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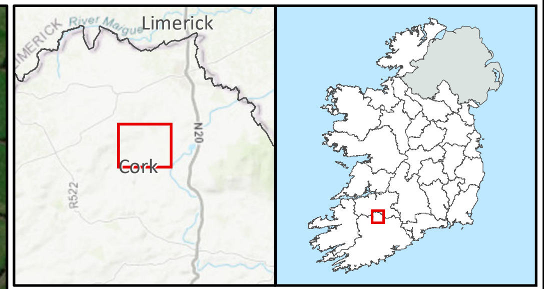

Legend

Site Boundary

Turbine Layout 500m Buffer

Turbine Layout

Flightlines

ID, Date, Time:

- 84, 12/10/2020, 15:18
- 88, 14/10/2020, 14:22
- 90, 04/11/2020, 10:46
- 91, 04/11/2020, 13:41
- 93, 03/11/2020, 11:29
- 96, 03/11/2020, 13:01
- 106, 28/12/2020, 10:50
- 108, 28/12/2020, 12:37
- 109, 28/12/2020, 12:42
- 110, 28/12/2020, 14:04
- 111, 28/12/2020, 15:20
- 113, 28/12/2020, 16:50
- 124, 19/01/2021, 12:17
- 134, 15/02/2021, 15:10
- 135, 15/02/2021, 15:19
- 136, 15/02/2021, 15:28
- 139, 15/02/2021, 17:20
- 141, 16/02/2021, 14:14
- 142, 16/02/2021, 14:47
- 149, 04/03/2021, 12:52
- 150, 04/03/2021, 14:18
- 151, 04/03/2021, 15:39
- 152, 04/03/2021, 16:09
- 156, 04/03/2021, 17:35
- 157, 04/03/2021, 17:56

TITLE:	Winter 2020 - 2021 Flightlines Buzzard		
PROJECT:	Annagh Wind Farm, Co. Cork		
FIGURE NO:	8G.2		
CLIENT:	EMPower		
SCALE:	1:12500	**REVISION:**	0
DATE:	13/10/2021	**PAGE SIZE:**	A3

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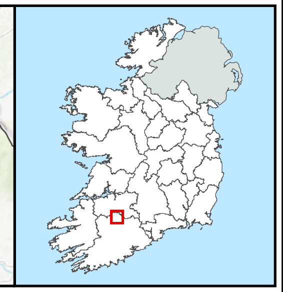

Legend

Site Boundary

Turbine Layout 500m Buffer

Turbine Layout

Flightlines

ID, Date, Time:

133, 15/02/2021, 11:12

TITLE:	Winter 2020 - 2021 Flightlines Goshawk
PROJECT:	Annagh Wind Farm, Co. Cork
FIGURE NO:	8U.2
CLIENT:	EMPower
SCALE: 1:12500	**REVISION:** 0
DATE: 13/10/2021	**PAGE SIZE:** A3

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0.5 0.25 0 0.5 Kilometers

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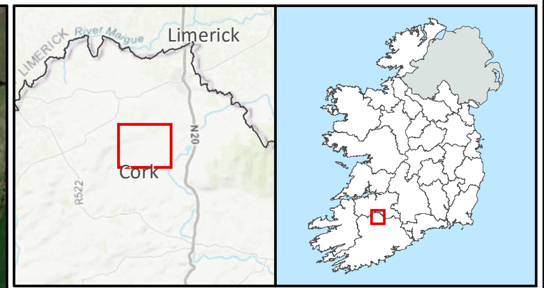

Legend

- Site Boundary
- Turbine Layout 500m Buffer
- Turbine Layout

Flightlines

ID, Date, Time:

- 59, 29/04/2020, 12:15
- 61, 29/04/2020, 12:49
- 205, 25/07/2020, 11:23
- 208, 26/07/2020, 09:50
- 209, 26/07/2020, 10:22
- 210, 26/07/2020, 13:15

TITLE: Summer 2020 Flightlines Heron	
PROJECT: Annagh Wind Farm, Co. Cork	
FIGURE NO: 8C.2	
CLIENT: EMPower	
SCALE: 1:13500	**REVISION:** 0
DATE: 13/10/2021	**PAGE SIZE:** A3

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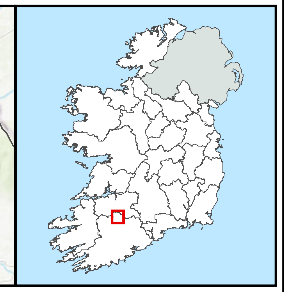

Legend

Site Boundary

Turbine Layout 500m Buffer

Turbine Layout

Flightlines

ID, Date, Time:

- 82, 12/10/2020, 10:58
- 89, 14/10/2020, 16:05
- 99, 03/11/2020, 15:28
- 126, 19/01/2021, 12:40
- 127, 19/01/2021, 13:08
- 128, 19/01/2021, 13:34
- 130, 19/01/2021, 16:37
- 143, 04/03/2021, 12:02
- 154, 04/03/2021, 16:36
- 158, 31/03/2021, 10:25
- 159, 31/03/2021, 11:31

TITLE:	Winter 2020 - 2021 Flightlines Heron		
PROJECT:	Annagh Wind Farm, Co. Cork		
FIGURE NO:	8L.2		
CLIENT:	EMPower		
SCALE:	1:12500	**REVISION:**	0
DATE:	13/10/2021	**PAGE SIZE:**	A3

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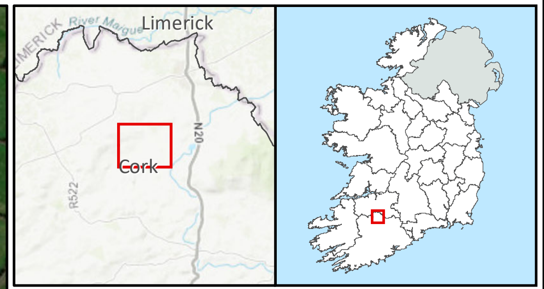

Legend

Site Boundary

Turbine Layout 500m Buffer

Turbine Layout

Flightlines

ID, Date, Time:

85, 14/10/2020, 09:40

196, 18/12/2020, 16:24

TITLE:	Winter 2020 - 2021 Flightlines Hen Harrier
PROJECT:	Annagh Wind Farm, Co. Cork
FIGURE NO:	8K.2
CLIENT:	EMPower
SCALE: 1:12500	**REVISION:** 0
DATE: 13/10/2021	**PAGE SIZE:** A3

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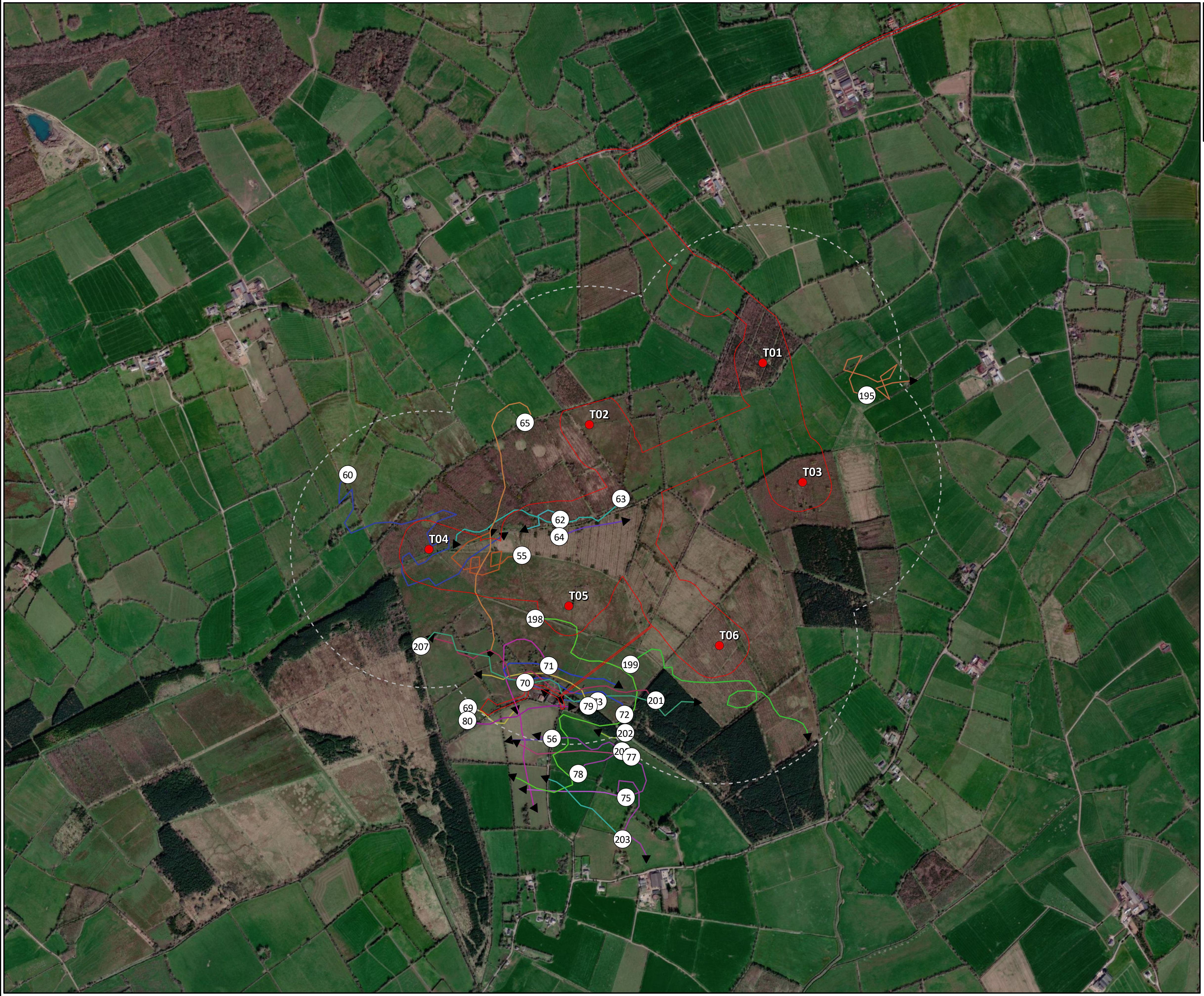

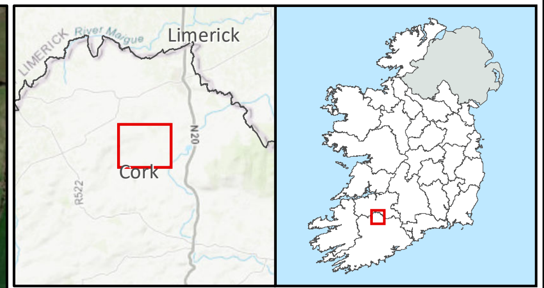

Legend

Site Boundary

Turbine Layout 500m Buffer

Turbine Layout

Flightlines

ID, Date, Time:

55, 29/04/2020, 09:56
56, 29/04/2020, 10:05
60, 29/04/2020, 12:33
62, 18/05/2020, 09:30
63, 18/05/2020, 10:43
64, 18/05/2020, 11:19
65, 18/05/2020, 12:09
69, 16/06/2020, 14:37
70, 16/06/2020, 14:41
71, 16/06/2020, 14:53
72, 25/06/2020, 11:17
73, 25/06/2020, 11:34
75, 25/06/2020, 12:15
77, 25/06/2020, 12:35
78, 25/06/2020, 13:03
79, 25/06/2020, 13:18
80, 25/06/2020, 13:36
195, 08/05/2020, 12:25
198, 29/06/2020, 17:44
199, 29/06/2020, 18:03
200, 29/06/2020, 18:44
201, 29/06/2020, 19:08
202, 29/06/2020, 19:53
203, 29/06/2020, 19:54
207, 25/07/2020, 14:02

