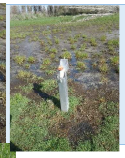
36	Spring	Depression	Permanent	1569551	5184038	Turbid spring area, connected to small man-made channel that cuts off and disappears. Slight flow N to S.	1.5	4	40	 
37	Seep	Depression	Intermittent?	1569547	5184094	Two thin strips of surface water, stagnant, no apparent flow.	0.4	6	3	
38	Seep	Depression	Intermittent?	1569512	5184089	Head of man-made drain flowing to Dudley Drain. Stagnant, little apparent flow.	0.7	1	5	 
39	Seep	Depression	Intermittent?	1569511	5184091	Isolated area of surface water, stagnant and boggy, no apparent flow.	0.4	2	3	
40	Spring	Depression	Intermittent?	1569480	5184090	Head of man-made drain flowing to Dudley Drain. Stagnant, little apparent flow. Large boggy area surrounding head, also boggy vegetated area for entire strip between two parallel drains	0.2	0.5	6	 
41	Spring	Depression	Intermittent?	1569426	5184086	Head of man-made drain flowing to Dudley Drain. Stagnant, little apparent flow. Large boggy area surrounding head, also boggy vegetated area for entire strip between two parallel drains	0.2	3	3	 
42	Spring	Artesian	Permanent	1569450	5184192	Large round depression. Spring - bubbling up evident. Flow to N towards drain.	4	2	7	 
43	Spring	Linear/Channel	Permanent	1569470	5184238	Source of Dudley drain - starts in NE corner of paddock, flows S towards diversion drain .	0.8	-	20	 
44	Seep	Depression	Intermittent?	1569288	5184117	Depression along NE edge paddock, seems dry, potentially been cut off by fill.	2	-	0	

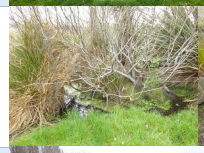
45	Seep	Depression	Intermittent?	1569303	5184111	Small depression with surface water. No obvious flow	2	0.6	2	
46	Seep	Depression	Intermittent?	1569334	5184065	Land boggy and vegetation overgrown on NE bank of drain at SE border of paddock (along Tysons Drain edge). At SE end only.	6	20	2	 
47	Seep	Depression	Intermittent?	1569315	5184116	Surface water in tyre tracks, surrounding area quite boggy	6	2	5	
48	Seep	Depression	Intermittent?	1569387	5184154	N extent of boggy area with patches of water (starting at 46, 47). Further 20-30m of boggy land to SW and NE.	40	10	8	 
49	Seep	Linear/Channel	Intermittent?	1569344	5184208	Drain along poplars, dry most of length but becomes damp in corner of paddock	1	3	5	
50	Spring	Artesian	Permanent	1569345	5184324	Large depression, spring. Flows to ditch on W side of poplars, separated from the ditch on E side of trees. Small flow, very murky.	10	10	0.5	 
51	Spring	Linear/Channel	Permanent	1569240	5184248	Piped springs entering paddock	-	-	-	
52	Seep	Depression	Intermittent?	1569335	5184450	Boggy depression with some surface water. No obvious flow	3	1.5	5	
53	Seep	Depression	Intermittent?	1569390	5184529	Dry depression, has been wet recently.	15	20	0	

54	Seep	Depression	Intermittent?	1569431	5184529	Boggy depression with some surface water. No obvious flow/	8	10	5		
55	Seep	Depression	Intermittent?	1569443	5184526	Multiple (15+) parallel strips of boggy depression with surface water (tyre marks?). Dimensions are average. Whole area between shed, hay bales and road (50x50m approx) very boggy. No obvious flow.	0.2	40	5		
56	Seep	Depression	Intermittent?	1569432	5184481	Boggy depression with some stagnant surface water. No obvious flow.	10	12	10		
57	Seep	Depression	Intermittent?	1569436	5184470	Ponding surface water with larger boggy area surrounding. No obvious flow.	7	20	10		
59	Seep	Depression	Intermittent?	1569462	5184421	Boggy depression with some ponding. (front pond in picture). No obvious flow.	8	2	5		
60	Seep	Depression	Intermittent?	1569447	5184401	Large boggy depression with ponding. (middle pond in picture). No obvious flow.	20	10	20		
61	Seep	Depression	Intermittent?	1569424	5184371	Boggy depression with some ponding. (far pond in picture). No obvious flow.	15	8	10		
62	Seep	Depression	Intermittent?	1569413	5184375	Boggy depression with some ponding. No obvious flow.	15	12	5		
63	Seep	Depression	Intermittent?	1569410	5184347	Patches of boggy depressions with surface water. No obvious flow.	8	3	5		

