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Understanding gravel dynamics with a focus on the success of gravel augmentation as a restoration technique.

UNDERSTANDING GRAVEL DYNAMICS WITH A FOCUS ON THE SUCCESS OF GRAVEL AUGMENTATION AS A RESTORATION TECHNIQUE

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Introduction: Dams and gravel

- Fragmentation
- Depletion of gravel beds
- Impact on salmonid spawning
- Gravel augmentation

Avon Dam

River Avon – Didworthy reach

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Aim of the project

To monitor gravel movement following augmentation to guide future gravel introductions on the River Avon, Devon England and other impounded Dartmoor rivers

Introduction: Gravel augmentation

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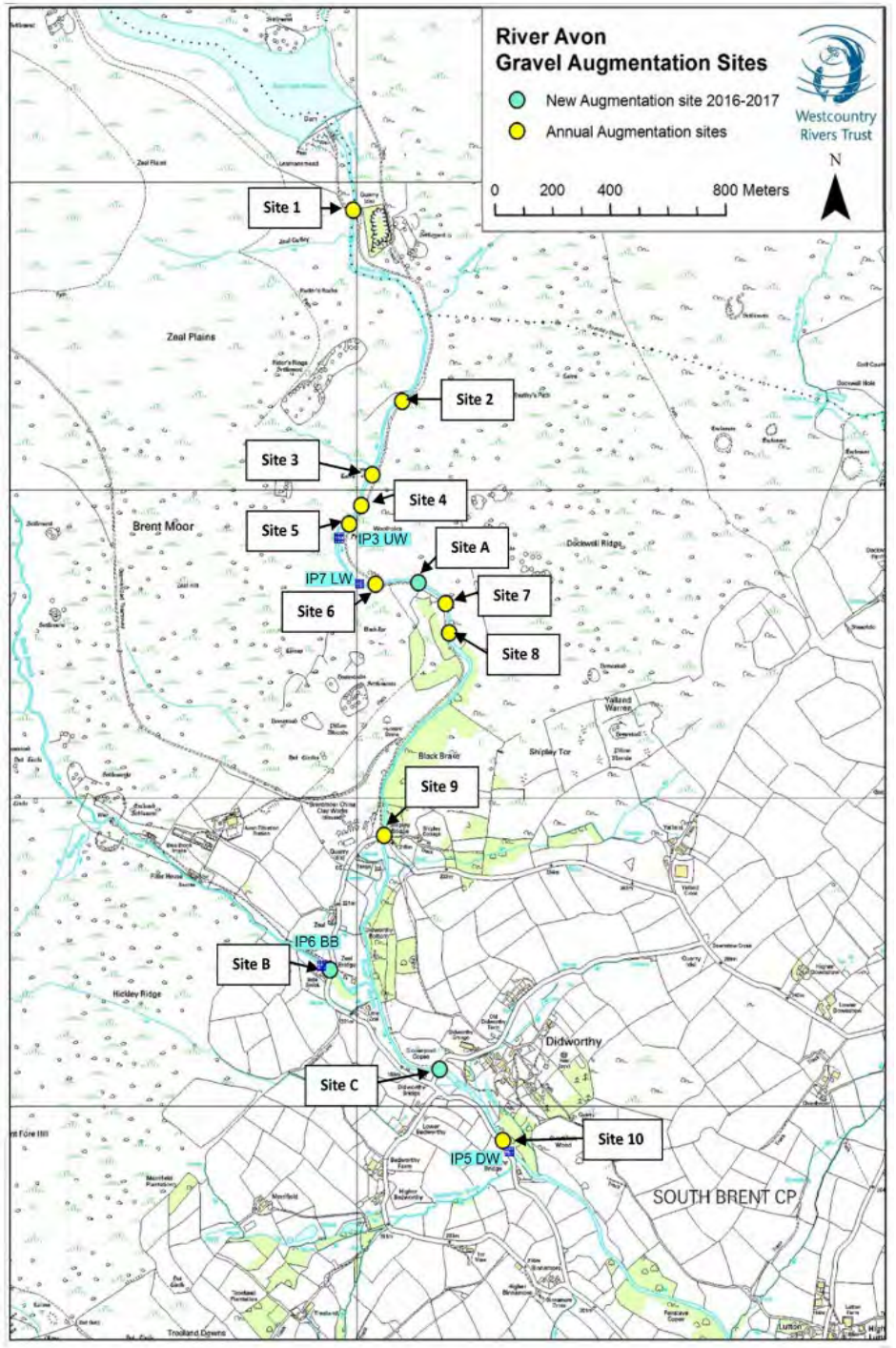
Augmentation sites, augmentation dates and tonnage

Site Code	Site name	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	Total (tonnes)
1	Top bridge	-	25	20	40	40	40	160
2	Riders Rings	-	6	3	-	-	-	9
3	Weir	-	30	20	40	40	40	170
4	Woolholes 1	-	15	20	-	-	-	35
5	Woolholes 2	-	5	20	-	-	-	25
6	Woolholes Bridge	-	3	14	30	30	30	107
7	Big Pool	-	10	8	10	10	-	38
8	Black Tor	-	35	15	10	10	20	90
9	Shipley Bridge	-	5	24	60	20	20	129
10	Badworthy	26	42	30	40	30	30	198
A	Below Woolhole Bridge	-	-	5	-	-	-	5
B	Zeal (Bala Brook)	-	-	7	20	40	40	107
C	Didworthy Bridge	-	-	14	50	-	-	64
	Total	26	186	200	300	220	220	1252