TITLE:	Summer 2020 Flightlines Kestrel		
PROJECT:	Annagh Wind Farm, Co. Cork		
FIGURE NO:	8D.2		
CLIENT:	EMPower		
SCALE:	1:13500	**REVISION:**	0
DATE:	13/10/2021	**PAGE SIZE:**	A3

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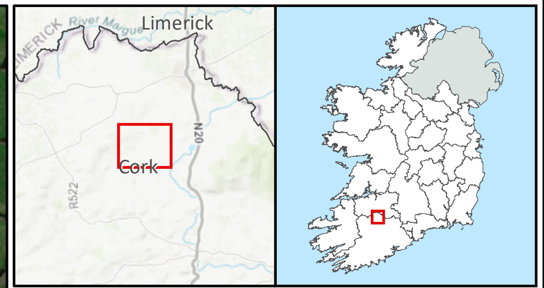

Legend

- Site Boundary
- Turbine Layout 500m Buffer
- Turbine Layout

Flightlines

ID, Date, Time:

- 81, 12/10/2020, 14:06
- 83, 12/10/2020, 14:12
- 86, 14/10/2020, 11:30
- 94, 03/11/2020, 12:44
- 95, 03/11/2020, 13:00
- 97, 03/11/2020, 13:07
- 98, 03/11/2020, 14:26
- 100, 18/12/2020, 11:29
- 102, 18/12/2020, 13:07
- 103, 18/12/2020, 15:36
- 104, 18/12/2020, 15:39
- 107, 28/12/2020, 10:50
- 116, 18/01/2021, 11:20
- 117, 18/01/2021, 11:31
- 119, 18/01/2021, 14:31
- 120, 18/01/2021, 14:38
- 122, 19/01/2021, 11:38
- 125, 19/01/2021, 12:22
- 131, 19/01/2021, 16:41
- 132, 19/01/2021, 16:43
- 138, 15/02/2021, 16:48
- 147, 04/03/2021, 12:18
- 153, 04/03/2021, 16:26

TITLE:	Winter 2020 - 2021 Flightlines Kestrel		
PROJECT:	Annagh Wind Farm, Co. Cork		
FIGURE NO:	8M.2		
CLIENT:	EMPower		
SCALE:	1:12500	**REVISION:**	0
DATE:	13/10/2021	**PAGE SIZE:**	A3

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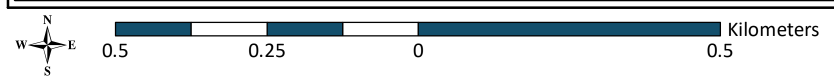

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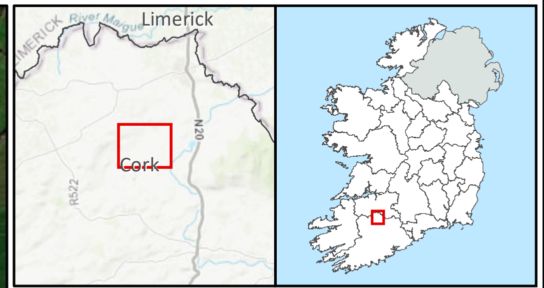

Legend

- Site Boundary
- Turbine Layout 500m Buffer
- Turbine Layout

Flightlines

ID, Date, Time:

- 67, 25/05/2020, 14:46
- 211, 04/09/2020, 08:34
- 212, 04/09/2020, 08:51
- 214, 04/09/2020, 09:32
- 215, 04/09/2020, 09:57
- 216, 04/09/2020, 11:14
- 217, 04/09/2020, 12:37

TITLE:	Summer 2020 Flightlines Lesser Black-backed Gull		
PROJECT:	Annagh Wind Farm, Co. Cork		
FIGURE NO:	8E.2		
CLIENT:	EMPower		
SCALE:	1:12500	**REVISION:**	0
DATE:	13/10/2021	**PAGE SIZE:**	A3

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0.5 0.25 0 0.5 Kilometers

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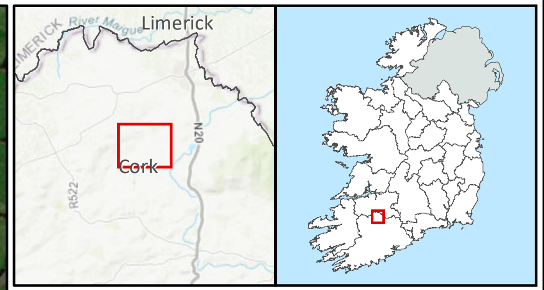

Legend

- Site Boundary
- Turbine Layout 500m Buffer
- Turbine Layout

Flightlines

ID, Date, Time:

- 53, 27/04/2020, 18:22

TITLE:	Summer 2020 Flightlines Little Egret		
PROJECT:	Annagh Wind Farm, Co. Cork		
FIGURE NO:	8F.2		
CLIENT:	EMPower		
SCALE:	1:12500	**REVISION:**	0
DATE:	13/10/2021	**PAGE SIZE:**	A3

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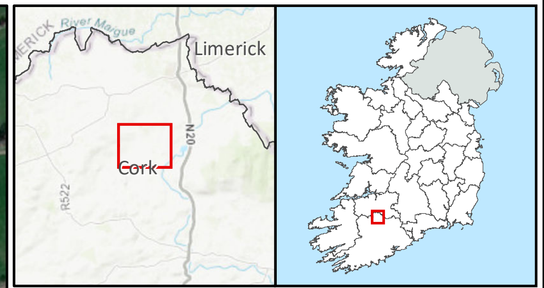

Legend

Site Boundary

Turbine Layout 500m Buffer

Turbine Layout

Flightlines

ID, Date, Time:

213, 04/09/2020, 08:59

TITLE:	Summer 2020 Flightlines Mallard		
PROJECT:	Annagh Wind Farm, Co. Cork		
FIGURE NO:	8Y.2		
CLIENT:	EMPower		
SCALE:	1:12500	**REVISION:**	0
DATE:	13/10/2021	**PAGE SIZE:**	A3

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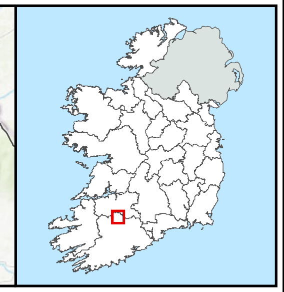

Legend

Site Boundary

Turbine Layout 500m Buffer

Turbine Layout

Flightlines

ID, Date, Time:

92, 04/11/2020, 14:54

TITLE:	Winter 2020 - 2021 Flightlines Mallard
PROJECT:	Annagh Wind Farm, Co. Cork
FIGURE NO:	8Y.2
CLIENT:	EMPower
SCALE: 1:12500	**REVISION:** 0
DATE: 13/10/2021	**PAGE SIZE:** A3

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0.5 0.25 0 0.5 Kilometers

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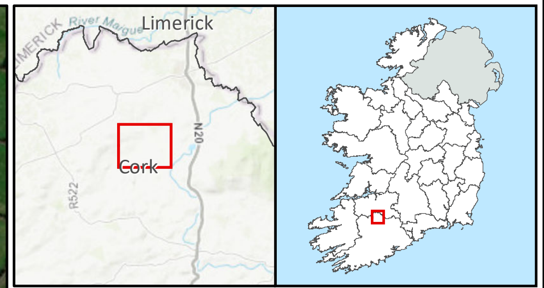
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community



Legend

- Site Boundary
- Turbine Layout 500m Buffer
- Turbine Layout

Flightlines

ID, Date, Time:

- 101, 18/12/2020, 13:05
- 137, 15/02/2021, 16:06

TITLE:	Winter 2020 - 2021 Flightlines Peregrine
PROJECT:	Annagh Wind Farm, Co. Cork
FIGURE NO:	8T.2
CLIENT:	EMPower
SCALE: 1:12500	**REVISION:** 0
DATE: 13/10/2021	**PAGE SIZE:** A3

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Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
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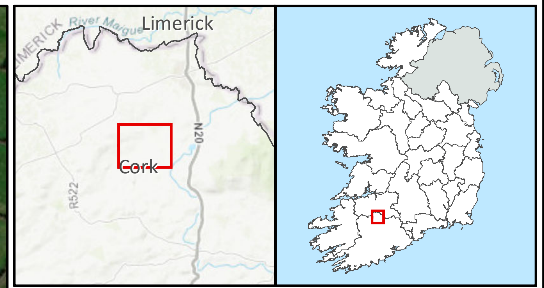

Legend

- Site Boundary
- Turbine Layout 500m Buffer
- Turbine Layout

Flightlines

ID, Date, Time:

- 114, 18/01/2021, 11:00
- 115, 18/01/2021, 11:06
- 118, 18/01/2021, 14:07
- 121, 18/01/2021, 16:19
- 144, 04/03/2021, 12:12
- 145, 04/03/2021, 12:16
- 146, 04/03/2021, 12:17
- 148, 04/03/2021, 12:27

TITLE:	Winter 2020 - 2021 Flightlines Snipe
PROJECT:	Annagh Wind Farm, Co. Cork
FIGURE NO:	8Q.2
CLIENT:	EMPower
SCALE: 1:12500	**REVISION:** 0
DATE: 13/10/2021	**PAGE SIZE:** A3

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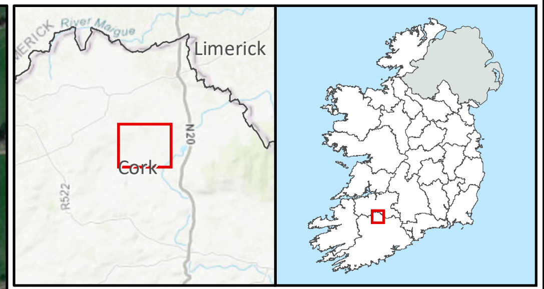

Legend

Site Boundary

Turbine Layout 500m Buffer

Turbine Layout

Flightlines

ID, Date, Time:

54, 27/04/2020, 18:23

218, 15/06/2020, 10:53

TITLE:	Summer 2020 Flightlines Sparrowhawk		
PROJECT:	Annagh Wind Farm, Co. Cork		
FIGURE NO:	8Z.2		
CLIENT:	EMPower		
SCALE:	1:12500	**REVISION:**	0
DATE:	13/10/2021	**PAGE SIZE:**	A3

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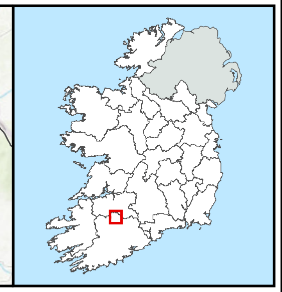

Legend

- Site Boundary
- Turbine Layout 500m Buffer
- Turbine Layout

Flightlines

ID, Date, Time:

- 87, 14/10/2020, 11:35
- 105, 18/12/2020, 15:51
- 112, 28/12/2020, 16:10
- 123, 19/01/2021, 11:46
- 129, 19/01/2021, 15:31
- 140, 15/02/2021, 17:33
- 155, 04/03/2021, 17:16
- 160, 31/03/2021, 13:41

TITLE:	Winter 2020 - 2021 Flightlines Sparrowhawk
PROJECT:	Annagh Wind Farm, Co. Cork
FIGURE NO:	8R.2
CLIENT:	EMPower
SCALE: 1:12500	**REVISION:** 0
DATE: 13/10/2021	**PAGE SIZE:** A3

