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Geological Survey Ireland

Report on the 2016 Rathcroghan Uplands Dye Tracing Programme

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1. Introduction

Since the 1980s, Geological Survey Ireland has undertaken a considerable amount of work developing Groundwater Protection Schemes throughout the country. Groundwater Source Protection Zones are the surface and subsurface areas surrounding a groundwater source, i.e. a well, wellfield or spring, in which water and contaminants may enter groundwater and move towards the source. Knowledge of where the water is coming from is critical when trying to interpret water quality data at the groundwater source. The 'Zone of Contribution' (ZOC) also provides an area in which to focus further investigation and is an area where protective measures can be introduced to maintain or improve the quality of groundwater.

Reports were prepared for the Corracreigh (Cloonyquin), Peak Mantua, Mid-Roscommon, Oran Ballintubber and Polecats Group Water Schemes (Kelly, *et al*, 2015; Meehan, *et al*, 2015) as part of the Rural Water Programme funding initiative of grants towards specific source protection works on Group Water Schemes (DECLG Circular L5/13 and Explanatory Memorandum). Recommendations from those reports included tracing from the Rathcroghan Uplands.

Funding was agreed to contribute to the tracing work and a report was prepared outlining the results of the tracing work conducted in 2015 (Kelly, *et al*, 2015). The report recommended additional tracing, in particular in the northern portions on the slopes to Peak Mantua and in the southern portion, north and west Oran Ballintubber and Carnalasson. This report details the tracing undertaken in 2016 and also provides updated Zones of Contribution to the sources based on the tracer testing work.

2. Physical Setting

The Rathcroghan Uplands is a relatively high plateau located in central County Roscommon, with elevations ranging between 40 – 150 m above sea level (**Figure 2-1**). The uplands generally receive around 800 mm of rainfall per year. There is a low density network of surface water rivers, streams and lakes on the plateau. This is because much of the rainfall infiltrates into the subsurface either 'diffusely' i.e. across the entire land surface due to the high permeability of the soils and bedrock, or at 'point locations'; *via* a series of swallow holes and reappears at the surface *via* a number of springs at the base. Several of these springs provide water to group water schemes including Polecats GWS, Peake-Mantua GWS, Corracreigh GWS, Mid-Roscommon GWS and Oran-Ballintubber GWS (**Figure 2-2**, **Figure 2-3**, **Figure 2-4**)

The bedrock geology described by Morris, *et al.,* (1999) consists predominantly of undifferentiated pure, bedded, karstified limestone with a relatively large number of mapped karst features that are critical to the hydrological and hydrogeological regime (**Figure 2-2**). The pure bedded limestones are classified as a Regionally Important Karst Aquifer dominated by conduit flow (**Rkc**). The main structural trend is southwest to northeast.

Deep, mineral, poorly drained, ('wet') soils are the dominant soils type across the area. Many areas of cutover peat, pockets of lacustrine clay and alluvium are also mapped. Glacial till ('boulder clay') deposits are the predominant subsoil type (**Figure 2-3**). Bedrock is generally close to the surface across the plateau.

Groundwater vulnerability is generally mapped as 'Extreme' across the majority of the area of the Rathcroghan Uplands, where bedrock is often close to surface and karst features (swallow holes, enclosed depressions and sinking streams) are present in abundance. In the northeast and the central portion of the area, where drumlins occur and where 'moderate' permeability till is present; the groundwater vulnerability is mapped as 'High'. Generally off the plateau and on the lower ground, 'Low' groundwater vulnerability is mapped due to the presence of thicker, 'low' permeability subsoil.

One of the assumptions made in understanding groundwater behaviour in the region is that the Rathcroghan Uplands is both a topographic/surface water divide and a groundwater divide (Hickey, 2009) with groundwater flow directions are expected to follow the topography. The results of tracing work carried out up to and including 2015, shown in **Figure 2-5**, demonstrate that this is largely the case. Each of the springs is fed by groundwater originating in the Uplands. There are traces which suggest that surface water and groundwater divides are not coincident in all cases, *e.g.,* traces to Corracreigh, Rathcarran and Donamon. The data also suggest that each of the main springs is fed by a specific zone of contribution. There are gaps in the data, *e.g.,* Peake Mantua and Polecats whereby it is unknown where their zones of contribution occur.

In order to better understand in detail groundwater flow on each side of the uplands area, and to improve the zones of contribution, further, trace studies were implemented.