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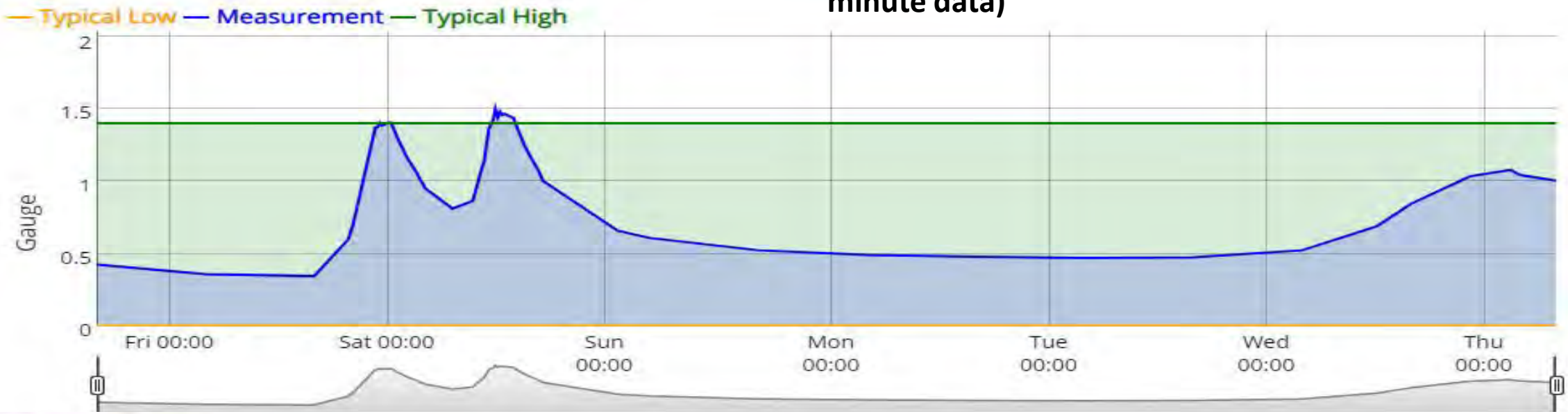
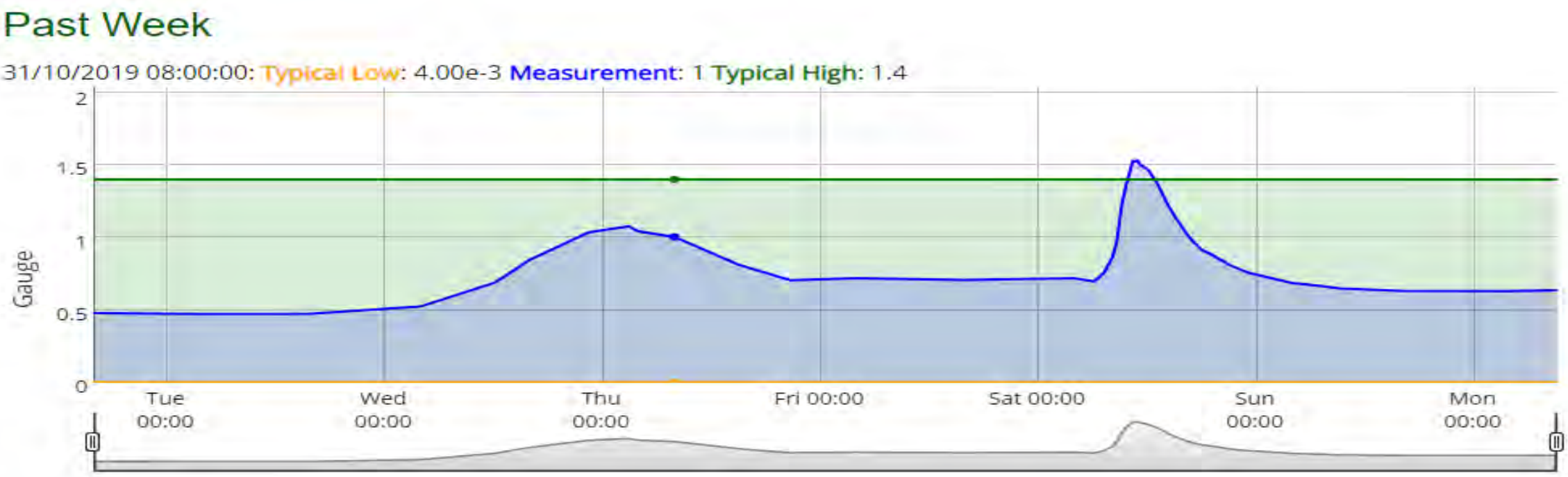
Floods of 26th and 31st October and 2nd November 2019 (EA 15 minute data)





Methods: Approach

1. To examine reach-scale gravel dynamics using RFID tagging of particles
2. To map and audit river-scale gravel habitat dynamics
3. To determine process-controls on timing on gravel dynamics via impact plates

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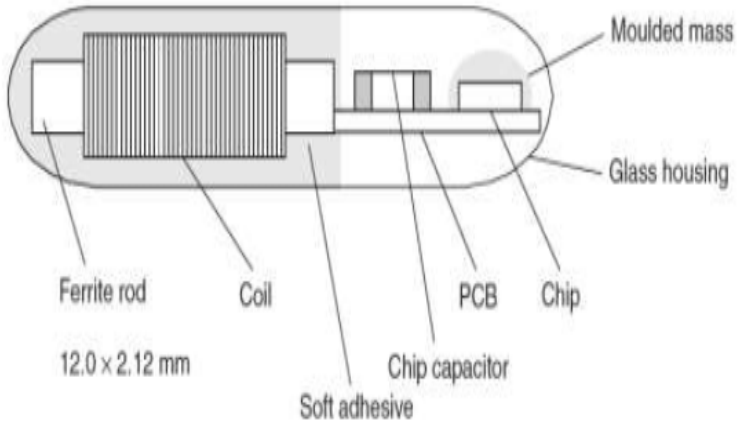
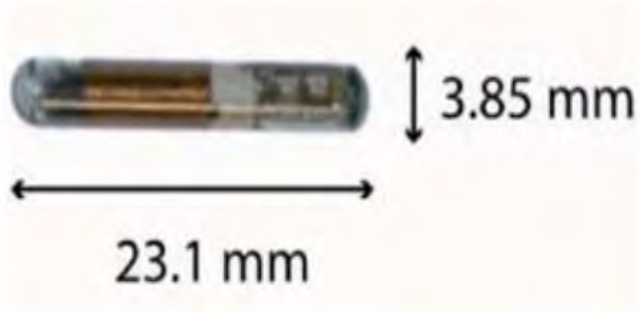
Methods (1): RFID tagging





Reach	Date of introduction	Number of tagged particles
Woolholes	28/10/2014 and 06/11/14	149
	19/09/2016	200
	18/10/2018	200
Didworthy	28/10/2014 and 06/11/14	120
	08/10/2016	200
	18/10/2018	200

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Methods (1): RFID detection

- PIT/RFID tag reader
- Range approx 0.45m from tagged particle
- Location using Trimble