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APPENDIX 4

Hinterland Survey Results

Hinterland Survey Data 2020/21

Site	Date	Cloud	Visibility	Rain	Wind	Common Name	Quantity
River Blackwater SAC/Annagh Bridge	27/04/2020	6/8	excellent	dry	f0-1	No target or additional species	-
Kilcolman Bog SPA	27/04/2020	6/8	excellent	dry	f0-1	No target or additional species	-
Ballyhouras	27/04/2020	6/8	excellent	dry	f0-1	No target or additional species	-
Casual Obs. East of Buttevant (ITM 558383 609600)	29/05/2020	7/8	excellent	dry	f3	Kestrel	1
ITM 560586 617793 (Ballyhouras)	29/05/2020	7/8	excellent	dry	f3	Kestrel	1
Kilcolman Bog SPA	29/05/2020	7/8	excellent	dry	f3	No target or additional species	
Large Quarry Lake (Ballinadrideen)	15/06/2020	5/8	excellent	dry	f1-2	Grey Heron	3
Large Quarry Lake (Ballinadrideen)	15/06/2020	5/8	excellent	dry	f1-2	Kestrel	1
Large Quarry Lake (Ballinadrideen)	15/06/2020	5/8	excellent	dry	f1-2	Black-headed Gull	5
River Blackwater SAC/Annagh Bridge	15/06/2020	5/8	excellent	dry	f1-2	No target or additional species	
Kilcolman Bog SPA	16/06/2020	8/8	very good	dry	f1	Reed Bunting	1
Ballyhoura Mountains SAC	26/06/2020	8/8	good - excellent	dry	f1-2	Mistle Thrush	1
Ballyhoura Mountains SAC	26/06/2020	8/8	good - excellent	dry	f1-2	Wren	1
Ballyhoura Mountains SAC	26/06/2020	8/8	good - excellent	dry	f1-2	Coal Tit	1
Ballyhoura Mountains SAC	26/06/2020	8/8	good - excellent	dry	f1-2	Jay	1
Ballyhoura Mountains SAC	26/06/2020	8/8	good - excellent	dry	f1-2	Meadow Pipit	Abundant
Ballyhoura Mountains SAC	26/06/2020	8/8	good - excellent	dry	f1-2	Greenfinch	1

Site	Date	Cloud	Visibility	Rain	Wind	Common Name	Quantity
River Blackwater SAC/Annagh Bridge	04/09/2020	8/8	very good	dry	f2 W	Swallow	6
River Blackwater SAC/Annagh Bridge	04/09/2020	8/8	very good	dry	f2 W	Blackbird	1
River Blackwater SAC/Annagh Bridge	04/09/2020	8/8	very good	dry	f2 W	Wren	1
River Blackwater SAC/Annagh Bridge	04/09/2020	8/8	very good	dry	f2 W	Blue Tit	1
River Blackwater SAC/Annagh Bridge	04/09/2020	8/8	very good	dry	f2 W	Dunnock	1
River Blackwater SAC/Annagh Bridge	04/09/2020	8/8	very good	dry	f2 W	Rook	4
River Blackwater SAC/Annagh Bridge	04/09/2020	8/8	very good	dry	f2 W	Jackdaw	2
Kilcolman Bog SPA	04/09/2020	8/8	very good	dry	f2 W	Kestrel	1
Kilcolman Bog SPA	04/09/2020	8/8	very good	dry	f2 W	Meadow Pipit	4
Kilcolman Bog SPA	04/09/2020	8/8	very good	dry	f2 W	Willow Warbler	1
Kilcolman Bog SPA	04/09/2020	8/8	very good	dry	f2 W	Hooded Crow	4
Kilcolman Bog SPA	04/09/2020	8/8	very good	dry	f2 W	Wren	1
Kilcolman Bog SPA	04/09/2020	8/8	very good	dry	f2 W	Goldfinch	3
Kilcolman Bog SPA	04/09/2020	8/8	very good	dry	f2 W	Chaffinch	1
Large Quarry Lake (Ballinadrideen)	04/09/2020	8/8	very good	dry	f2 W	Cormorant	1
Large Quarry Lake (Ballinadrideen)	04/09/2020	8/8	very good	dry	f2 W	Lesser Black-backed Gull	5
Large Quarry Lake (Ballinadrideen)	04/09/2020	8/8	very good	dry	f2 W	Swallow	4
Large Quarry Lake (Ballinadrideen)	04/09/2020	8/8	very good	dry	f2 W	Hooded Crow	4
Large Quarry Lake (Ballinadrideen)	04/09/2020	8/8	very good	dry	f2 W	Rook	2
Ballyhoura Mountains SAC	04/09/2020	8/8	very good	dry	f2 W	Kestrel	1
Ballyhoura Mountains SAC	04/09/2020	8/8	very good	dry	f2 W	Swallow	Not counted
Ballyhoura Mountains SAC	04/09/2020	8/8	very good	dry	f2 W	Stonechat	Not counted
Ballyhoura Mountains SAC	04/09/2020	8/8	very good	dry	f2 W	Meadow Pipit	Not counted

Site	Date	Cloud	Visibility	Rain	Wind	Common Name	Quantity
River Blackwater SAC/ Buttevant	22/10/2020	6/8	good	dry	f2 W	Little Egret	2
River Blackwater SAC/ Buttevant	22/10/2020	6/8	good	dry	f2 W	Grey Heron	1
River Blackwater SAC/ Buttevant	22/10/2020	6/8	good	dry	f2 W	Green Sandpiper	1
River Blackwater SAC/ Buttevant	22/10/2020	6/8	good	dry	f2 W	Rook	Not counted
River Blackwater SAC/ Buttevant	22/10/2020	6/8	good	dry	f2 W	Jackdaw	Not counted
River Blackwater SAC/ Buttevant	22/10/2020	6/8	good	dry	f2 W	Woodpigeon	Not counted
River Blackwater SAC/ Buttevant	22/10/2020	6/8	good	dry	f2 W	Blackbird	Not counted
River Blackwater SAC/ Buttevant	22/10/2020	6/8	good	dry	f2 W	Redwing	Not counted
River Blackwater SAC/ Buttevant	22/10/2020	6/8	good	dry	f2 W	Pied/White Wagtail	Not counted
River Blackwater SAC/ Buttevant	22/10/2020	6/8	good	dry	f2 W	Robin	Not counted
River Blackwater SAC/ Buttevant	22/10/2020	6/8	good	dry	f2 W	Hooded Crow	Not counted
Eagle Lough pNHA	22/10/2020	6/8	good	dry	f2 W	No target or additional species	
Kilcolman Bog SPA	22/10/2020	6/8	good	dry	f2 W	Teal	12
Kilcolman Bog SPA	22/10/2020	6/8	good	dry	f2 W	Mallard	2
Kilcolman Bog SPA	22/10/2020	6/8	good	dry	f2 W	Dunnock	Not counted
Kilcolman Bog SPA	22/10/2020	6/8	good	dry	f2 W	Blackbird	Not counted
Kilcolman Bog SPA	22/10/2020	6/8	good	dry	f2 W	Robin	Not counted
Kilcolman Bog SPA	22/10/2020	6/8	good	dry	f2 W	Wren	Not counted
Kilcolman Bog SPA	22/10/2020	6/8	good	dry	f2 W	Hooded Crow	Not counted
Kilcolman Bog SPA	22/10/2020	6/8	good	dry	f2 W	Rook	Not counted
Kilcolman Bog SPA	22/10/2020	6/8	good	dry	f2 W	Long-tailed Tit	Not counted
Ballinvonear Pond	22/10/2020	6/8	good	dry	f2 W	No target or additional species	-
Ballyhoura Mountains SAC	22/10/2020	6/8	good	dry	f2 W	Golden Plover	c40

Site	Date	Cloud	Visibility	Rain	Wind	Common Name	Quantity
Ballyhoura Mountains SAC	22/10/2020	6/8	good	dry	f2 W	Sparrowhawk	1
Large Quarry Lake (Ballinadrideen)	22/10/2020	6/8	good	dry	f2 W	Mute Swan	3
Large Quarry Lake (Ballinadrideen)	22/10/2020	6/8	good	dry	f2 W	Grey Heron	1
Small Quarry Lake (Ballyroe)	22/10/2020	6/8	good	dry	f2 W	Buzzard	1
Small Quarry Lake (Ballyroe)	22/10/2020	6/8	good	dry	f2 W	No target or additional species	-
Castle Lake (Milltown)	22/10/2020	6/8	good	dry	f2 W	Mute Swan	2
Castle Lake (Milltown)	22/10/2020	6/8	good	dry	f2 W	Teal	20
Castle Lake (Milltown)	22/10/2020	6/8	good	dry	f2 W	Mallard	2
River Blackwater SAC/Annagh Bridge	22/10/2020	6/8	good	dry	f2 W	Whooper Swan	8
River Blackwater SAC/Annagh Bridge	22/10/2020	6/8	good	dry	f2 W	Mallard	17
River Blackwater SAC/Annagh Bridge	22/10/2020	6/8	good	dry	f2 W	Wigeon	17
River Blackwater SAC/Annagh Bridge	22/10/2020	6/8	good	dry	f2 W	Lapwing	39
River Blackwater SAC/Annagh Bridge	22/10/2020	6/8	good	dry	f2 W	Teal	24
River Blackwater SAC/Annagh Bridge	22/10/2020	6/8	good	dry	f2 W	Golden Plover	15
River Blackwater SAC/Annagh Bridge	22/10/2020	6/8	good	dry	f2 W	Mute Swan	2
River Awbeg	22/10/2020	6/8	good	dry	f2 W	Mute Swan	2
Kilcolman Bog SPA	06/11/2020	7/8	good	dry	f3SW	Shoveler	70
Kilcolman Bog SPA	06/11/2020	7/8	good	dry	f3SW	Wigeon	100
Kilcolman Bog SPA	06/11/2020	7/8	good	dry	f3SW	Teal	50
Kilcolman Bog SPA	06/11/2020	7/8	good	dry	f3SW	Coot	1
Kilcolman Bog SPA	06/11/2020	7/8	good	dry	f3SW	Mallard	11
Kilcolman Bog SPA	06/11/2020	7/8	good	dry	f3SW	Redwing	Not Counted
Kilcolman Bog SPA	06/11/2020	7/8	good	dry	f3SW	Fieldfare	Not Counted