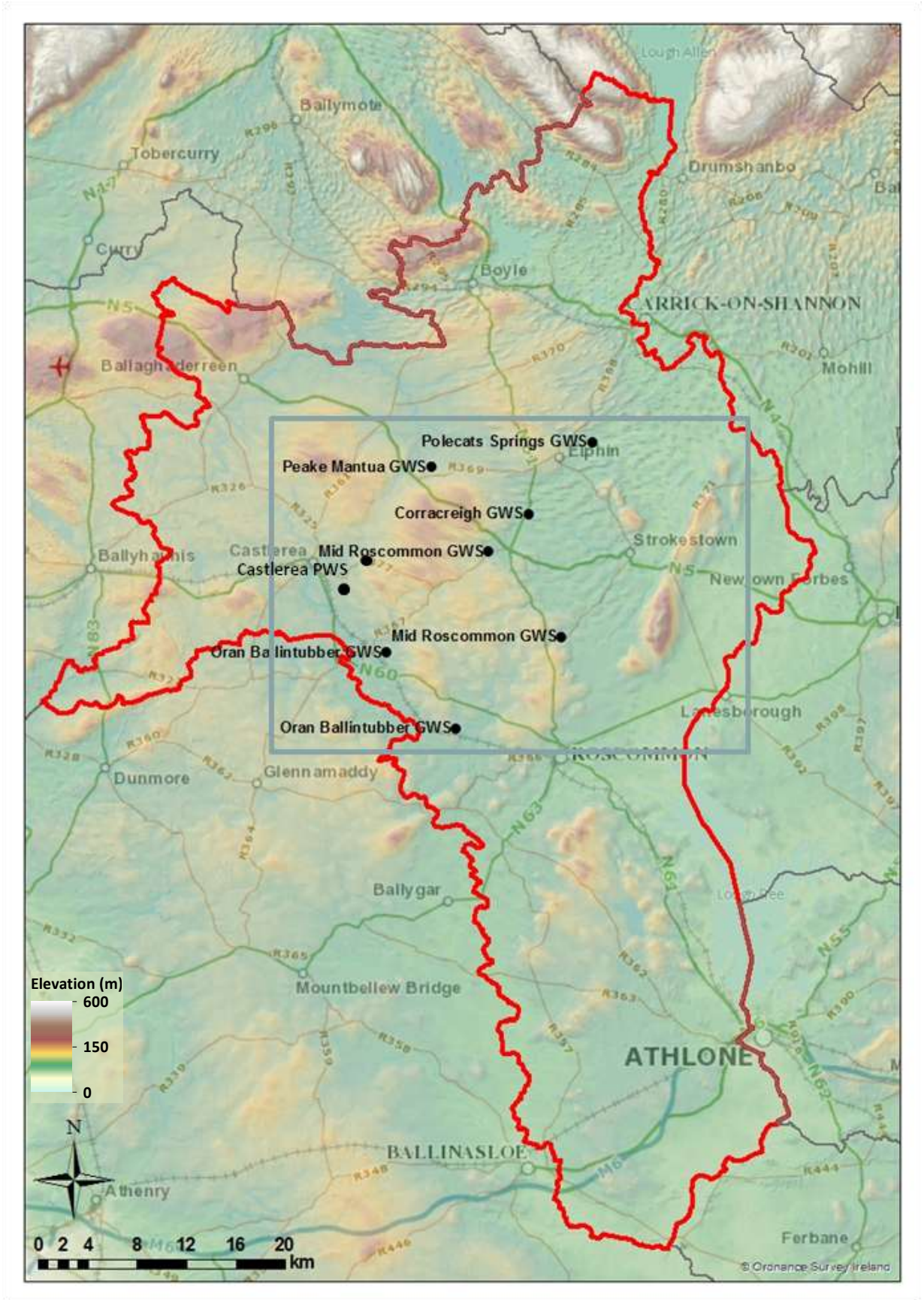

Figure 2-1 **Location and topography of the Rathcroghan Uplands, County Roscommon**