  Geo 7X GPS and

  Flightwave™ ranger

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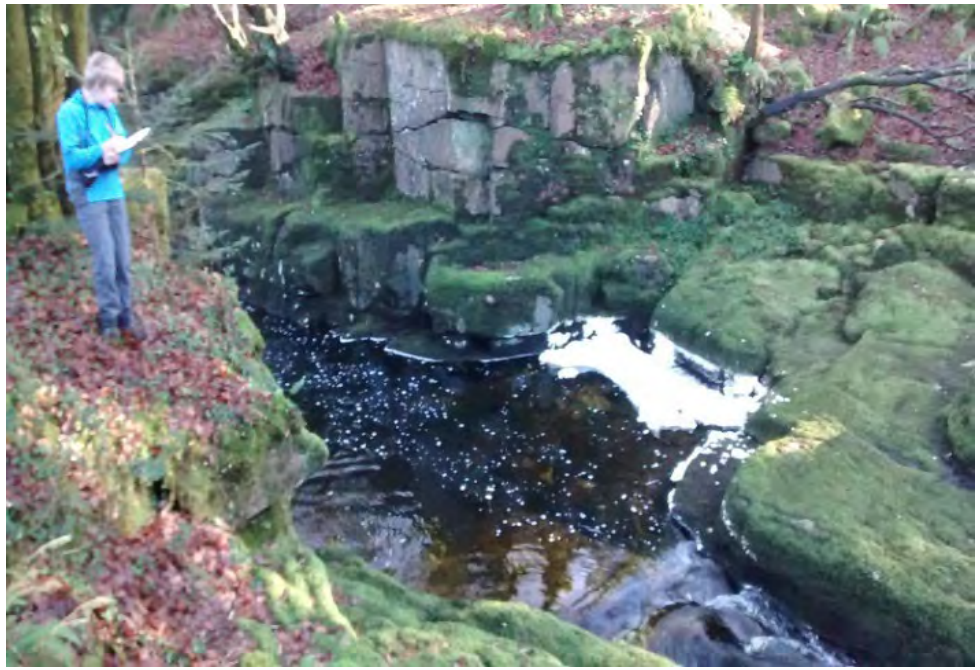
Methods (2): Fluvial Audits

Walk over surveys (Hand-held Trimble GPS)

- Size of gravel deposits (Very Large-very small)
- Location (Left bank, Bed, Right bank)
- Above/below water line



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Methods (2): Fluvial audits

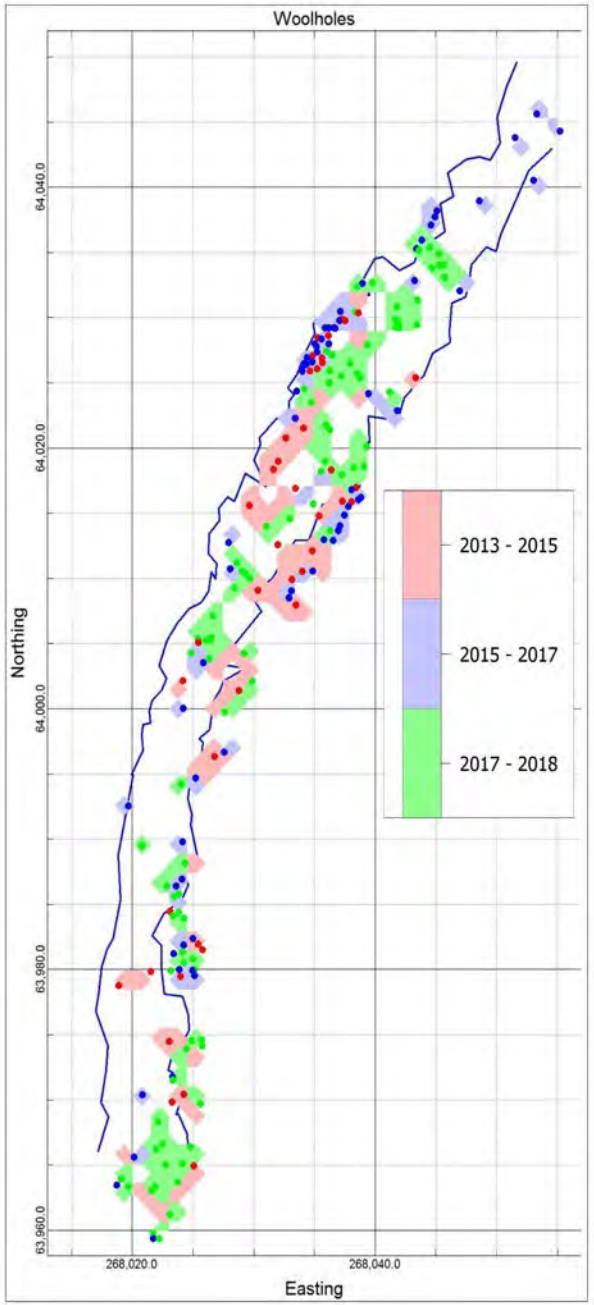
Reach	Reach description	Distance from dam(m)	Reach Length (m)
Reach 1	Top bridge to weir	369-1610	1241
Reach 2	Weir to Woolholes Bridge	1611-2144	533
Reach 3	Woolholes Bridge to Big Pool	2145-2373	228
Reach 4	Big Pool to Shipley Bridge	2374-3483	1109
Reach 5	Zeal bridge, Bala Brook to Avon Confluence	N/A	182
Reach 6	Shipley Bridge to Didworthy	3484-4914	1430
Reach 7	Didworthy to start of Penstave Copse	4915-5797	882