Site	Date	Cloud	Visibility	Rain	Wind	Common Name	Quantity
Kilcolman Bog SPA	06/11/2020	7/8	good	dry	f3SW	Blackbird	Not Counted
Kilcolman Bog SPA	06/11/2020	7/8	good	dry	f3SW	Robin	Not Counted
Kilcolman Bog SPA	06/11/2020	7/8	good	dry	f3SW	Wren	Not Counted
Ballyhoura Mountains SAC	06/11/2020	7/8	good	dry	f3SW	No target or additional species	-
Glanmore Flats	06/11/2020	7/8	good	dry	f3SW	Mute Swan	3
River Blackwater SAC/Annagh Bridge	06/11/2020	7/8	good	dry	f3SW	Wigeon	16
River Blackwater SAC/Annagh Bridge	06/11/2020	7/8	good	dry	f3SW	Lapwing	25
River Blackwater SAC/Annagh Bridge	06/11/2020	7/8	good	dry	f3SW	Mallard	1
River Blackwater SAC/Annagh Bridge	06/11/2020	7/8	good	dry	f3SW	Mute Swan	7
River Blackwater SAC/Annagh Bridge	06/11/2020	7/8	good	dry	f3SW	Whooper Swan	24
River Blackwater SAC/Annagh Bridge	06/11/2020	7/8	good	dry	f3SW	Grey Heron	1
River Blackwater SAC/Annagh Bridge	06/11/2020	7/8	good	dry	f3SW	Greylag Goose	52
River Blackwater SAC/Annagh Bridge	06/11/2020	7/8	good	dry	f3SW	Canada Goose	2
Castle Lake (Milltown)	06/11/2020	7/8	good	dry	f3SW	No target or additional species	-
Small Quarry Lake (Ballyroe)	06/11/2020	7/8	good	dry	f3SW	Curlew	7
Large Quarry Lake (Ballinadrideen)	06/11/2020	7/8	good	dry	f3SW	Mallard	5
Large Quarry Lake (Ballinadrideen)	06/11/2020	7/8	good	dry	f3SW	Lapwing	8
River Awbeg	06/11/2020	7/8	good	dry	f3SW	Mute Swan	2
River Awbeg	06/11/2020	7/8	good	dry	f3SW	Mallard	37
River Awbeg	06/11/2020	7/8	good	dry	f3SW	Lapwing	48
Eagle Lough pNHA	06/11/2020	7/8	good	dry	f3SW	No target or additional species	-
River Blackwater SAC/ Buttevant	06/11/2020	7/8	good	dry	f3SW	Mute Swan	2
Kilcolman Bog SPA	26/11/2020	8/8	good	dry	f1 NE	Mallard	23

Site	Date	Cloud	Visibility	Rain	Wind	Common Name	Quantity
Kilcolman Bog SPA	26/11/2020	8/8	good	dry	f1 NE	Teal	200
Kilcolman Bog SPA	26/11/2020	8/8	good	dry	f1 NE	Wigeon	220
Kilcolman Bog SPA	26/11/2020	8/8	good	dry	f1 NE	Tufted Duck	2
Kilcolman Bog SPA	26/11/2020	8/8	good	dry	f1 NE	Gadwall	2
Kilcolman Bog SPA	26/11/2020	8/8	good	dry	f1 NE	Shoveler	51
Kilcolman Bog SPA	26/11/2020	8/8	good	dry	f1 NE	Moorhen	1
Kilcolman Bog SPA	26/11/2020	8/8	good	dry	f1 NE	Coot	1
Ballyhoura Mountains SAC	26/11/2020	8/8	good	dry	f1 NE	No target or additional species	
Castle Lake (Milltown)	26/11/2020	8/8	good	dry	f1 NE	Mute Swan	2
River Blackwater SAC/Annagh Bridge	26/11/2020	8/8	good	dry	f1 NE	Whooper Swan	13
River Awbeg	26/11/2020	8/8	good	dry	f1 NE	Cormorant	1
Glanmore Flats	26/11/2020	8/8	good	dry	f1 NE	No target or additional species	-
Large Quarry Lake (Ballinadrideen)	26/11/2020	8/8	good	dry	f1 NE	Curlew	46
Large Quarry Lake (Ballinadrideen)	26/11/2020	8/8	good	dry	f1 NE	Lapwing	150
Large Quarry Lake (Ballinadrideen)	26/11/2020	8/8	good	dry	f1 NE	Mallard	32
Large Quarry Lake (Ballinadrideen)	26/11/2020	8/8	good	dry	f1 NE	Wigeon	9
Large Quarry Lake (Ballinadrideen)	26/11/2020	8/8	good	dry	f1 NE	Teal	48
Large Quarry Lake (Ballinadrideen)	26/11/2020	8/8	good	dry	f1 NE	Lesser Black-backed Gull	1
Small Quarry Lake (Ballyroe)	26/11/2020	8/8	good	dry	f1 NE	No target or additional species	-
Eagle Lough pNHA	26/11/2020	8/8	good	dry	f1 NE	Mallard	4
Eagle Lough pNHA	26/11/2020	8/8	good	dry	f1 NE	Moorhen	1
Eagle Lough pNHA	26/11/2020	8/8	good	dry	f1 NE	Little Grebe	1
River Blackwater SAC/ Buttevant	26/11/2020	8/8	good	dry	f1 NE	Mute Swan	2

Site	Date	Cloud	Visibility	Rain	Wind	Common Name	Quantity
River Blackwater SAC/ Buttevant	26/11/2020	8/8	good	dry	f1 NE	Little Egret	1
River Blackwater SAC/ Buttevant	26/11/2020	8/8	good	dry	f1 NE	Grey Heron	1
River Blackwater SAC/ Buttevant	26/11/2020	8/8	good	dry	f1 NE	Teal	5
River Blackwater SAC/ Buttevant	07/12/2020	8/8	fair	dry	calm	Mallard	25
Eagle Lough pNHA	07/12/2020	8/8	fair	dry	calm	Mute Swan	2
Eagle Lough pNHA	07/12/2020	8/8	fair	dry	calm	Mallard	33
Eagle Lough pNHA	07/12/2020	8/8	fair	dry	calm	Teal	20
Eagle Lough pNHA	07/12/2020	8/8	fair	dry	calm	Wigeon	35
Ballyhouras	07/12/2020	8/8	poor	dry	calm	No target or additional species	-
Castle Lake (Milltown)	07/12/2020	8/8	fair	dry	calm	Mute Swan	2
River Blackwater SAC/Annagh Bridge	07/12/2020	8/8	fair	dry	calm	Whooper Swan	52
River Blackwater SAC/Annagh Bridge	07/12/2020	8/8	fair	dry	calm	Greylag Goose	7
River Blackwater SAC/Annagh Bridge	07/12/2020	8/8	fair	dry	calm	Little Egret	1
River Awbeg	07/12/2020	8/8	poor	dry	calm	No target or additional species	-
Glanmore Flats	07/12/2020	8/8	poor	dry	calm	No target or additional species	-
Large Quarry Lake (Ballinadrideen)	07/12/2020	8/8	poor	dry	calm	No target or additional species	-
Small Quarry Lake (Ballyroe)	07/12/2020	8/8	poor	dry	calm	No target or additional species	-
Kilcolman Bog SPA	07/12/2020	8/8	fair	dry	calm	Teal	150
Kilcolman Bog SPA	07/12/2020	8/8	fair	dry	calm	Wigeon	215
Kilcolman Bog SPA	07/12/2020	8/8	fair	dry	calm	Mallard	13
Kilcolman Bog SPA	07/12/2020	8/8	fair	dry	calm	Shoveler	50
Kilcolman Bog SPA	07/12/2020	8/8	fair	dry	calm	Gadwall	2
Kilcolman Bog SPA	07/12/2020	8/8	fair	dry	calm	Little Grebe	1

Site	Date	Cloud	Visibility	Rain	Wind	Common Name	Quantity
Kilcolman Bog SPA	07/12/2020	8/8	fair	dry	calm	Mute Swan	1
Kilcolman Bog SPA	07/12/2020	8/8	fair	dry	calm	Greylag Goose	40
Kilcolman Bog SPA	07/12/2020	8/8	fair	dry	calm	White-fronted Goose	1
Kilcolman Bog SPA	07/12/2020	8/8	fair	dry	calm	Pink-footed Goose	1
River Awbeg	16/12/2020	7/8	good	dry	f3 SW	No target or additional species	-
Glanmore Flats	16/12/2020	7/8	good	dry	f3 SW	No target or additional species	-
Large Quarry Lake (Ballinadrideen)	16/12/2020	7/8	good	dry	f3 SW	Curlew	53
Large Quarry Lake (Ballinadrideen)	16/12/2020	7/8	good	dry	f3 SW	Wigeon	25
Large Quarry Lake (Ballinadrideen)	16/12/2020	7/8	good	dry	f3 SW	Teal	147
Large Quarry Lake (Ballinadrideen)	16/12/2020	7/8	good	dry	f3 SW	Grey Heron	2
Large Quarry Lake (Ballinadrideen)	16/12/2020	7/8	good	dry	f3 SW	Mallard	5
Small Quarry Lake (Ballyroe)	16/12/2020	7/8	good	dry	f3 SW	No target or additional species	-
Ballyhouras	16/12/2020	7/8	good	dry	f3 SW	No target or additional species	-
River Blackwater SAC/Annagh Bridge	16/12/2020	7/8	good	dry	f3 SW	Whooper Swan	92
River Blackwater SAC/Annagh Bridge	16/12/2020	7/8	good	dry	f3 SW	Greylag Goose	101
River Blackwater SAC/Annagh Bridge	16/12/2020	7/8	good	dry	f3 SW	Canada Goose	2
Large Quarry Lake (Ballinadrideen)	29/12/2020	5/8	good	dry	f3 NW	Teal	150
Large Quarry Lake (Ballinadrideen)	29/12/2020	5/8	good	dry	f3 NW	Wigeon	50
Large Quarry Lake (Ballinadrideen)	29/12/2020	5/8	good	dry	f3 NW	Mallard	15
River Blackwater SAC/ Buttevant	26/01/2021	8/8	good	dry	f1 SW	Teal	26
River Blackwater SAC/ Buttevant	26/01/2021	8/8	good	dry	f1 SW	Grey Heron	1
Eagle Lough pNHA	26/01/2021	8/8	good	dry	f1 SW	Snipe	4
Eagle Lough pNHA	26/01/2021	8/8	good	dry	f1 SW	Mallard	2

Site	Date	Cloud	Visibility	Rain	Wind	Common Name	Quantity
Eagle Lough pNHA	26/01/2021	8/8	good	dry	f1 SW	Shoveler	2
Eagle Lough pNHA	26/01/2021	8/8	good	dry	f1 SW	Wigeon	18
Eagle Lough pNHA	26/01/2021	8/8	good	dry	f1 SW	Little Grebe	2
Kilcolman Bog SPA	26/01/2021	8/8	good	dry	f1 SW	Teal	49
Kilcolman Bog SPA	26/01/2021	8/8	good	dry	f1 SW	Wigeon	59
Kilcolman Bog SPA	26/01/2021	8/8	good	dry	f1 SW	Mallard	11
Kilcolman Bog SPA	26/01/2021	8/8	good	dry	f1 SW	Shoveler	47
Kilcolman Bog SPA	26/01/2021	8/8	good	dry	f1 SW	Coot	5
Kilcolman Bog SPA	26/01/2021	8/8	good	dry	f1 SW	Little Grebe	2
Kilcolman Bog SPA	26/01/2021	8/8	good	dry	f1 SW	Mute Swan	2
Kilcolman Bog SPA	26/01/2021	8/8	good	dry	f1 SW	Moorhen	1
Glanmore Flats	26/01/2021	8/8	good	dry	f1 SW	Mute Swan	2
River Awbeg	26/01/2021	8/8	good	dry	f1 SW	No target or additional species	-
Ballyhoura Mountains SAC	26/01/2021	8/8	good	dry	f1 SW	No target or additional species	-
Large Quarry Lake (Ballinadrideen)	26/01/2021	8/8	good	dry	f1 SW	Wigeon	27
Large Quarry Lake (Ballinadrideen)	26/01/2021	8/8	good	dry	f1 SW	Curlew	1
Large Quarry Lake (Ballinadrideen)	26/01/2021	8/8	good	dry	f1 SW	Teal	29
Large Quarry Lake (Ballinadrideen)	26/01/2021	8/8	good	dry	f1 SW	Cormorant	1
Large Quarry Lake (Ballinadrideen)	26/01/2021	8/8	good	dry	f1 SW	Mallard	1
Large Quarry Lake (Ballinadrideen)	26/01/2021	8/8	good	dry	f1 SW	Grey Heron	1
Small Quarry Lake	26/01/2021	8/8	good	dry	f1 SW	No target or additional species	
Castle Lake (Milltown)	26/01/2021	8/8	good	dry	f1 SW	Mute Swan	2
River Blackwater SAC/Annagh Bridge	26/01/2021	8/8	good	dry	f1 SW	No target or additional species	-