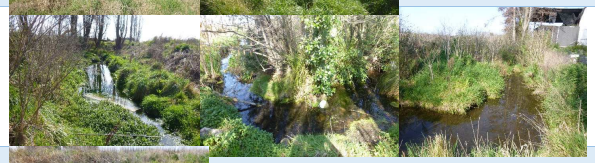
64	Seep	Depression	Intermittent?	1569402	5184346	Patches of boggy depressions with surface water (Left pond in picture). No obvious flow.	12	6	5	 
65	Seep	Depression	Intermittent?	1569397	5184336	Patches of boggy depressions with surface water (Right pond in picture). No obvious flow.	5	5	5	 
66	Seep	Depression	Intermittent?	1569444	5184354	Patches of boggy depressions with surface water. No obvious flow.	4	6	5	
67	Seep	Depression	Intermittent?	1569463	5184311	Patches of boggy depressions with surface water. Pz1 in this boggy area. No obvious flow.	30	30	5	  
68	Seep	Depression	Intermittent?	1569510	5184333	Large boggy depression with ponding. No obvious flow.	30	40	20	 
69	Seep	Depression	Intermittent?	1569524	5184334	Patches of boggy depressions with surface water. No obvious flow.	30	4	10	
70	Seep	Depression	Intermittent?	1569531	5184370	Multiple (15+) parallel strips of boggy depression with surface water. No obvious flow.	0.2	10	3	
71	Seep	Depression	Intermittent?	1569479	5184366	Patches of boggy depressions with surface water. 4 major areas of ponding. No obvious flow.	20	20	5	
72	Seep	Depression	Intermittent?	1569487	5184390	Patches of boggy depressions with surface water. No obvious flow.	3	4	5	

73	Seep	Depression	Intermittent?	1569467	5184385	Patches of boggy depressions with surface water. No obvious flow.	2	3	5	
74	Seep	Depression	Intermittent?	1569452	5184370	Patches of boggy depressions with surface water. No obvious flow.	1	0.5	5	
75	Spring	Artesian	Permanent	1569046	5184402	Spring - large pond in back section of property.	20	15	-	
76	Spring	Artesian	Permanent	1569059	5184258	Spring - piped under property by owner towards ponds at rear of section	-	-	-	
77	Spring	Artesian	Permanent	1569087	5184294	Spring - pond in back section of property	8	10	-	
78	Spring	Artesian	Permanent	1569138	5184374	Spring - pond in back section of property	6	8	-	
79	Spring	Artesian	Permanent	1569172	5184332	Spring - pond in back section of property	30	20	-	
Bh01	Bore	-	-	1569247	5184153	Old bore, flows when sluice valve opened - artesian. 6-8" diameter	-	-	-	
Bh02	Bore	-	-	1569104	5184401	Old bore in back section of lifestyle block. Didn't open.	-	-	-	

Cul_01	Culvert	-	-	1569618	5183717		-	-	-	
Cul_02	Culvert	-	-	1569321	5184029	No flow observed	-	-	-	
Pz01	Piezo	-	-	1569463	5184304	Piezo in SW corner of paddock, flowing artesian when cap pulled off. Surrounding area extremely boggy and includes large pond.	-	-	-	 
Pz02	Piezo	-	-	1569373	5184566	Peizo in NE corner paddock 5. Water depth approx 1m from lip of pipe.	-	-	-	
Pz03	Piezo	-	-	1569255	5184425	Piezo in NW corner paddock G	-	-	-	no image