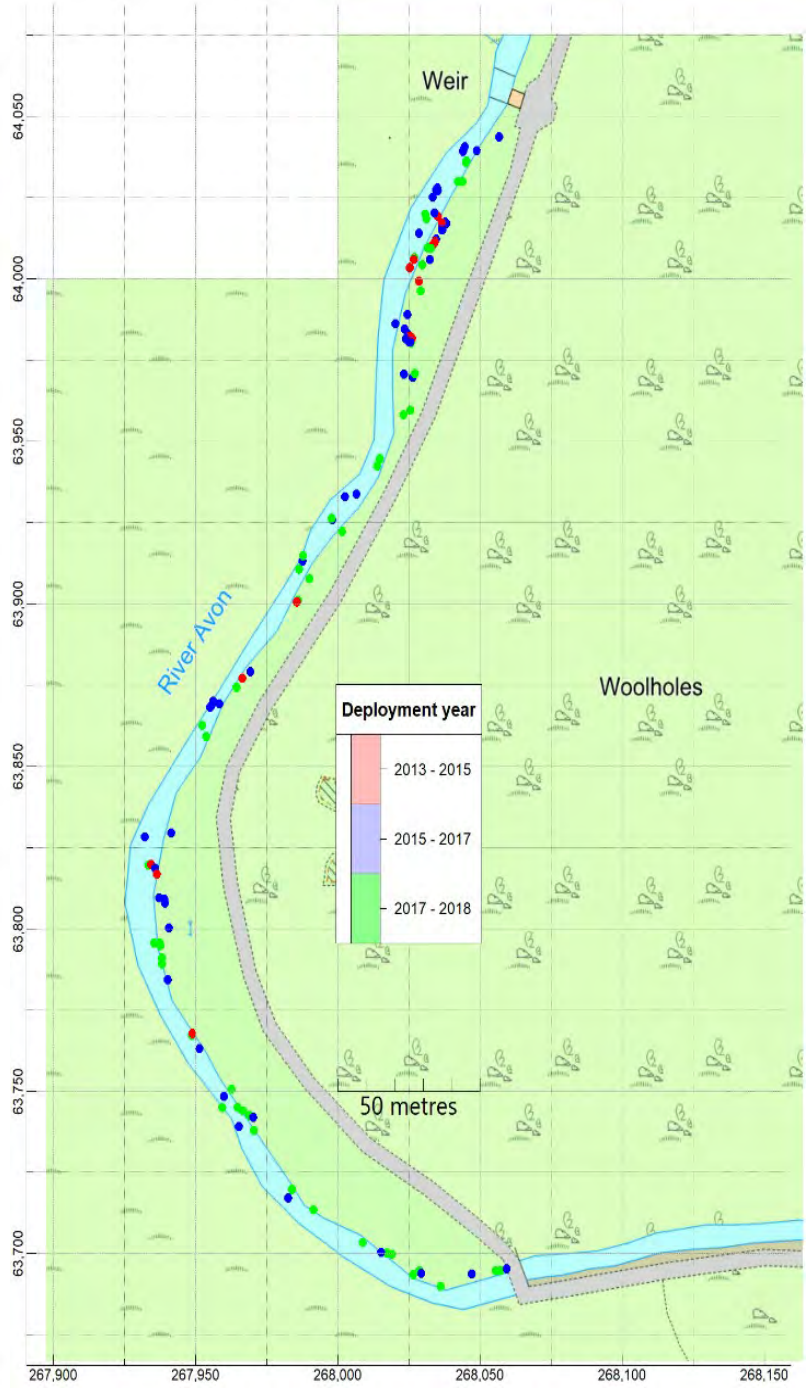
Methods (3): Impact Plates

- 150 x 130 x 6 mm steel top plate mounted onto a paving slab
- Impact > 10 mm recorded.
- Record at 5 Hz (*i.e.*, 5 particles per second)
- Logging 64,000 pre-defined periods (maximum of 255 counts in each period)
- Set at 2.5 minute intervals. Downloading interval < 3.5 months.

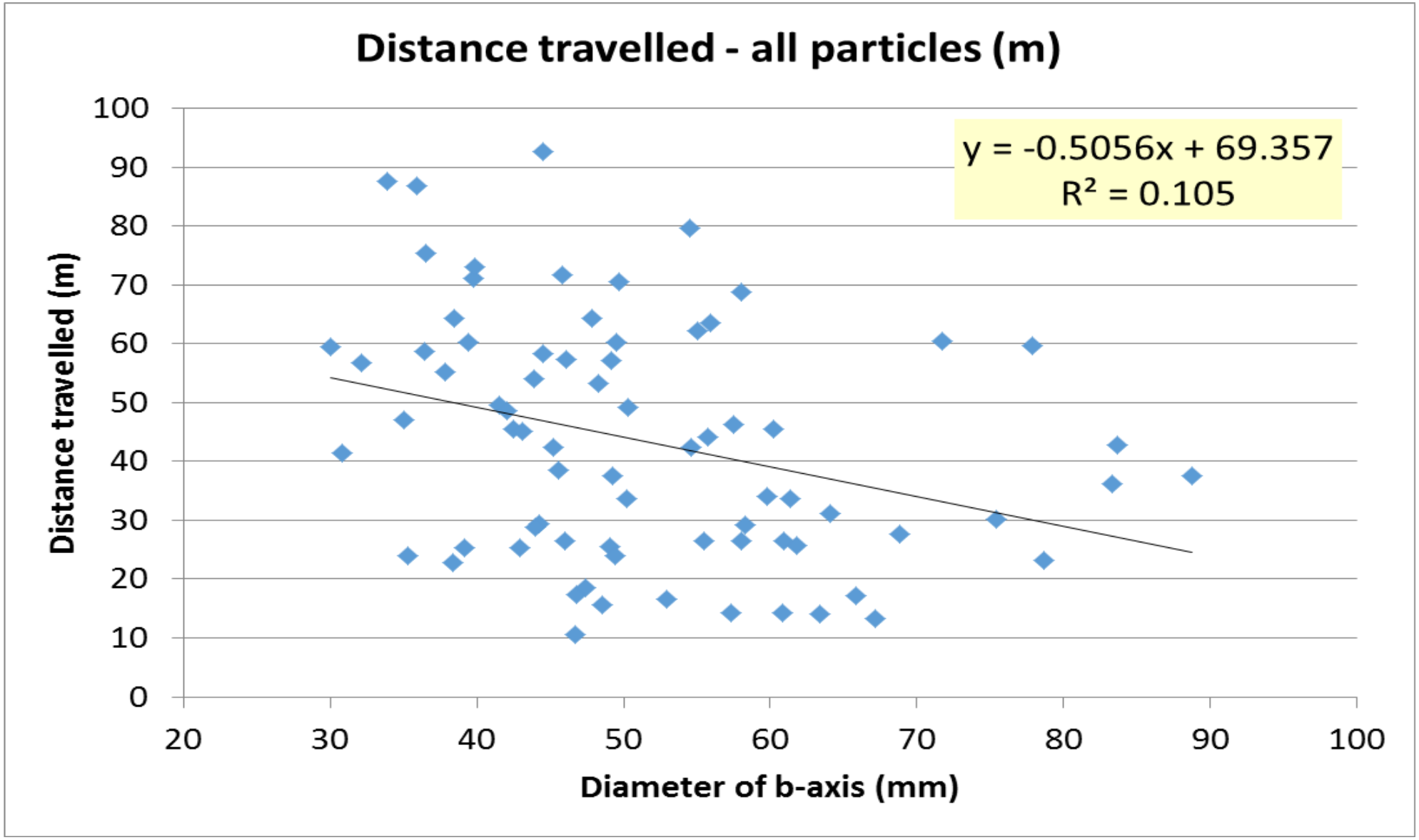
Results: dispersal and fate Woolholes reach