Site	Date	Cloud	Visibility	Rain	Wind	Common Name	Quantity
River Blackwater SAC/Annagh Bridge	15/02/2021	4/8	good	dry	f1 S	Whooper Swan	20
River Blackwater SAC/Annagh Bridge	15/02/2021	4/8	good	dry	f1 S	Greylag Goose	14
Kilcolman Bog SPA	16/02/2021	3/8	good	dry	f2 W	Whooper Swan	22
Kilcolman Bog SPA	16/02/2021	3/8	good	dry	f2 W	Mute Swan	2
Kilcolman Bog SPA	16/02/2021	3/8	good	dry	f2 W	Gadwall	4
Kilcolman Bog SPA	16/02/2021	3/8	good	dry	f2 W	Coot	6
Kilcolman Bog SPA	16/02/2021	3/8	good	dry	f2 W	Shoveler	84
Kilcolman Bog SPA	16/02/2021	3/8	good	dry	f2 W	Little Grebe	2
Kilcolman Bog SPA	16/02/2021	3/8	good	dry	f2 W	Moorhen	2
Kilcolman Bog SPA	16/02/2021	3/8	good	dry	f2 W	Teal	28
Kilcolman Bog SPA	16/02/2021	3/8	good	dry	f2 W	Wigeon	92
Kilcolman Bog SPA	16/02/2021	3/8	good	dry	f2 W	Greylag Goose	80
River Blackwater SAC/Annagh Bridge	16/02/2021	3/8	good	dry	f2 W	Whooper Swan	107
River Blackwater SAC/Annagh Bridge	16/02/2021	3/8	good	dry	f2 W	Greylag Goose	26
River Awbeg	16/02/2021	3/8	good	dry	f2 W	No target or additional species	-
North of Buttevant (R504110)	16/02/2021	3/8	good	dry	f2 W	Whooper Swan	14
River Blackwater SAC/ Buttevant	16/02/2021	3/8	good	dry	f2 W	Teal	2
Eagle Lough pNHA	26/02/2021	5/8	good	dry	f3 W	Shoveler	7
Eagle Lough pNHA	26/02/2021	5/8	good	dry	f3 W	Moorhen	2
Eagle Lough pNHA	26/02/2021	5/8	good	dry	f3 W	Mallard	2
Eagle Lough pNHA	26/02/2021	5/8	good	dry	f3 W	Little Grebe	1
Kilcolman Bog SPA	26/02/2021	5/8	good	dry	f3 W	Mallard	14
Kilcolman Bog SPA	26/02/2021	5/8	good	dry	f3 W	Tufted Duck	8

Site	Date	Cloud	Visibility	Rain	Wind	Common Name	Quantity
Kilcolman Bog SPA	26/02/2021	5/8	good	dry	f3 W	Little Grebe	7
Kilcolman Bog SPA	26/02/2021	5/8	good	dry	f3 W	Coot	14
Kilcolman Bog SPA	26/02/2021	5/8	good	dry	f3 W	Moorhen	3
Kilcolman Bog SPA	26/02/2021	5/8	good	dry	f3 W	Wigeon	90
Kilcolman Bog SPA	26/02/2021	5/8	good	dry	f3 W	Teal	27
Kilcolman Bog SPA	26/02/2021	5/8	good	dry	f3 W	Gadwall	1
Kilcolman Bog SPA	26/02/2021	5/8	good	dry	f3 W	Shoveler	10
Ballyhoura Mountains SAC	26/02/2021	5/8	good	dry	f3 W	Buzzard	1
Large Quarry Lake (Ballinadrideen)	26/02/2021	5/8	good	dry	f3 W	Shoveler	8
Large Quarry Lake (Ballinadrideen)	26/02/2021	5/8	good	dry	f3 W	Cormorant	6
Large Quarry Lake (Ballinadrideen)	26/02/2021	5/8	good	dry	f3 W	Curlew	8
Large Quarry Lake (Ballinadrideen)	26/02/2021	5/8	good	dry	f3 W	Mallard	5
Large Quarry Lake (Ballinadrideen)	26/02/2021	5/8	good	dry	f3 W	Wigeon	9
Large Quarry Lake (Ballinadrideen)	26/02/2021	5/8	good	dry	f3 W	Teal	46
Large Quarry Lake (Ballinadrideen)	26/02/2021	5/8	good	dry	f3 W	Grey Heron	3
Small Quarry Lake	26/02/2021	5/8	good	dry	f3 W	Whooper Swan	38
Small Quarry Lake	26/02/2021	5/8	good	dry	f3 W	Mallard	2
Castle Lake (Milltown)	26/02/2021	5/8	good	dry	f3 W	Mute Swan	2
River Blackwater SAC/Annagh Bridge	26/02/2021	5/8	good	dry	f3 W	Whooper Swan	6
River Blackwater SAC/Annagh Bridge	26/02/2021	5/8	good	dry	f3 W	Grey Heron	1
Nth of Buttevant R504110	26/02/2021	5/8	good	dry	f3 W	Whooper Swan	3
Railway crossing north of Buttevant	26/02/2021	5/8	good	dry	f3 W	Little Egret	1
Kilcolman Bog SPA	23/03/2021	7/8	excellent	dry	f3-4 S	Greylag Goose	40
Kilcolman Bog SPA	23/03/2021	7/8	excellent	dry	f3-4 S	Greenland White-fronted Goose	1

Site	Date	Cloud	Visibility	Rain	Wind	Common Name	Quantity
Kilcolman Bog SPA	23/03/2021	7/8	excellent	dry	f3-4 S	Whooper Swan	23
Kilcolman Bog SPA	23/03/2021	7/8	excellent	dry	f3-4 S	Coot	3
Kilcolman Bog SPA	23/03/2021	7/8	excellent	dry	f3-4 S	Wigeon	23
Kilcolman Bog SPA	23/03/2021	7/8	excellent	dry	f3-4 S	Shoveler	5
Kilcolman Bog SPA	23/03/2021	7/8	excellent	dry	f3-4 S	Teal	25
Kilcolman Bog SPA	23/03/2021	7/8	excellent	dry	f3-4 S	Mallard	2
Eagle Lough pNHA	23/03/2021	7/8	excellent	dry	f3-4 S	Coot	1
Eagle Lough pNHA	23/03/2021	7/8	excellent	dry	f3-4 S	Moorhen	2
Eagle Lough pNHA	23/03/2021	7/8	excellent	dry	f3-4 S	Mallard	1
Glanmore Flats	23/03/2021	7/8	excellent	dry	f3-4 S	Buzzard	1
River Awbeg	23/03/2021	7/8	excellent	dry	f3-4 S	Cormorant	4
River Blackwater SAC/Annagh Bridge	23/03/2021	7/8	excellent	dry	f3-4 S	Whooper Swan	22
Castle Lake (Milltown)	23/03/2021	7/8	excellent	dry	f3-4 S	Teal	2
Castle Lake (Milltown)	23/03/2021	7/8	excellent	dry	f3-4 S	Moorhen	2
Castle Lake (Milltown)	23/03/2021	7/8	excellent	dry	f3-4 S	Little Grebe	1
Large Quarry Lake (Ballinadrideen)	23/03/2021	7/8	excellent	dry	f3-4 S	No target or additional species	-
Large Quarry Lake (Ballinadrideen)	23/03/2021	7/8	excellent	dry	f3-4 S	Whooper Swan	1
Large Quarry Lake (Ballinadrideen)	23/03/2021	7/8	excellent	dry	f3-4 S	Mallard	3
Large Quarry Lake (Ballinadrideen)	23/03/2021	7/8	excellent	dry	f3-4 S	Grey Heron	1
Large Quarry Lake (Ballinadrideen)	23/03/2021	7/8	excellent	dry	f3-4 S	Teal	50
Large Quarry Lake (Ballinadrideen)	23/03/2021	7/8	excellent	dry	f3-4 S	Wigeon	13
Large Quarry Lake (Ballinadrideen)	23/03/2021	7/8	excellent	dry	f3-4 S	Great Crested Grebe	2
Ballyhoura Mountains SAC	23/03/2021	7/8	excellent	dry	f3-4 S	Buzzard	3
Ballyhoura Mountains SAC	23/03/2021	7/8	excellent	dry	f3-4 S	Red Grouse (Droppings)	-

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APPENDIX 8.5

Aquatic Report

Aquatic Ecological Impact Assessment Report (EIAR) for Annagh wind farm, Co. Cork

Prepared by Triturus Environmental Ltd. for Fehily Timoney & Company

October 2021

Please cite as:

Triturus (2021). Aquatic Ecological Impact Assessment Report (EIAR) for Annagh wind farm, Co. Cork. Report prepared by Triturus Environmental Ltd. for Fehily Timoney & Company, Cork. October 2021.

Table of contents

1. Introduction

1.1 Background

This report assesses the potential impact of the proposed Annagh wind farm on aquatic ecology, through its various developmental phases of construction, operation and decommissioning. Key elements of the design proposals have been assessed in the context of aquatic ecological sensitivities of the receiving environment.

The following report provides a baseline assessment of the aquatic ecology including fisheries and biological water quality as well as protected aquatic species and habitats in the vicinity of the project. This report also assesses the potential impacts of the proposed wind farm on the receiving aquatic environment based on its known sensitivities (i.e. quality of water, ecological status, presence of protected species etc.) along with proposed mitigation measures and any residual impacts of the proposed project (**sections 5, 6 & 7**). An assessment of the hydrological impacts of the proposed wind farm project on the receiving aquatic environment are discussed in Chapter 10 (Hydrology and Water Quality).

Undertaken on a catchment-wide scale, the baseline surveys focused on aquatic habitats in relation to fisheries potential (including both salmonid and lamprey habitat), white-clawed crayfish (*Austropotamobious pallipes*), freshwater pearl mussel (*Margaritifera margaritifera*), otter (*Lutra lutra*), macro-invertebrates, macrophytes, aquatic invasive species, and fish of conservation value which may use the watercourses in the vicinity of the proposed project. Aquatic surveys were undertaken in September 2020, with environmental DNA (eDNA) analysis for white-clawed crayfish and crayfish plague (*Aphanomyces astaci*) carried out in April 2021.

The proposed survey sites were located on numerous watercourses within the Awbeg [Buttevant]_SC_010 river sub-catchment near Charleville, Co. Cork. The survey area also overlapped with the Munster Blackwater *Margaritifera* sensitive area (**Figure 2.1**). Whilst the proposed wind farm site was not located within a European site, several watercourses draining the site (i.e. the Fiddane Stream, Ardglass River and Oakfront River) shared downstream hydrological connectivity with the Blackwater River SAC (site code: 002170). Furthermore, the proposed grid cable route (GCR) crosses the Rathnacally Stream which shares downstream hydrological connectivity with the Blackwater River SAC (002170). A proposed internal access track crosses the Oakfront River at a single location within the proposed wind farm boundary. **Figure 1.1** gives the location of the proposed Annagh Wind Farm with respect to relevant watercourses and their connectivity with European sites.

1.2 Project description

The proposed Annagh Wind Farm is located in a lowland agricultural area within the townlands of Annagh North, Coolcaum, Fiddane and Cooliney in County Cork, approximately 6km south-west of Charleville (**Figure 1.1**). A full description of the proposed project is provided in Chapter 3 of the main EIAR report.