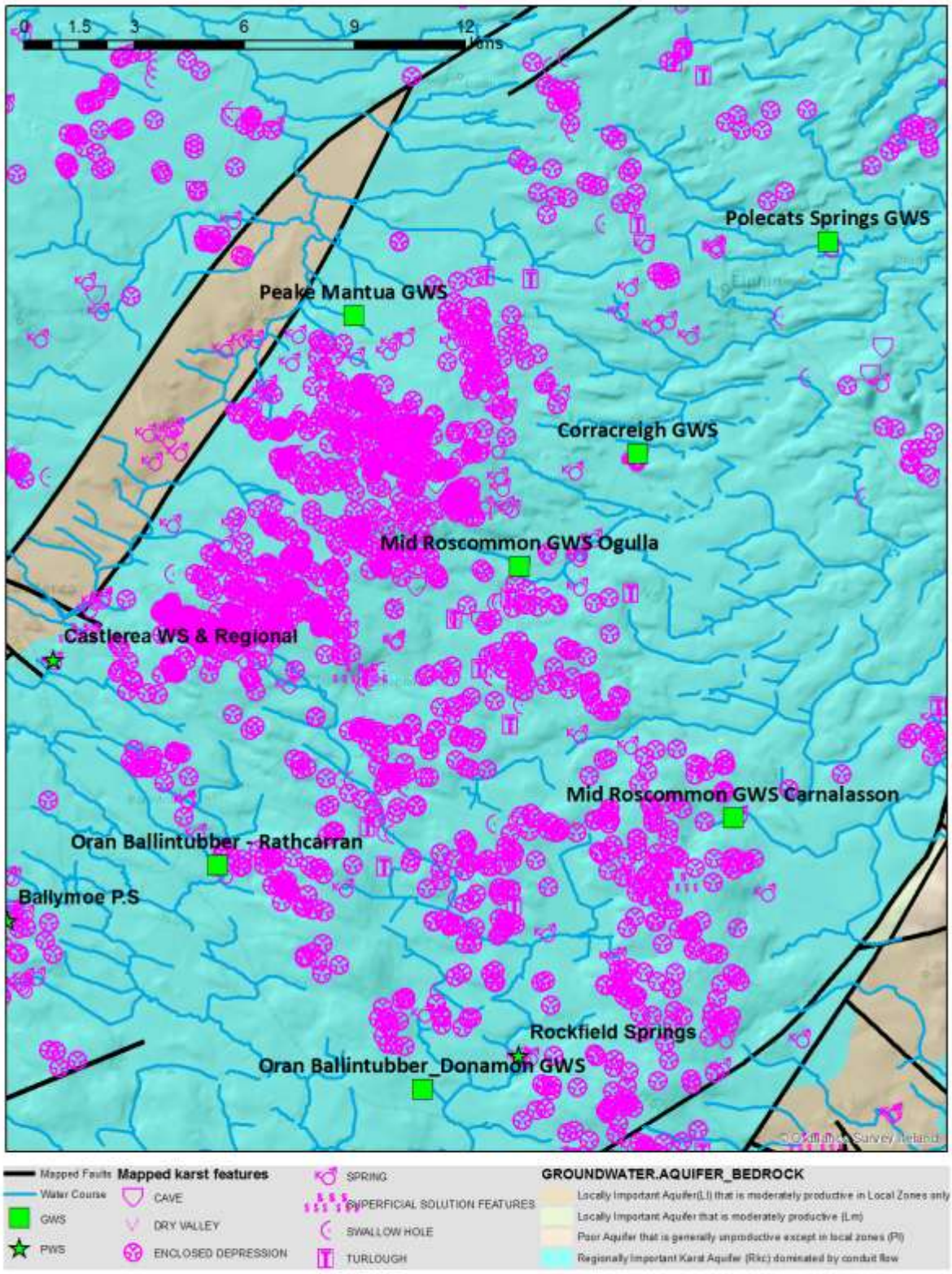

Figure 2-2 **Mapped bedrock aquifer and karst features across the Rathcroghan Uplands**