		Distance in metres (change from previous survey)			
Site survey	Number of Tags/recovery rate	Minimum	Mean	Maximum	Notes
Woolholes June 2017	107 (30.6%)	0.7	34.3	156.1	
Woolholes February 2018	84 (24.0%)	4.9	60.3 (+26)	157.9 (1.8)	
Woolholes January 2019	199 (36.0%)	0.2	102.3 (+42)	359.7 (201.8)	
Woolholes June 2020	117 (21.3%)	2.9	158.3 (+56)	354.1 (-5.8)	
Didworthy June 2017	77 (23.4%)	4.9	60.4	157.9	
Didworthy February 2018	35 (10.6%)	6.03	26.9 (-32.9)	58.6	Survey curtailed due to snowfall
Didworthy January 2019	200 (37.8%)	5.38	141.2 (+114.7/+54.3)	416.0 (357.4/226.1))	
Didworthy July 2020	108 (20.4%)	5.82	168.2 (27m)	457.8) (41.8)	

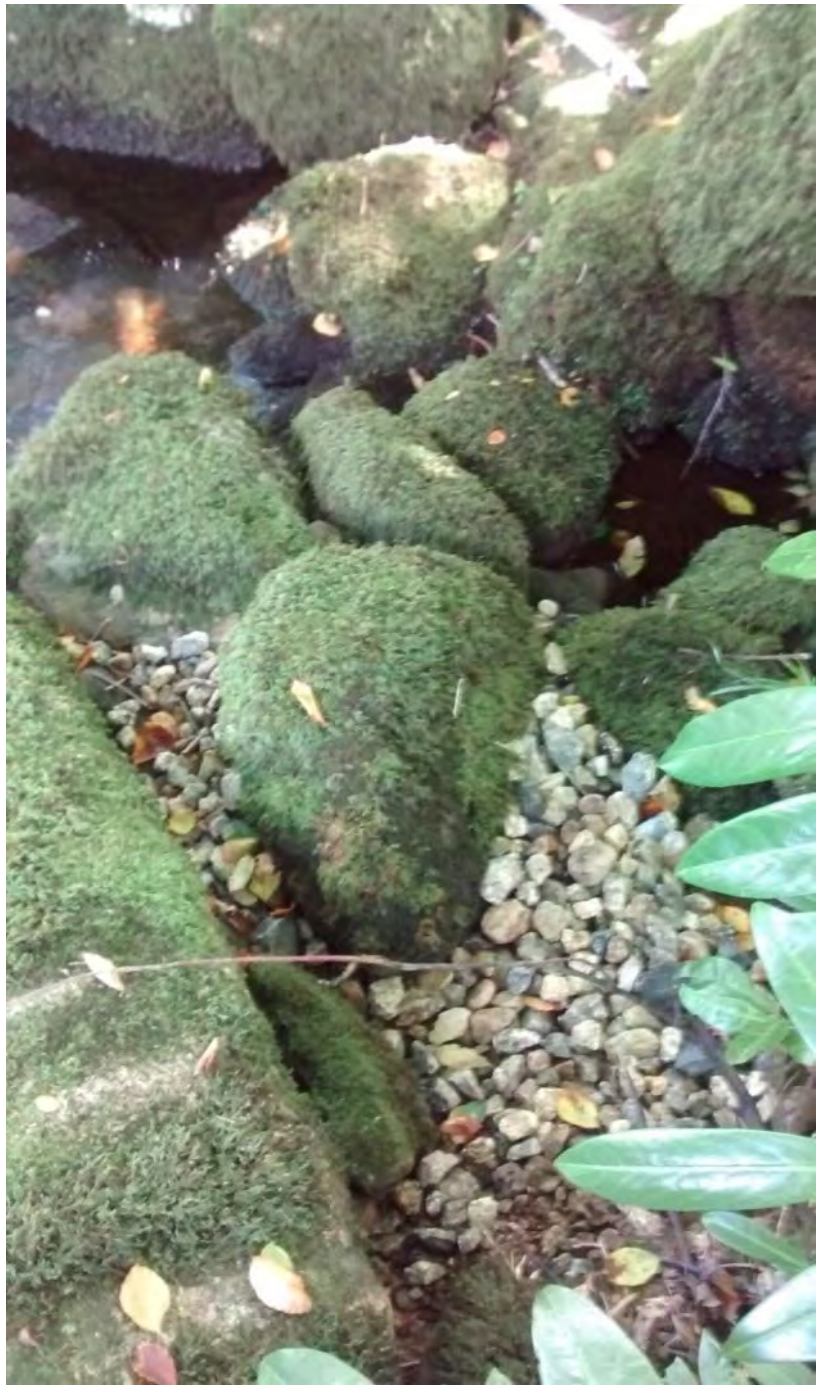




Results – RFID gravel dispersal



Results - Gravel deposit dispersal and fate



Results: Gravel deposits fate

Reach/ Survey Date	Reach 1	Reach 2	Reach 3	Reach 4	Reach 6	Reach7	Total number of gravel patches (% change since previous survey)
October 2016	32(26)	25 (47)	23 (100)	40 (36)	28 (22)	35 (39)	183
December 2016	40(32)	43 (81)	18 (78)	27 (24)	33 (23)	51 (58)	212 (+29)
July 2017	73 (58)	96 (180)	21 (92)	79 (71)	80 (56)	97 (109)	446 (+234)
February 2018	101 (81)	122 (228)	43 (186)	178(160)	216 (151)	168 (190)	828 (+382)
April 2019	242 (195)	159 (298)	65 (285)	256(230)	290 (202)	290 (348	1302 (+474)
May 2020	197 (159)	209 (392)	76 (333)	287 (258)	234 (163)	189 (226)	1192 (-110)