In summary, the project will consist of a wind farm with 6 no. turbines, access roads, hardstand areas, sub-station, tree-felling, grid connection and turbine delivery route.

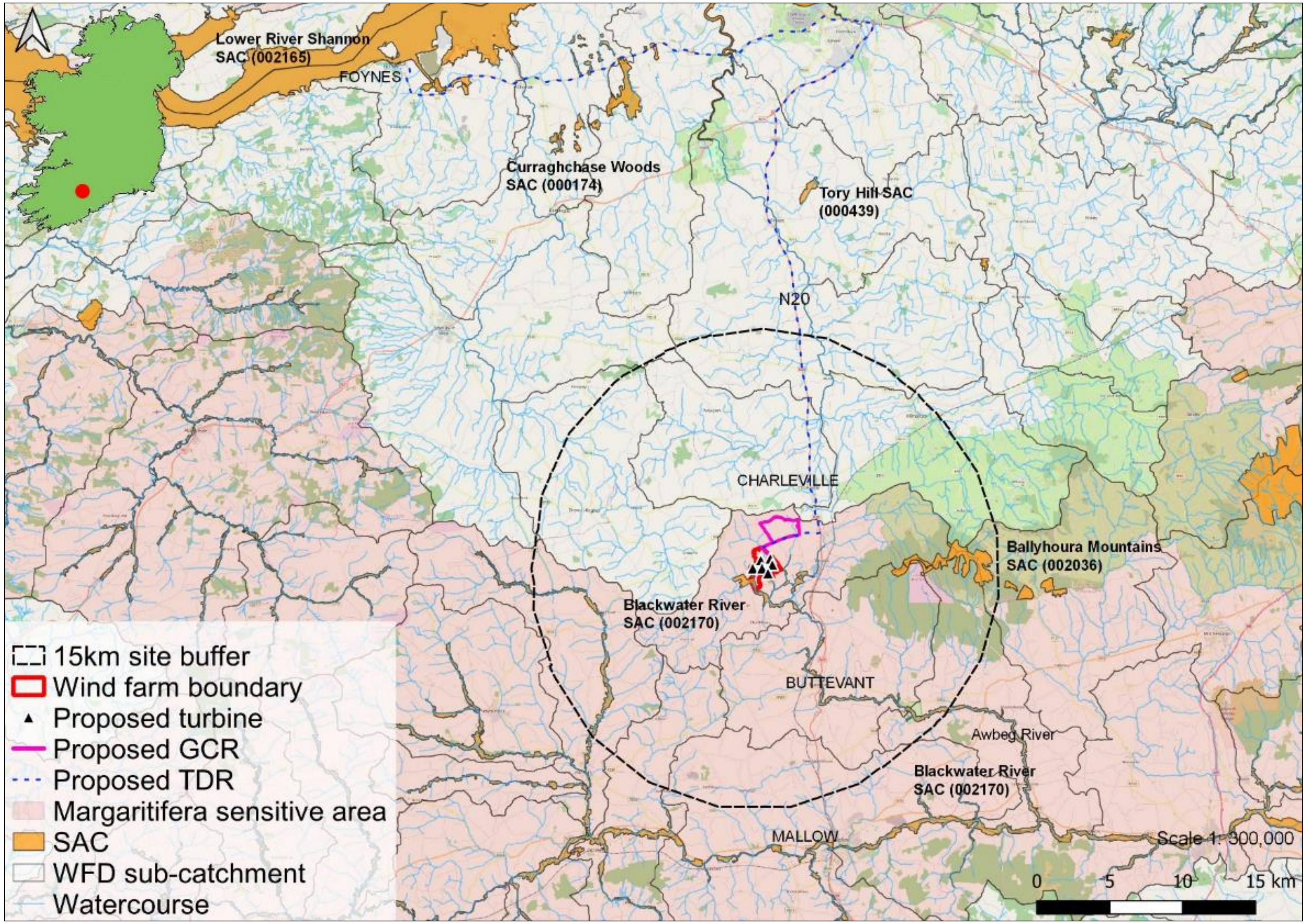


Figure 1.1 Location of the proposed Annagh wind farm project, Co. Cork showing European sites within a 15km buffer.

2. Methodology

2.1 Relevant guidance

The general approach used for the evaluation of ecological receptors and assessment of potential impacts for this current assessment is based on the 'Guidelines for Ecological Impact Assessment in the UK and Ireland' (CIEEM, 2018). The evaluation of ecological receptors contained within this report uses the geographic scale and criteria defined in the Guidelines for Assessment of Ecological Impacts of National Road Schemes (NRA, 2009).

The assessment of potential impacts uses the impact significance scale defined in the 'Guidelines on the Information to Be Contained in Environmental Impact Assessment Reports' (EPA, 2017), as follows:

Imperceptible → Not significant → Slight → Moderate → Significant → Very significant → Profound

An impact assessed as 'imperceptible' using this scale is considered to be a negligible impact. An impact assessed as 'significant', 'very significant' or 'profound' corresponds to a significant impact in the context of the EIA Directive. Such an impact is considered to represent an impact "that supports [positive impact] or undermines [negative impact] biodiversity conservation objectives" for the relevant receptor (CIEEM, 2019). Duration of impacts will is also be considered according to Environmental Protection Agency (EPA) guidance (EPA, 2017). The magnitude of an impact will depend on the nature and sensitivity of the ecological features and will be influenced by intensity, duration (temporary/permanent), timing, frequency and reversibility of the potential impact (CIEEM, 2016).

Other guidance considered in the preparation of this report included the following;

- DHPLG (2019). Draft Revised Wind Energy Development Guidelines. December 2019. Prepared by the Department of Housing, Planning and Local Government.
- EPA (2015). Advice Notes for Preparing Environmental Impact Statements.
- IFI (2016). Guidelines on protection of fisheries during construction works in and adjacent to waters. Inland Fisheries Ireland.
- Irish Wind Energy Association (2012). Best Practice Guidelines for the Irish Wind Energy Industry. Irish Wind Energy Association.
- NRA (2008). Guidelines for the Crossing of Watercourses during the Construction of National Road Schemes. National Roads Authority.

2.2 Selection of watercourses for assessment

All freshwater watercourses which could be affected directly or indirectly by the proposed wind farm project were considered as part of the current assessment. This included watercourses draining the proposed wind farm site as well as those crossed by the proposed grid connection route and turbine delivery route (where any works had potential to cause impacts). A total of *n*=11 sites were selected for detailed aquatic assessment (see **Table 2.1, Figure 2.1** below). The nomenclature for the watercourses surveyed is as per the Environmental Protection Agency's (EPA) online map viewer.

Surveys at each of these sites included a fisheries assessment (electro-fishing, habitat appraisal), white-clawed crayfish survey (sweep netting, hand searching) and biological water quality sampling (Q-sampling) (**Figure 2.1**). A Stage 1 freshwater pearl mussel survey was undertaken in September 2020. In addition to traditional surveys, environmental DNA (eDNA) analysis was also undertaken on water samples from the Awbeg River for white-clawed crayfish and crayfish plague (*Aphanomyces astaci*). This holistic approach informed the overall aquatic ecological evaluation of each site in context of the proposed wind farm project.

Please note this aquatic report should be read in conjunction with the final Environmental Impact Assessment Report (EIAR) prepared for the proposed project. More specific aquatic methodology is outlined below and in the appendices of this report.

Table 2.1 Aquatic survey locations for the proposed Annagh wind farm project, Co. Cork (watercourse names are according to the EPA)

Site no.	Watercourse	EPA code	Location	X (ITM)	Y (ITM)
A1	Fiddane Stream	18F19	Annagh Bogs	549427	617248
A2	Ardglass River	18A23	Annagh Bogs	549606	616770
A3	Awbeg River	18A09	Annagh Bridge	549823	615649
B1	Milltown Stream	18M57	Milltown	550461	619714
B2	Oakfront River	18O02	Cooliney Bridge	550181	618654
B3	Oakfront River	18O02	Milltown	550651	617869
B4	Oakfront River	18O02	Springfort	550775	617421
B5	Oakfront River	18O02	Bridge at Coolcaum	551050	616256
C1	Rathnacally Stream	18R32	Clashganniv	552439	620511
C2	Rathnacally Stream	18R32	Bridge at Rathnacally	552633	619468
C3	Rathnacally Stream	18R32	Bridge at Ballynadrideen	552222	618157

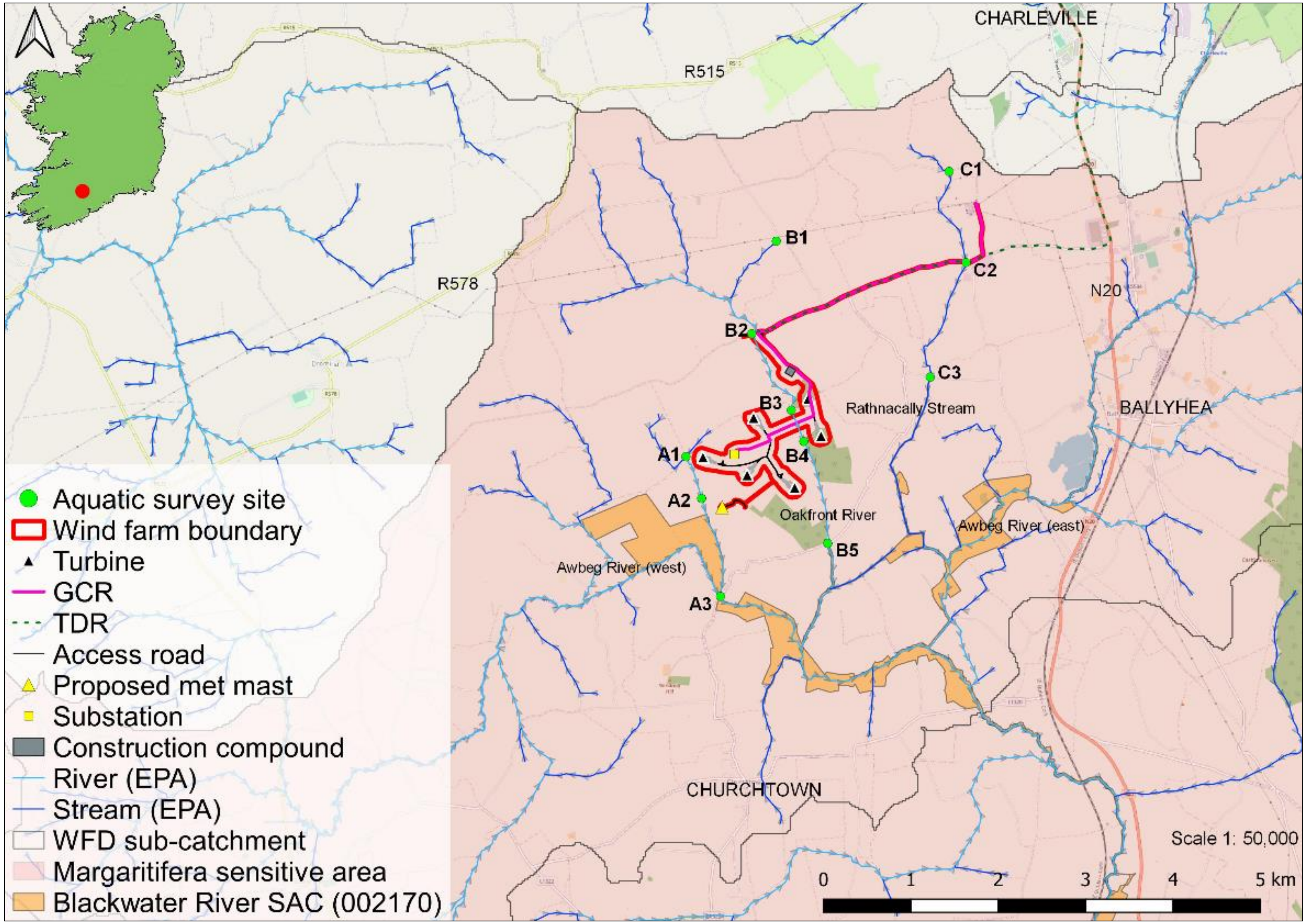


Figure 2.1 Overview of the aquatic survey locations for the proposed Annagh wind farm project, Co. Cork

2.3 Site surveys

Site surveys of the watercourses within the vicinity of the proposed wind farm project were conducted in September 2020. Survey effort focused on both instream and riparian habitats approx. 150m upstream and 150m downstream of each sampling point (see **Figure 2.1** above). The watercourses at each survey site were described in terms of the important aquatic habitats and species. This helped to evaluate species and habitats of ecological value in the vicinity of each site. The aquatic baseline prepared would inform mitigation for the wind farm project.