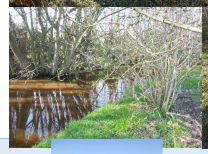
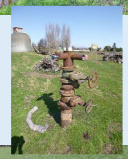
ID	Type	Morphology	Permanence	Easting	Northing	Description	Approx Width (m)	Approx Length (m)	Approx Depth (cm)	Photo
1	Spring	Depression	Permanent	1569606	5183711	Boggy, shallow pool in area planted with flax etc. Head of drain. Outflows into man-made drain cut towards Dudley drain.	1	8	9	
2	Spring	Depression	Permanent	1569596	5183745	Spring head next to playground. Rocks placed in spring, ponded water. Outflows N toward man-made channel.	2	2	10	
3	Seep	Depression	Intermittent?	1569596	5183745	Small damp spot , lacks spring vent, no flow.	1	3	3	
4	Seep	Depression	Intermittent?	1569548	5183752	Spring head amongst large boggy area.	1	2	5	
5	Spring	Artesian	Permanent	1569531	5183706	Spring head under wooden bridge, flows towards Spring 2, and joins before outletting to drain .Obvious flow.	3	3	10	
6	Spring	Depression	Permanent	1569495	5183733	Planted area around springs with ponded water. Surrounding planted area all boggy. Outlets to diversion drain (slight flow visible).	5	10	2	 
7	Seep	Depression	Intermittent?	1569567	5183776	Ponded water in rounded depression. No obvious flow.	8	8	5	
8	Seep	Depression	Intermittent?	1569578	5183818	Ponded water in elongated depression. No obvious flow.	4	13	6	

9	Spring	Linear/Channel	Permanent	1569337	5183973	SW end of manmade drain against embankment (on E side). Head of drain spring fed. Intersects with another small channel then connects into Tyson drain system 30m from head. Very slight flow only. Surrounded by boggy overgrown area 20m E and 50m to W. Shed with infilled yard to NW, filled area with vehicle access through a lot of area to SE. Stopbanks have been built up on SE of stream.	1.2	30	12		
10	Spring	Linear/Channel	Permanent	1569287	5183941	Head of another small drain that feeds into the start of Tysons Drain. Intersects perpendicular with the drain from spring 9. Very slight flow only.	0.8	15	15	 	
11	Spring	Linear/Channel	Permanent	1569456	5183948	Spring with very slight flow showing. Channel meanders back toward fill, outlets to Dudley drain.	1	1	10	 	
12	Spring	Linear/Channel	Permanent	1569352	5183934	Small depression with ponded water, no outflow. Boggy channel with reeds leads away from depression. Cut off by fill, no obvious flow.	2	5	10	  	
13	Seep	Depression	Intermittent?	1569336	5183871	Spring - ponded water and boggy area. Reeds, no obvious outflow.	10	15	10	 	
14	Seep	Depression	Intermittent?	1569391	5183837	Possible ephemeral spring area	30	30	0		628
15	Seep	Depression	Intermittent?	1569387	5183796	Head of spring area. All area vegetated, flow along side of cycleway 20m from edge of seal. No outflow present	2	5	4	 	
16	Seep	Linear/Channel	Intermittent?	1569410	5183775	Spring 15 water starts again	1.5	10	10		
17	Spring	Linear/Channel	Permanent	1569438	5183941	Spring, bubbling evident where fill diverts channel paths	0.5	4	40		

18	Spring	Linear/Channel	Permanent	1569480	5183931	Spring, some ponded water with larger 10x10m boggy area, no outflow	5	5	5	
19	Spring	Linear/Channel	Permanent	1569272	5183959	Source of Tyson's Drain (connects with several other small spring fed chaneels). Next to shed on infilled land. Some flow coming from PVC culvert. Good flow evident.	1.5	2	20	
20	Spring	Linear/Channel	Permanent	1539260	5183986	Another small drain feeding into the start of the Tysons Drain system.	1.2			
21	Spring	Artesian	Permanent	1569288	5184001	Whole area boggy, with a large spring pond. Slow moving flow evident, feeds into Tysons Drain	30	30	30	
22	Spring	Linear/Channel	Permanent	1569295	5184021	Boggy area with springs around S and E margins of compound. Flow moves from shed around a bend and then S along embankment and into Tysons drain system.	15	15	80	
23	Spring	Depression	Permanent	1569294	5184011	Boggy springy area	5	8	5	
24	Seep	Depression	Intermittent?	1569392	5184080	Depression with ponding water (stagnant). No obvious flow.	8	6	15	
25	Seep	Depression	Intermittent?	1569354	5184046	Ponding water in muddy depression in infilled area. Possible filled over spring. No obvious flow.	3	2	5	
26	Seep	Depression	Intermittent?	1569343	5184027	Ponding water in muddy depression in infilled area. Possible filled over spring. No obvious flow.	6	2	10	