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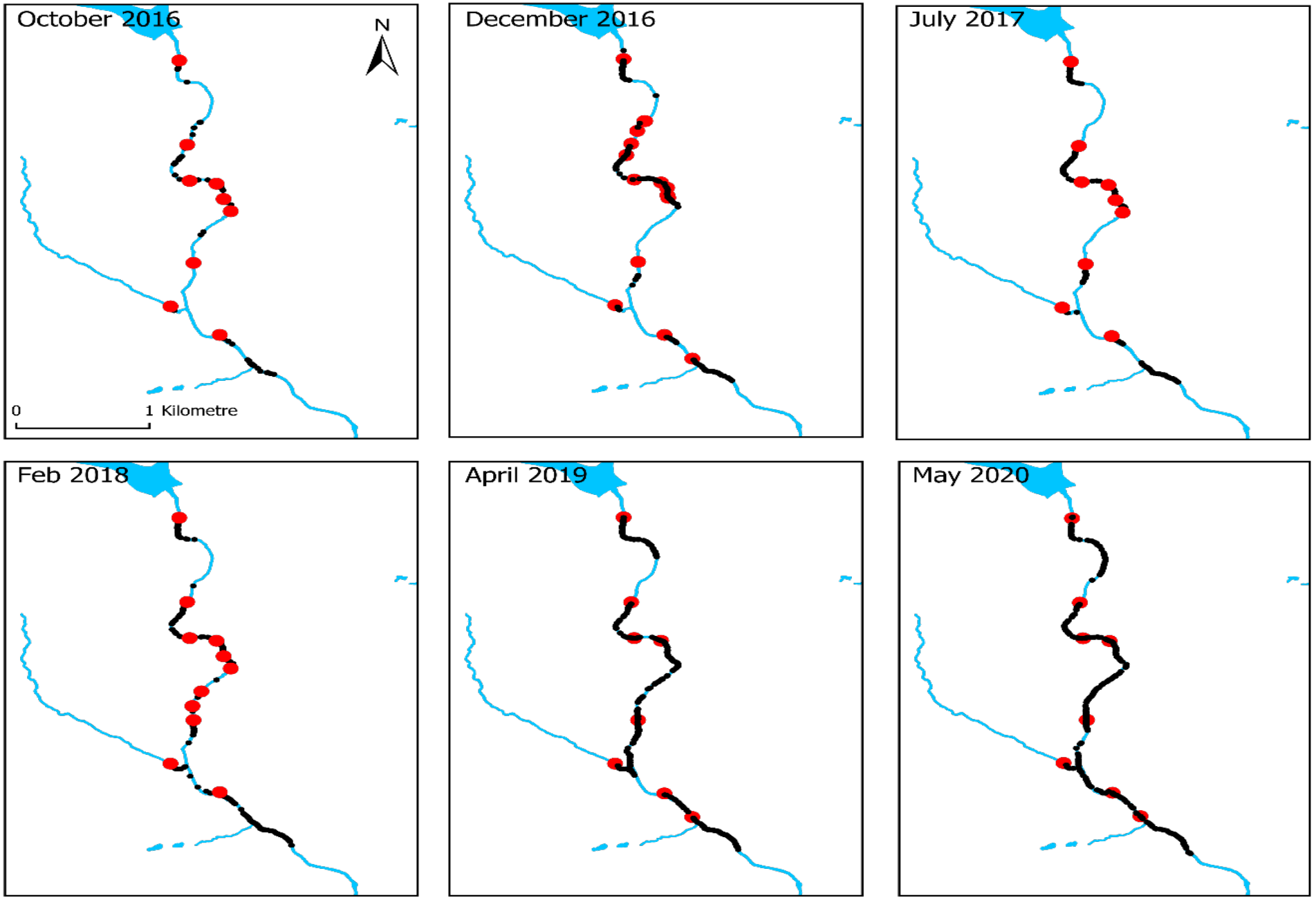
Results: Gravel deposits fate



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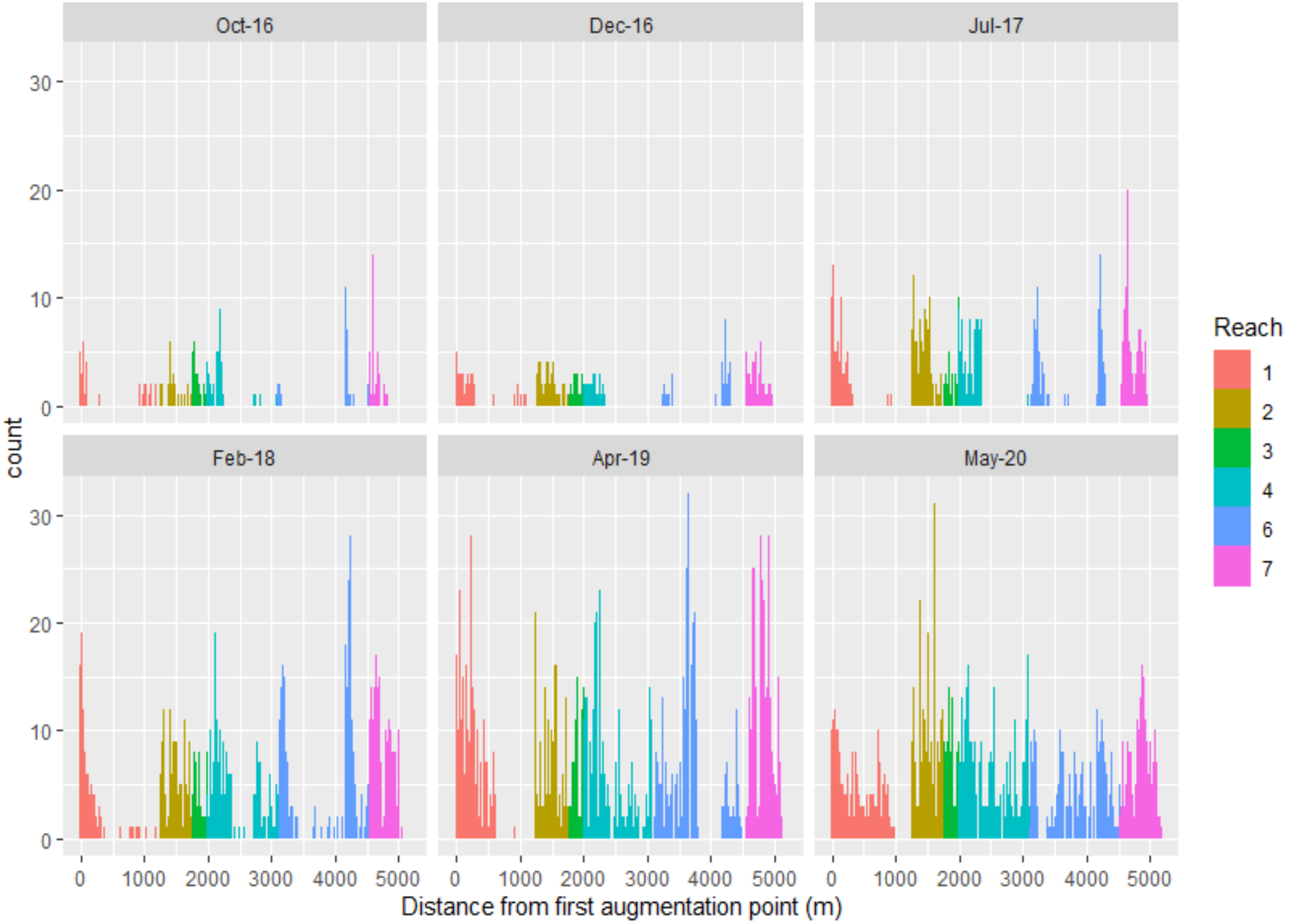