A broad aquatic habitat assessment was conducted utilising elements of the methodology given in the Environment Agency's 'River Habitat Survey in Britain and Ireland Field Survey Guidance Manual 2003' (EA, 2003) and the Irish Heritage Council's 'A Guide to Habitats in Ireland' (Fossitt, 2000). All sites were assessed in terms of:

- Physical watercourse/waterbody characteristics (i.e. width, depth etc.)
- Substrate type, listing substrate fractions in order of dominance (i.e. bedrock, boulder, cobble, gravel, sand, silt etc.)
- Flow type, listing percentage of riffle, glide and pool in the sampling area
- An appraisal of the macrophyte and aquatic bryophyte community at each site
- Riparian vegetation composition

2.4 Catchment-wide electro-fishing

A catchment-wide electro-fishing (CWEF) survey of the watercourses within the vicinity of the proposed wind farm (*n*=11 sites, **Figure 2.1**) was conducted on the 2nd and 3rd September 2020, under the conditions of a Department of Communications, Climate Action & Environment (DCCAE) licence. The survey was undertaken in accordance with best practice (CEN, 2003; CFB, 2008; Matson et al., 2018) and Section 14 licencing requirements.

Furthermore, a fisheries habitat appraisal of the survey watercourses (**Figure 2.1**) was undertaken to establish their importance for salmonid, lamprey, European eel and other fish species. The baseline assessment considered the quality of spawning, nursery and holding habitat within the vicinity of the survey sites using Life Cycle Unit (salmonids) and Lamprey Habitat Quality Index scores (lamprey).

For detailed survey methodology, please refer to accompanying fisheries assessment report in **Appendix A.**

2.5 White-clawed crayfish survey

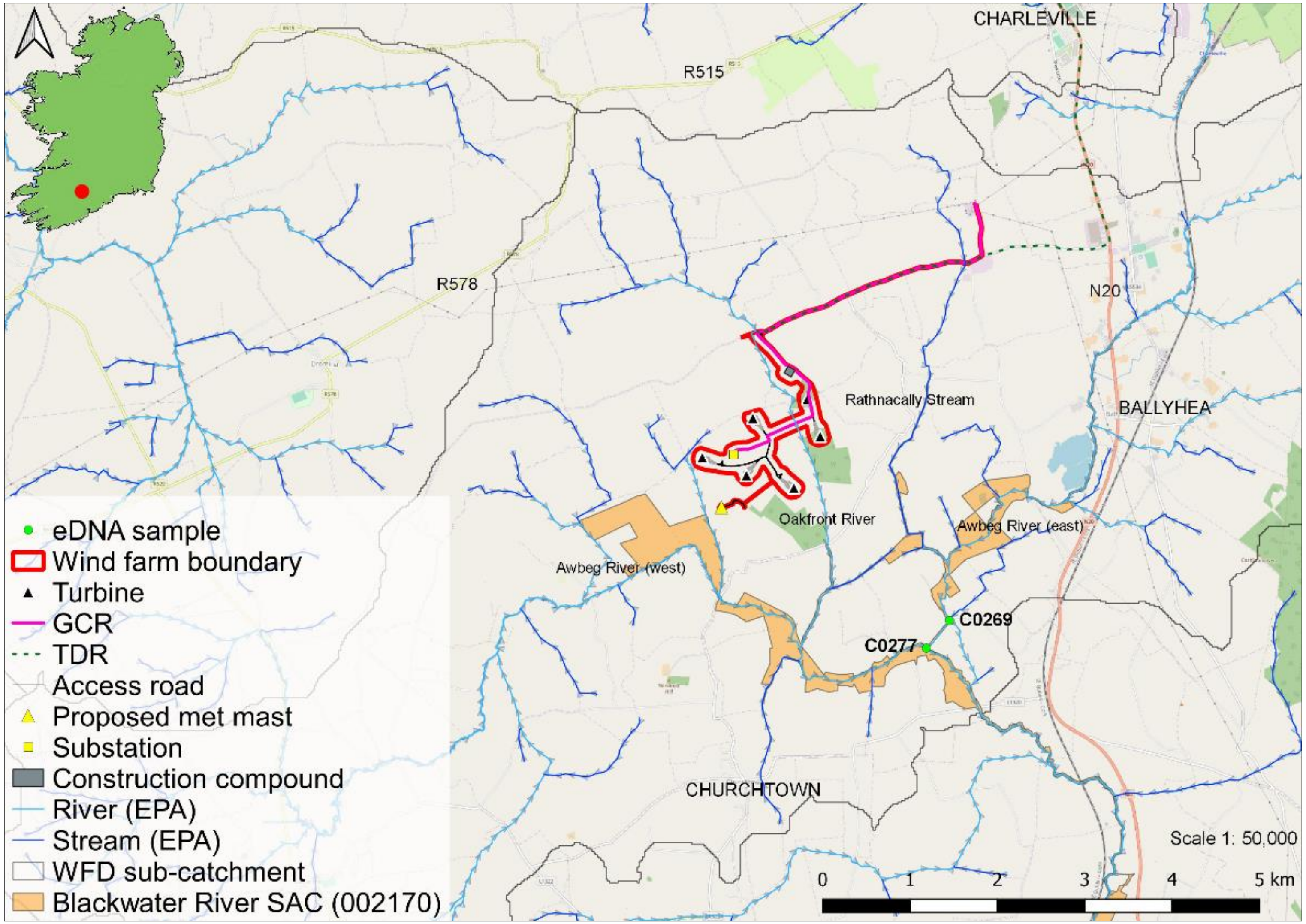
White-clawed crayfish (*Austropotamobius pallipes*) surveys were undertaken at the aquatic survey sites in September 2020 under a National Parks and Wildlife (NPWS) open licence (no. C79/2020), as prescribed by Sections 9, 23 and 34 of the Wildlife Act (1976-2021), to capture and release crayfish to their site of capture, under condition no. 5 of the licence. As per Inland Fisheries Ireland recommendations, the crayfish licence sampling started at the uppermost site(s) of the wind farm catchment/sub-catchments in the survey area to minimise the risk of transfer invasive propagules (including crayfish plague) in an upstream direction.

Hand-searching of instream refugia and sweep netting was undertaken according to Reynolds et al. (2010). Trapping of crayfish was not feasible given the small nature of most aquatic survey sites sampled. An appraisal of white-clawed crayfish habitat at each site was also carried out based on physical channel attributes, water chemistry and incidental records in mustelid spraint. Additionally, a desktop review of crayfish records within the wider Awbeg River and Awbeg_SC_010 sub-catchment was undertaken.

2.6 eDNA analysis

To validate traditional surveys (outlined above) and to detect potentially cryptically-low populations within the study area, a total of *n*=2 samples from the Awbeg River were analysed for white-clawed crayfish environmental DNA (eDNA) (**Figure 2.2**). Furthermore, samples were also analysed for crayfish plague (hitherto unrecorded from the wider Munster Blackwater catchment). Samples were collected on 2nd April 2021, with the sites strategically chosen to maximise longitudinal (instream) coverage within the catchment (i.e. facilitating a greater likelihood of detection).

In accordance with best practice, composite (500ml) water samples were collected from each sampling point, maximising the geographic spread within each site (20 x 25ml samples at each site), thus increasing the chance of detecting the target species' DNA. Each composite sample was filtered on site using a sterile proprietary eDNA sampling kit. Fixed samples were stored at room temperature and sent to the laboratory for analysis. A total of *n*=12 qPCR replicates were analysed for each site. Given the high sensitivity of eDNA analysis, a single positive qPCR replicate is considered as proof of the species' presence (termed qPCR No Threshold, or qPCR NT). Whilst an eDNA approach is not currently quantitative, the detection of the target species' DNA indicates the presence of the species at and or upstream of the sampling point. Please refer to **Appendix D** for full eDNA laboratory analysis methodology.


CHARLEVILLE
R515
R578
N20
BALLYHEA
Rathnacally Stream
Oakfront River
Awbeg River (east)
Awbeg River (west)
C0269
C0277
CHURCHTOWN
eDNA sample
Wind farm boundary
Turbine
GCR
TDR
Access road
Proposed met mast
Substation
Construction compound
River (EPA)
Stream (EPA)
WFD sub-catchment
Blackwater River SAC (002170)
Scale 1: 50,000
0 1 2 3 4 5 km

2.7 Freshwater pearl mussel survey

A freshwater pearl mussel (*Margaritifera margaritifera*) survey was undertaken in September 2020 at a total of *n*=14 sites on the Ardglass River, Oakfront River, Awbeg River (east and west branches) and Rathnacally Stream (under NPWS licence C201/2020). Methodology followed NPWS guidance (Anon, 2004) and included bathyscope and snorkel surveys, dependant on local water depths and flow regimes. Assessments were made of the habitat suitability for freshwater pearl mussels, based on the criteria of Hastie et al. (2000) and Skinner et al. (2003). Please refer to **Appendix B** for detailed methodology.

2.8 Biological water quality (Q-sampling)

Given the unsuitability of some sites (lack of flow, lack of water or too deep), biological water quality was assessed at a total of *n*=7 aquatic survey sites through Q-sampling during September 2020 (**Figure 2.3**). Macro-invertebrate samples were converted to Q-ratings as per Toner et al. (2005). All riverine samples were taken with a standard kick sampling hand net (250mm width, 500µm mesh size) from areas of riffle/glide utilising a three-minute sample. Large cobble was also washed at each site where present and samples were elutriated and fixed in 70% ethanol for subsequent laboratory identification. Any rare invertebrate species were identified from the NPWS Red List publications for beetles (Foster et al., 2009), mayflies (Kelly-Quinn & Regan, 2012), stoneflies (Feeley et al., 2020) and other relevant taxa (i.e. Byrne et al., 2009; Nelson et al., 2011).

Table 2.2 Reference categories for EPA Q-ratings (Q1 to Q5)

Q Value	WFD Status	Pollution status	Condition
Q5 or Q4-5	High status	Unpolluted	Satisfactory
Q4	Good status	Unpolluted	Satisfactory
Q3-4	Moderate status	Slightly polluted	Unsatisfactory
Q3 or Q2-3	Poor status	Moderately polluted	Unsatisfactory
Q2, Q1-2 or Q1	Bad status	Seriously polluted	Unsatisfactory

2.9 Otter signs

The presence of otter (*Lutra lutra*) at each aquatic survey site was determined through the recording of otter signs within 150m upstream and downstream of the site. These included holts, couches, spraints, latrines, slides and prints which are useful determinants of otter utilisation of watercourses. The location of signs was recorded via handheld GPS.