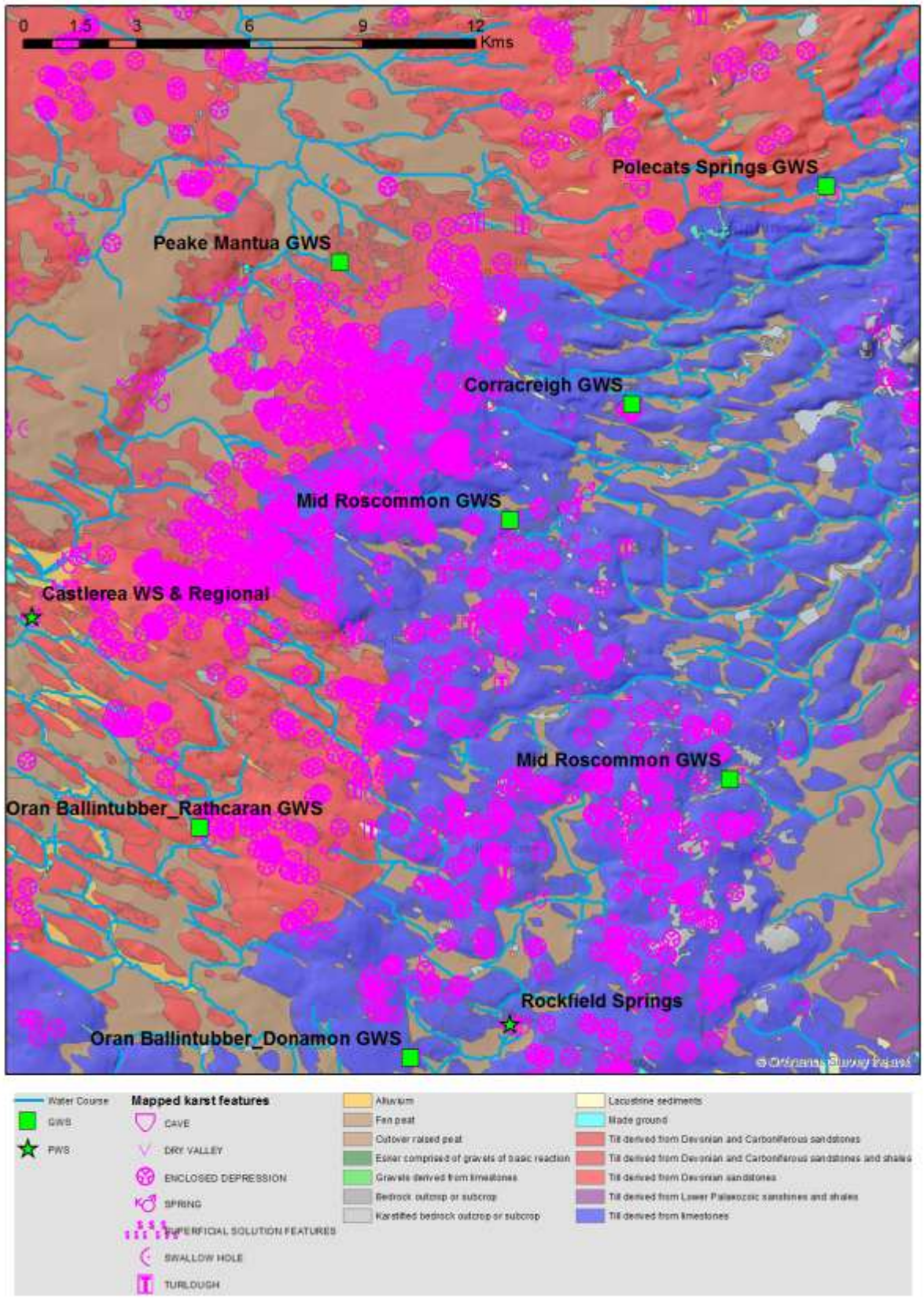

Figure 2-3 Mapped subsoils across the Rathcroghan Uplands

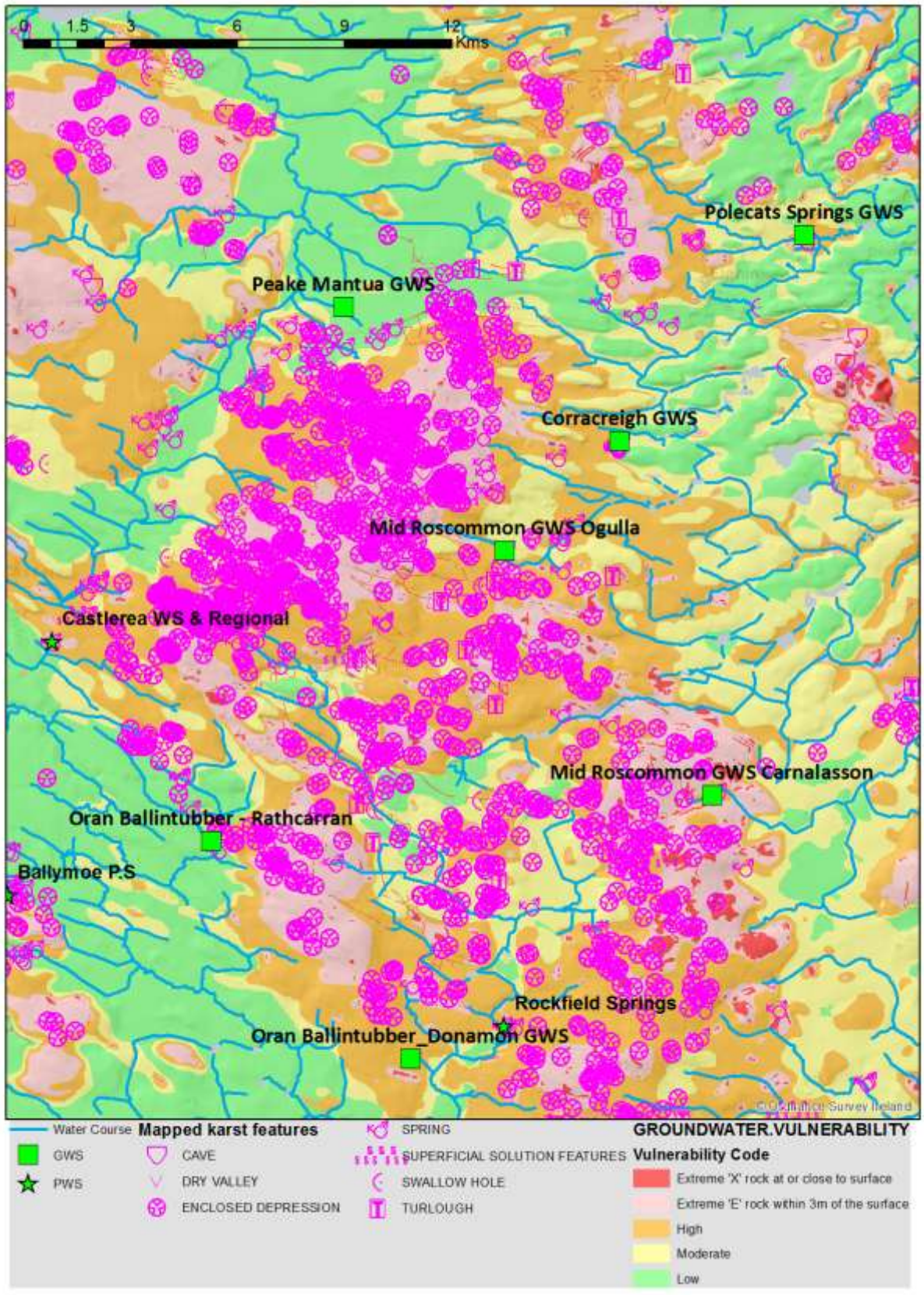

Figure 2-4 **Mapped groundwater vulnerability across the Rathcroghan Uplands**

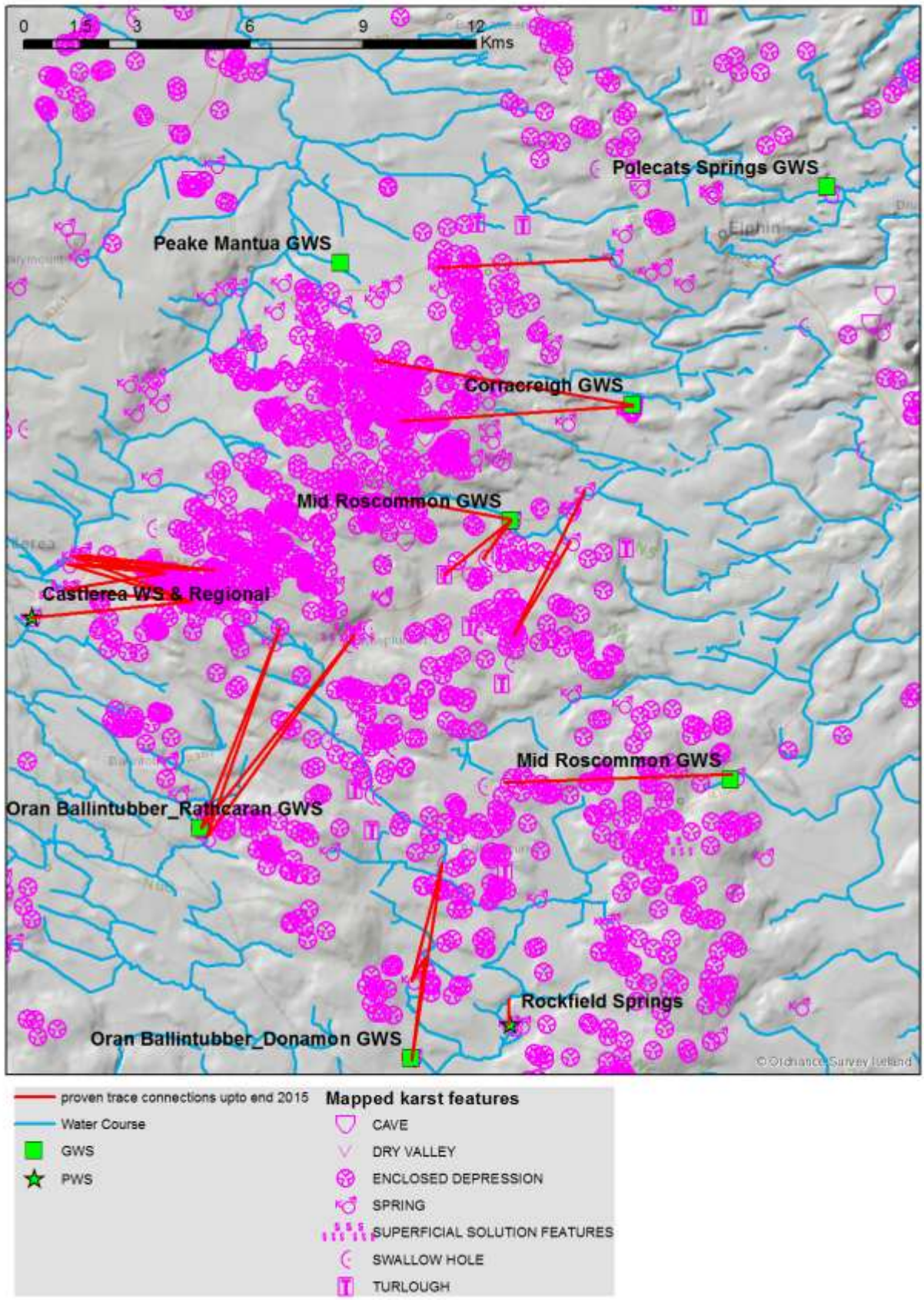

Figure 2-5 Trace lines up to end 2015

3. Tracing 2016

Tracing was carried out in the following locations (**Figure 3-1**).

- A swallow hole in Carrowreagh (Ballintubber) – approximately 5 km northeast of Rathcarran and due west of Carnalasson;
- A swallow hole in Carrowreagh/Rathkineely, in the vicinity of the N5, 2 km south of Peak Mantua;
- Pollhesby swallow hole in Runnaboll, 8.5 km northwest of Polecats GWS; and,
- Pollcartron swallow hole in Carrownurlar/Emlagh, 2 km southwest of Polecats GWS.

The tracing was conducted in June, July and October 2016. Summary details including dye types and amounts used are provided in **Table 3-1**. The sampling strategy included the selection of suitable possible outlets where the dyes might appear, selecting the appropriate sampling frequency for each one, and mobilisation of equipment. This was completed according to Geological Survey Ireland's good practice and experience. The sampling locations for the traces are shown in **Figure 3-1**. All possible springs, including those of the group water schemes were identified through desk studies and walkovers. The sites were sampled using opaque glass bottles to take water grab samples, and *via* the placement of activated charcoal and unbleached cotton wool detectors.