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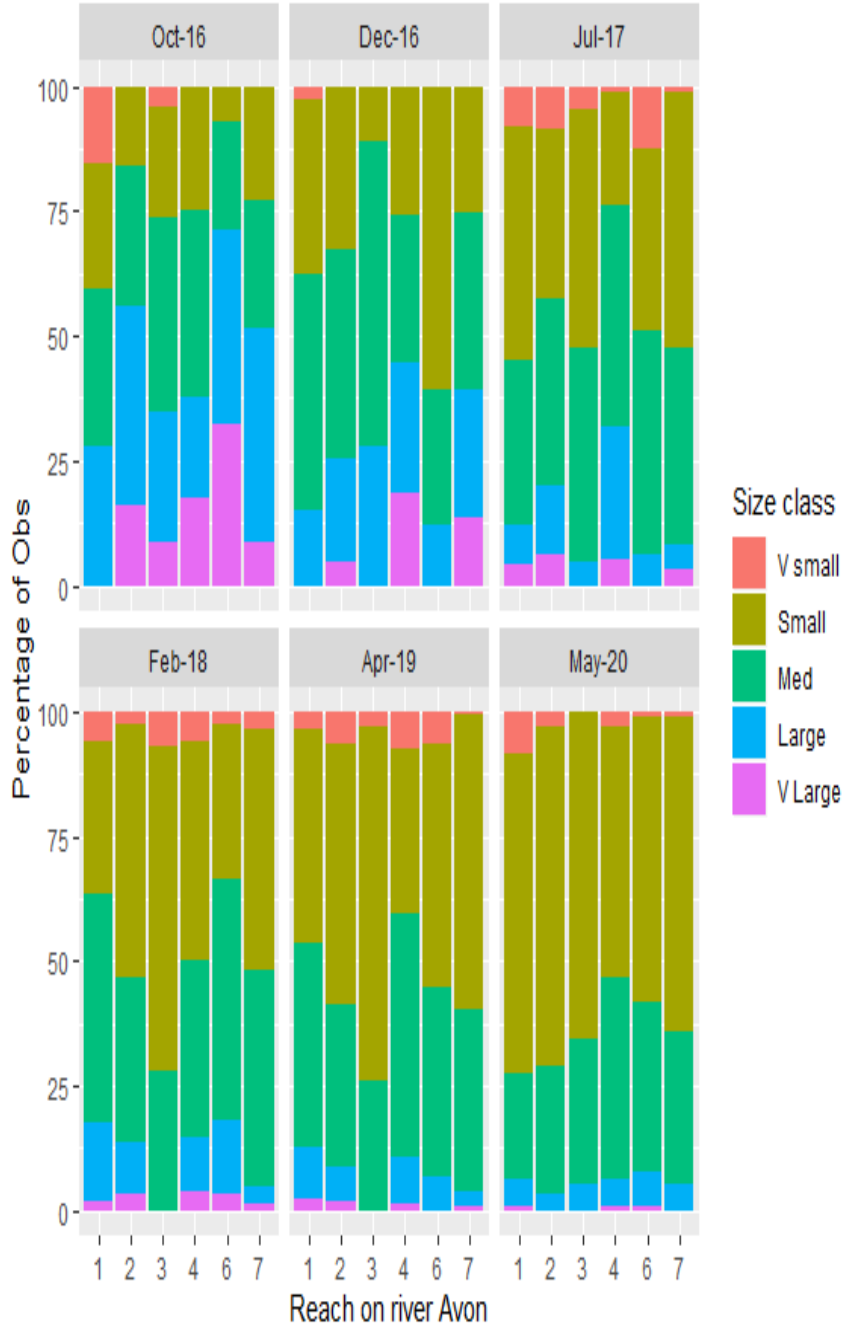
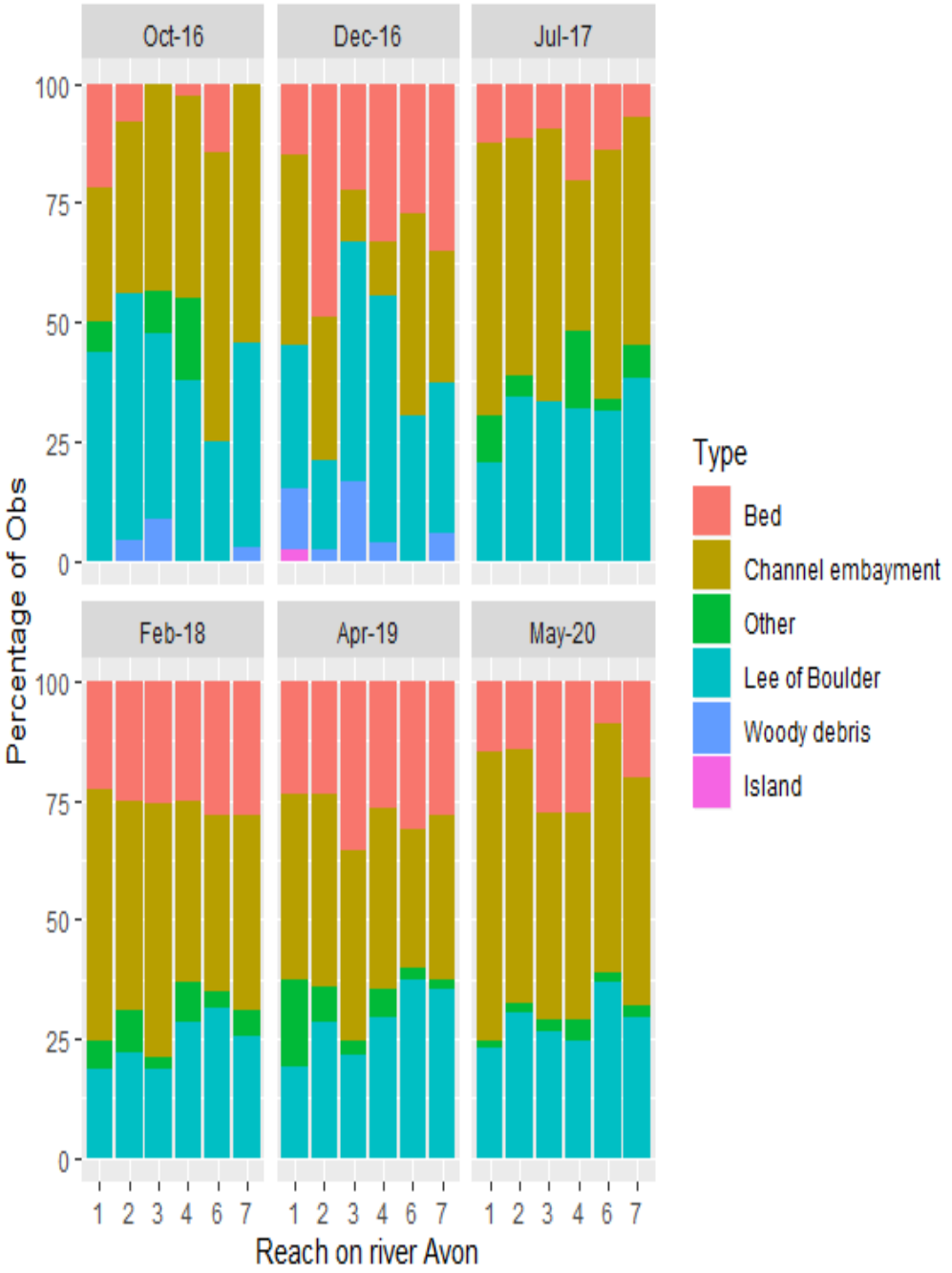
Results: Gravel deposits fate