27	Seep	Depression	Intermittent?	1569358	5184006	Ponding water in muddy depression in infilled area. Possible filled over spring. No obvious flow.	6	3	5	
28	Seep	Depression	Intermittent?	1569360	5184007	2 small areas of ponding water in muddy depression in infill area. Possible filled over spring. No obvious flow.	2	2	5	 
29	Seep	Depression	Intermittent?	1569375	5184015	Ponding water in muddy depression in infilled area. Possible filled over spring. No obvious flow.	1	1	3	
30	Seep	Depression	Intermittent?	1569373	5183969	Ponding water in muddy depression in infilled area. Possible filled over spring. No obvious flow.	2	4	6	
31	Seep	Depression	Intermittent?	1569571	5183878	Large area of standing water. Some bubbles in middle of pond, no outflow.	20	30	5	
32	Spring	Depression	Permanent	1569555	5183913	Large spring area. Very slight flow to man-made outlet channel.	20	20	5	  
33	Spring	Depression	Permanent	1569588	5183923	Small culvert (black plastic pipe) cuts across a small side junction to Dudley Drain - pipe broken, flow can be heard into pipe.	0.6	2	8	
34	Spring	Artesian	Permanent	1569651	5183957	Spring bubbling up in small pool, man-made cut leads to drain Dudley Drain	1	1	6	 
35	Spring	Artesian	Permanent	1569587	5183966	L shaped spring (artesian - bubbling up), flows into manmade drain Dr_C5, outletting to Dudley Drain	1	0.8	6	

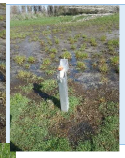
36	Spring	Depression	Permanent	1569551	5184038	Turbid spring area, connected to small man-made channel that cuts off and disappears. Slight flow N to S.	1.5	4	40	 
37	Seep	Depression	Intermittent?	1569547	5184094	Two thin strips of surface water, stagnant, no apparent flow.	0.4	6	3	
38	Seep	Depression	Intermittent?	1569512	5184089	Head of man-made drain flowing to Dudley Drain. Stagnant, little apparent flow.	0.7	1	5	 
39	Seep	Depression	Intermittent?	1569511	5184091	Isolated area of surface water, stagnant and boggy, no apparent flow.	0.4	2	3	
40	Spring	Depression	Intermittent?	1569480	5184090	Head of man-made drain flowing to Dudley Drain. Stagnant, little apparent flow. Large boggy area surrounding head, also boggy vegetated area for entire strip between two parallel drains	0.2	0.5	6	 
41	Spring	Depression	Intermittent?	1569426	5184086	Head of man-made drain flowing to Dudley Drain. Stagnant, little apparent flow. Large boggy area surrounding head, also boggy vegetated area for entire strip between two parallel drains	0.2	3	3	 
42	Spring	Artesian	Permanent	1569450	5184192	Large round depression. Spring - bubbling up evident. Flow to N towards drain.	4	2	7	 
43	Spring	Linear/Channel	Permanent	1569470	5184238	Source of Dudley drain - starts in NE corner of paddock, flows S towards diversion drain .	0.8	-	20	 
44	Seep	Depression	Intermittent?	1569288	5184117	Depression along NE edge paddock, seems dry, potentially been cut off by fill.	2	-	0	

45	Seep	Depression	Intermittent?	1569303	5184111	Small depression with surface water. No obvious flow	2	0.6	2	
46	Seep	Depression	Intermittent?	1569334	5184065	Land boggy and vegetation overgrown on NE bank of drain at SE border of paddock (along Tysons Drain edge). At SE end only.	6	20	2	 
47	Seep	Depression	Intermittent?	1569315	5184116	Surface water in tyre tracks, surrounding area quite boggy	6	2	5	
48	Seep	Depression	Intermittent?	1569387	5184154	N extent of boggy area with patches of water (starting at 46, 47). Further 20-30m of boggy land to SW and NE.	40	10	8	 
49	Seep	Linear/Channel	Intermittent?	1569344	5184208	Drain along poplars, dry most of length but becomes damp in corner of paddock	1	3	5	
50	Spring	Artesian	Permanent	1569345	5184324	Large depression, spring. Flows to ditch on W side of poplars, separated from the ditch on E side of trees. Small flow, very murky.	10	10	0.5	 
51	Spring	Linear/Channel	Permanent	1569240	5184248	Piped springs entering paddock	-	-	-	
52	Seep	Depression	Intermittent?	1569335	5184450	Boggy depression with some surface water. No obvious flow	3	1.5	5	
53	Seep	Depression	Intermittent?	1569390	5184529	Dry depression, has been wet recently.	15	20	0	