Table 3-1 Dyes and amounts for the traces undertaken as part of GW3D

Location	GSI Karst Database Feature No.	Date	Time	Weather	Flow	Dye input	Dye amount
Carrowreagh/Rathkineely	1727NWK188	15/06/2016	16:30	Dry, overcast	flowing	Rhodamine	10 L
Carrowreagh (Ballintober)	1727NWK315	21/07/2016	16:30	Dry, overcast	flowing	Rhodamine	10 L
Pollhesby	1729SWK045	17/10/2016	15:20	Dry, overcast	flowing	Rhodamine	5 L
Pollcatron	1727NEK013	17/10/2016	16:05	Dry, overcast	flowing	Fluorescein	1.2 L

The road improvement project being undertaken in relation to the N5 National Route study includes an investigation of the hydrogeology in the vicinity of the road. The project consultants, in consultation with Geological Survey Ireland, undertook dye tracing in the vicinity of the proposed road corridor, shown in **Figure 3-1**, which comprised:

- A repeat of the 2015 trace from Polloweneen swallow hole, 10.5 km west of Polecats GWS; and,
- A swallow hole, in Lugboy, 3 km southeast of Elphin and 3.5 km south of Polecats GWS.

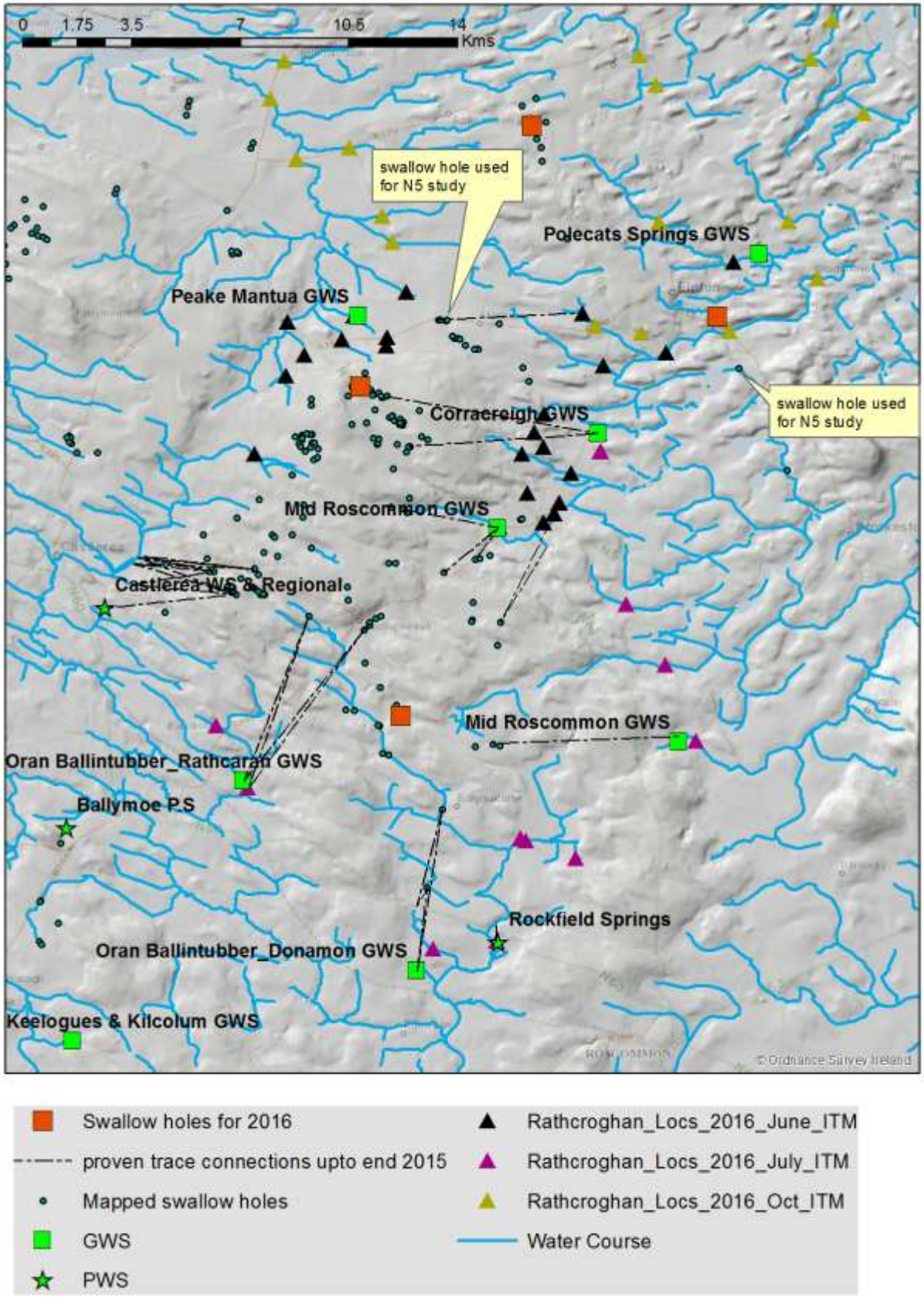

Figure 3-1 Locations of input and monitoring points

4. Results 2016

Positive traces from the GW3D programme and the study for the N5 were proven to Polecats GWS, Rathcarran Springs (Oran Ballintubber GWS), Peake Mantua and Corracreigh GWSs and other smaller unnamed springs (**Figure 4-1**). The positive traces were rapid, appearing in the springs within days.