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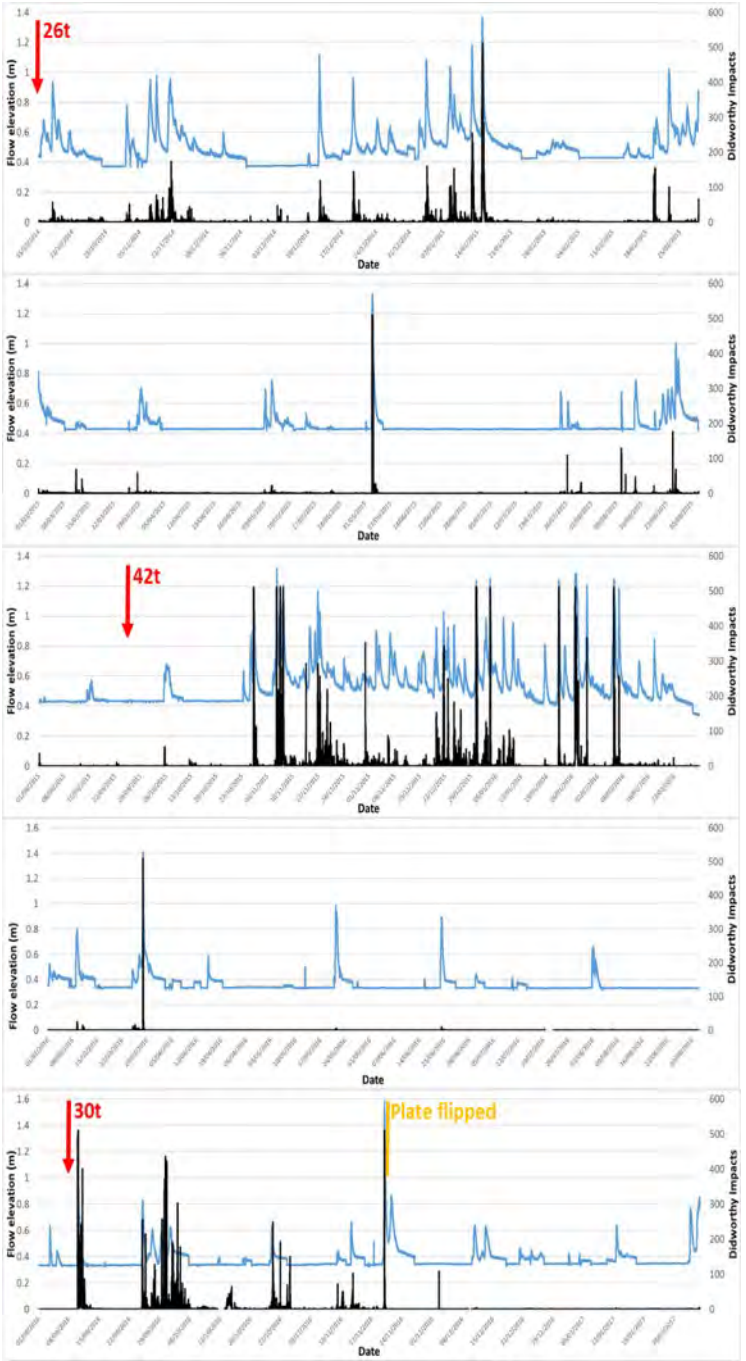
Results: Particle transport

Didworthy – upstream site



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Conclusions

- Gravel dynamics are a function of particle mobility mediated by high retention. Boulder bedded reaches and reaches with “embayments” have the highest retention. Stream power is secondary.
- Monitoring suggests gravel augmentations will be required to maintain the gravel habitat at current levels but the number of locations, frequency and volumes of gravel augmentation can be significantly reduced.
- The results suggest that augmentation on a 5-yearly timescale at 3 locations on the river would maintain gravel habitat close to what we now see.
- Since the start of the project in 2015 there has been an upward trend in both salmon and trout species in the upper catchment.

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Thank You

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