54	Seep	Depression	Intermittent?	1569431	5184529	Boggy depression with some surface water. No obvious flow/	8	10	5		
55	Seep	Depression	Intermittent?	1569443	5184526	Multiple (15+) parallel strips of boggy depression with surface water (tyre marks?). Dimensions are average. Whole area between shed, hay bales and road (50x50m approx) very boggy. No obvious flow.	0.2	40	5		
56	Seep	Depression	Intermittent?	1569432	5184481	Boggy depression with some stagnant surface water. No obvious flow.	10	12	10		
57	Seep	Depression	Intermittent?	1569436	5184470	Ponding surface water with larger boggy area surrounding. No obvious flow.	7	20	10		
59	Seep	Depression	Intermittent?	1569462	5184421	Boggy depression with some ponding. (front pond in picture). No obvious flow.	8	2	5		
60	Seep	Depression	Intermittent?	1569447	5184401	Large boggy depression with ponding. (middle pond in picture). No obvious flow.	20	10	20		
61	Seep	Depression	Intermittent?	1569424	5184371	Boggy depression with some ponding. (far pond in picture). No obvious flow.	15	8	10		
62	Seep	Depression	Intermittent?	1569413	5184375	Boggy depression with some ponding. No obvious flow.	15	12	5		
63	Seep	Depression	Intermittent?	1569410	5184347	Patches of boggy depressions with surface water. No obvious flow.	8	3	5		

64	Seep	Depression	Intermittent?	1569402	5184346	Patches of boggy depressions with surface water (Left pond in picture). No obvious flow.	12	6	5	 
65	Seep	Depression	Intermittent?	1569397	5184336	Patches of boggy depressions with surface water (Right pond in picture). No obvious flow.	5	5	5	 
66	Seep	Depression	Intermittent?	1569444	5184354	Patches of boggy depressions with surface water. No obvious flow.	4	6	5	
67	Seep	Depression	Intermittent?	1569463	5184311	Patches of boggy depressions with surface water. Pz1 in this boggy area. No obvious flow.	30	30	5	  
68	Seep	Depression	Intermittent?	1569510	5184333	Large boggy depression with ponding. No obvious flow.	30	40	20	 
69	Seep	Depression	Intermittent?	1569524	5184334	Patches of boggy depressions with surface water. No obvious flow.	30	4	10	
70	Seep	Depression	Intermittent?	1569531	5184370	Multiple (15+) parallel strips of boggy depression with surface water. No obvious flow.	0.2	10	3	
71	Seep	Depression	Intermittent?	1569479	5184366	Patches of boggy depressions with surface water. 4 major areas of ponding. No obvious flow.	20	20	5	
72	Seep	Depression	Intermittent?	1569487	5184390	Patches of boggy depressions with surface water. No obvious flow.	3	4	5	

73	Seep	Depression	Intermittent?	1569467	5184385	Patches of boggy depressions with surface water. No obvious flow.	2	3	5	
74	Seep	Depression	Intermittent?	1569452	5184370	Patches of boggy depressions with surface water. No obvious flow.	1	0.5	5	
75	Spring	Artesian	Permanent	1569046	5184402	Spring - large pond in back section of property.	20	15	-	
76	Spring	Artesian	Permanent	1569059	5184258	Spring - piped under property by owner towards ponds at rear of section	-	-	-	
77	Spring	Artesian	Permanent	1569087	5184294	Spring - pond in back section of property	8	10	-	
78	Spring	Artesian	Permanent	1569138	5184374	Spring - pond in back section of property	6	8	-	
79	Spring	Artesian	Permanent	1569172	5184332	Spring - pond in back section of property	30	20	-	
Bh01	Bore	-	-	1569247	5184153	Old bore, flows when sluice valve opened - artesian. 6-8" diameter	-	-	-	
Bh02	Bore	-	-	1569104	5184401	Old bore in back section of lifestyle block. Didn't open.	-	-	-	

Cul_01	Culvert	-	-	1569618	5183717		-	-	-	
Cul_02	Culvert	-	-	1569321	5184029	No flow observed	-	-	-	
Pz01	Piezo	-	-	1569463	5184304	Piezo in SW corner of paddock, flowing artesian when cap pulled off. Surrounding area extremely boggy and includes large pond.	-	-	-	 
Pz02	Piezo	-	-	1569373	5184566	Peizo in NE corner paddock 5. Water depth approx 1m from lip of pipe.	-	-	-	
Pz03	Piezo	-	-	1569255	5184425	Piezo in NW corner paddock G	-	-	-	no image