GW3D traces:

- The input to a swallow hole in Carrowreagh (Ballintubber) was traced to both:
  a. Rathcarran Springs and
  b. a spring upgradient of them (greater than 80 m/hr; approximately 3 days).

- The input to swallow hole in Carrowreagh/Rathkineely, in the vicinity of the N5, 2 km south of Peak Mantua, was traced to:
  a. Peak Mantua GWS spring (2 days to arrive; greater than 60 m/hr); and
  b. a small spring upgradient and approximately 1 km south of Peak Mantua spring in Carrowreagh (1 day, greater than 60 m/hr); and,
  c. Corracreigh GWS spring approximately 4 to 5 days to arrive at Corracreigh (80 m/hr) approximately 8 km east.

  This trace indicates groundwater flowing both north and east, though the proportion flow to Peak Mantua is considered to be greater due in part to the discolouration of the Peak Mantua spring and a smaller spring upgradient.

- The input to Pollhesby swallow hole in Runnaboll, 8.5 km northwest of Polecats GWS arrived at Polecats Spring (greater than 70 m/hr; approximately 5 days).

- The input to Pollcartron swallow hole in Carrownurlar/Emlagh, 2 km southwest of Polecats GWS, arrived at Polecats Spring (greater than 30 m/hr; approximately 3 days).

N5 study traces:

- The trace from Polloweneen swallow hole, 10.5 km west of Polecats GWS arrived at Polecats spring (approximately 40 m/hr; approximately 12 days).
- The trace from a swallow hole, in Lugboy, 3 km southeast of Elphin and 3.5 km south of Polecats GWS tested positive from a sample at Drumullin Bridge on the Owenrur river (approximately 15 days). The samples taken upstream of Drumullin Bridge at Ballyslish Bridge were all negative. It is likely that the dye arrived at a spring on the banks of the Owenrur River between these two bridges or into the river itself.

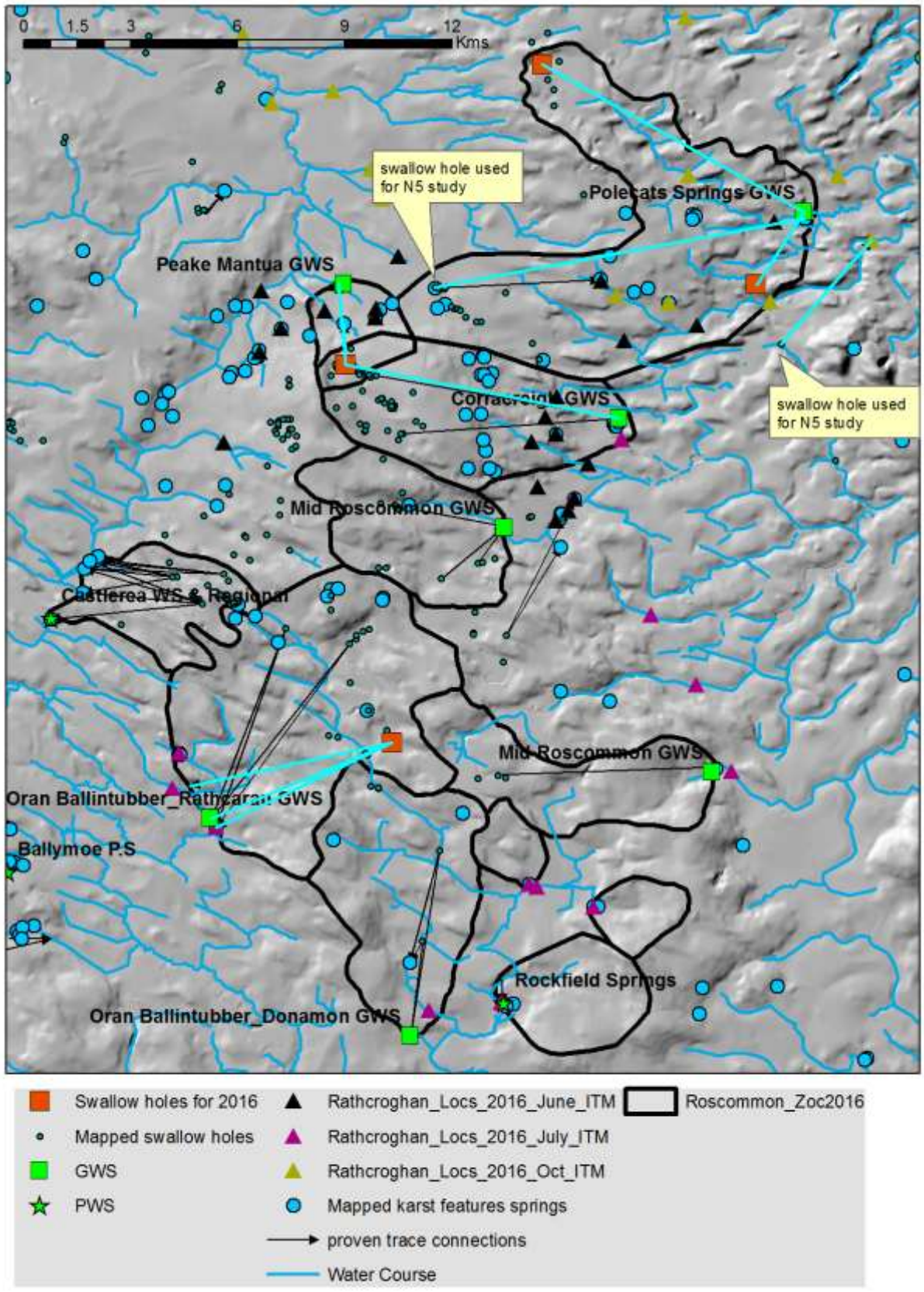

Figure 4-1 **Redefined Zones of Contribution and All traces to end 2016 (highlighted in cyan are 2016 traces)**

5. Discussion

The tracing to date provides a great deal of information on the overall groundwater flow directions to the main springs and enables the previously delineated zones of contribution (ZOC) to be updated with greater confidence, though there are still uncertainties. The redefined ZOCs are given in **Figure 4-1**.

Corracreigh GWS: The traces indicate that the groundwater catchment extends westwards beyond the surface water/topographic catchment, which shows that the groundwater flow directions in the Rathcroghan Uplands are not wholly related to topography. Consequently, the surface river catchments cannot be delineated by topographical divides alone, if they are to take into account their groundwater inputs. The zone of contribution is approximately 25.5 km^2.

Oran Ballintubber (Rathcarran and Donamon) GWS: The traces indicate that the groundwater catchment extends northwards for Rathcarran beyond the surface water/topographic catchments, indicating that the groundwater flow directions in the Rathcroghan Uplands are not wholly related to topography. Consequently, the surface river catchments cannot be delineated by topographical divides alone, if they are to take into account their groundwater inputs. The zone of contribution is approximately 45.5 km^2.

The traces also indicate a convergence on the Rathcarran springs. Updating the catchment to Rathcarran influences the previous zone of contribution delineated for Donamon, although not significantly. However, there is still uncertainty regarding the boundary between Rathcarran and Donamon ZOCs in the vicinity of Carrowreagh, Rathnalulleagh and Peak.

Peak Mantua GWS: The traces indicate that the groundwater catchment is smaller than previously delineated. The zone of contribution is approximately 6 km^2 and the southern portion of it overlaps with the catchment to Corracreigh.

Polecats GWS: The traces indicate that the groundwater catchment is larger than previously delineated, in particular, extending the catchment southwest. The zone of contribution is approximately 52 km^2. Similar to Corracreigh and Rathcarran there are number of springs in close proximity and there is a large groundwater discharge in the area of the springs.

Mid-Roscommon (Ogulla and Carnalasson) GWS: The traces indicate that the groundwater catchment for Ogulla includes 'Area 1 and Area 2a' (Meehan, *et al*, 2015). The 'Area 2b' does not appear to contribute groundwater to Ogulla; part of it is included in the catchment to Rathcarran. The ZOC is approximately 17 km^2. The ZOC to Carnalasson is unchanged from the previously delineated catchment. None of the tracing appears to have arrived at Carnalasson.

Water balance calculations are used to support the hydrogeological mapping and to confirm that the ZOC delineated is big enough to supply the quantity of water at the source. All of the ZOC areas are larger than what is required to meet the respective abstractions. However, the ZOC areas will relate to the total spring discharge and the important unknown is the mean flow from the springs (abstraction plus overflow), which may need to include the other large springs that occur in close proximity to the main abstraction springs, as well as the springs that occur in the low-lying areas around the perimeter of the Rathcroghan Uplands.

6. Conclusions & Recommendations

The tracing results from the work done through 2015 and 2016 have been successful and have enabled the zones of contribution to the GWS springs to be updated with significantly more confidence. Whilst there are uncertainties with some of the boundaries the zones of contribution are reasonably well detailed. The zones of contribution have also been updated on the Geological Survey Ireland's website.

Further tracing in a number of areas would improve the zones of contribution, *e.g.*, Brierfield Turlough (west of Castleplunket Turlough); other swallow holes on the plateau; and, from swallow holes close to the boundary between the zone of contribution to Rathcarran and Donamon. This latter trace is intended to be conducted during 2017 by the Geological Survey to assist the recently established Groundwater Flooding project that includes Castleplunket Turlough. This work will include flow gauging, tracing in the area of the boundary between the zone of contribution to Rathcarran and Donamon.

7. Costs

Contractors' time amounted to over 55 days in 2016 and is approximately €13,500. It does not include Geological Survey time or expenses. The dye and material costs is approximately €2,000. The NRWSC/NFWS contribution as agreed was €4,000.