2.10 Aquatic ecological evaluation

The evaluation of aquatic ecological receptors contained within this report uses the geographic scale and criteria defined in the 'Guidelines for Assessment of Ecological Impacts of National Road Schemes' (NRA, 2009).

2.11 Biosecurity

A strict biosecurity protocol including the Check-Clean-Dry approach was adhered to during surveys for all equipment and PPE used. Disinfection of all equipment and PPE before and after use with Virkon™ was conducted to prevent the transfer of pathogens or invasive propagules between survey sites. Surveys were undertaken at sites in a downstream order to minimise the risk of upstream propagule mobilisation. Any aquatic invasive species or pathogens recorded within or adjoining the survey areas were geo-referenced.

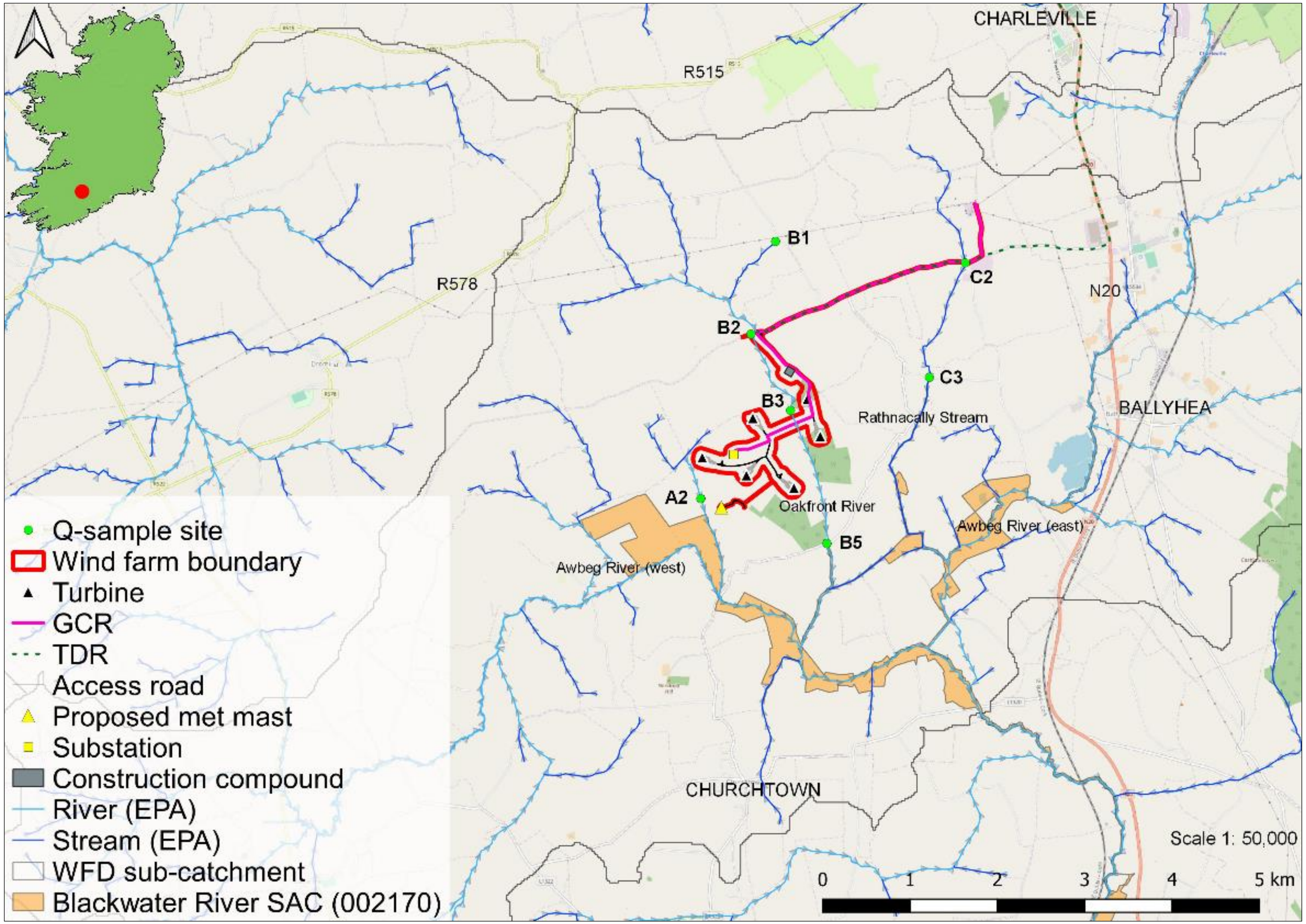


Figure 2.3 Overview of biological water quality (Q-sampling) locations for the proposed Annagh wind farm project, Co. Cork

3. Receiving environment

3.1 Sites designated for aquatic interests

There was a single European site with downstream hydrological connectivity to the proposed Annagh wind farm project, namely Blackwater River SAC (site code: 002170) (**Figure 1.1**).

3.1.1 Blackwater River SAC (002170)

The River Blackwater is one of the largest rivers in Ireland, draining a major part of Co. Cork and five ranges of mountains. The site consists of the freshwater stretches of the River Blackwater as far upstream as Ballydesmond, the tidal stretches as far as Youghal Harbour and many tributaries, the larger of which include the Awbeg, Licky, Bride, Flesk, Chimneyfield, Finisk, Araglin, Awbeg (Buttevant), Clyda, Glen, Allow, Dalua, Brogeen, Rathcool, Finnow, Owentaraglin and Awnaskirtaun.

The River Blackwater is of considerable conservation significance for the occurrence of good examples of habitats and populations of plant and animal species that are listed on Annexes I and II of the E.U. Habitats Directive, respectively. Furthermore, the site is of high conservation value for the populations of bird species that use it. Two Special Protection Areas, designated under the E.U. Birds Directive, are also located within the site - Blackwater Callows and Blackwater Estuary. Additionally, the importance of the site is enhanced by the presence of a suite of uncommon plant species (NPWS, 2016).

The proposed wind farm boundary was not located within the European site although the lower reaches of the Ardglass River formed a border with the SAC to the west of the site (**Figure 2.1**). Furthermore, potential downstream hydrological connectivity existed between the proposed wind farm site and associated infrastructure and Blackwater River SAC via the Oakfront River, Rathnacally Stream and Awbeg River (west branch). The shortest potential hydrological pathway between proposed site infrastructure and the Blackwater River SAC was approx. 700m from the turbine T4 hardstand via the Ardglass River (i.e. over-land and by water distance). The access road to turbine T2 crossed the Oakfront River approx. 1.7km instream distance from the Blackwater SAC site. The GCR did not cross over watercourses within or part of the Blackwater River SAC although hydrological connectivity was present via the Oakfront River and Rathnacally Stream (1.7km and 1.5km instream distance, respectively). The proposed TDR crossed the Rathnacally Stream approx. 1.5km upstream of the Blackwater River SAC boundary.

The Blackwater River SAC is designated for the following qualifying interests (NPWS, 2012), namely;

- Estuaries [1130]
- Mudflats and sandflats not covered by seawater at low tide [1140]
- Perennial vegetation of stony banks [1220]
- Salicornia and other annuals colonising mud and sand [1310]
- Atlantic salt meadows (Glauco-Puccinellietalia maritimae) [1330]
- Mediterranean salt meadows (Juncetalia maritimi) [1410]

- Water courses of plain to montane levels with the *Ranunculion fluitantis* and Ca*llitricho-Batrachion* vegetation [3260]
- Old sessile oak woods with *Ilex* and *Blechnum* in the British Isles [91A0]
- Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (Alno-Padion, Alnion incanae, Salicion albae) [91E0]
- *Margaritifera margaritifera* (freshwater pearl mussel) [1029]
- *Austropotamobius pallipes* (white-clawed crayfish) [1092]
- *Petromyzon marinus* (sea lamprey) [1095]
- *Lampetra planeri* (brook lamprey) [1096]
- *Lampetra fluviatilis* (river lamprey) [1099]
- *Alosa fallax fallax* (twaite shad) [1103]
- *Salmo salar* (Atlantic salmon) [1106]
- *Lutra lutra* (otter) [1355]
- *Trichomanes speciosum* (Killarney fern) [1421]

3.2 Sensitive species data request

A sensitive species data request of aquatic interest was submitted (20th January 2021) to the National Parks and Wildlife Service for the 10km grid squares containing and adjoining the proposed wind farm project (i.e. R41, R50, R51, R52 & R60) and was received on the 26th January 2021. Records for a number of rare or protected species were available although most did not overlap directly with the survey area.

Numerous records for white-clawed crayfish (*Austropotamobius pallipes*) records were available from the Awbeg River (**Figure 3.1**). In the vicinity of the proposed wind farm (Awbeg [Buttevant]_SC_010 sub-catchment), the majority of crayfish records were for the Awbeg River (east branch), i.e. a watercourse with no downstream hydrological connectivity to the proposed project. However, a low number of records were available for Annagh Bridge and the L1320 road bridge (2003-2012 period), sites which had downstream hydrological connectivity to the proposed wind farm site. The nearest crayfish record to proposed wind farm infrastructure with potential hydrological connectivity was at Annagh Bridge on the Awbeg River, located approx. 1.7km from the turbine T4 hardstand via the Ardglass River (i.e. over-land and by water distance).

A single sea lamprey (*Petromyzon marinus*) record (spawning) was available for the Awbeg River (east branch) at Longford Bridge (grid square R51). However, this location did not share any downstream hydrological connectivity with the proposed wind farm project or associated infrastructure (see **Figure 3.1**).

Although located within the Munster Blackwater *Margaritifera* sensitive area, there were no freshwater pearl mussel (*Margaritifera margaritifera*) records available for the respective 10km grid squares in the vicinity of the proposed wind farm. The nearest downstream freshwater pearl mussel record was in the vicinity of Ballyhooly on the River Blackwater, >45km instream distance from the proposed wind farm. Please refer to **Appendix B** (freshwater pearl mussel report for further details)

Common frog (*Rana temporaria*) were widespread throughout 10km grid squares R41, R50, R51, R52 & R60 although no records overlapped directly with the proposed wind farm footprint. Several frog records were available for the Annagh Bogs area, located to the immediate northwest of the proposed site boundary.

Numerous records for kingfisher (*Alcedo atthis*) were available on the Awbeg River for grid squares R50 and R60 (downstream of Buttevant). No records were available in the vicinity of the proposed wind farm.

A low number of otter (*lutra lutra*) records were spread throughout the relevant grid squares, with records available for the Awbeg River at multiple locations. This included the L1320 road bridge (downstream of the proposed wind farm), as well as downstream of Buttevant.

3.3 Annagh wind farm catchment and survey area description

The proposed wind farm project is located in a lowland area in the townlands of Annagh North and Coolcaum, approx. 6km south-west of Charleville, Co. Cork. The Annagh wind farm site is within the South Western River Basin District and within hydrometric area 18 (Blackwater (Munster)). The aquatic survey sites were located on numerous watercourses within the Awbeg [Blackwater] SC_010 river sub-catchments near Charleville, Co. Cork. The survey area also overlapped with the Blackwater (Munster) *Margaritifera* sensitive area (**Figure 2.1**).

The following watercourses drained the proposed wind farm site:

- **Fiddane Stream** (EPA code: 18F19): the Fiddane Stream is a small, historically modified tributary of the Ardglass River located to the north-west of the site boundary
- **Ardglass River** (18A23): the Ardglass River is a small, historically modified tributary of the Awbeg River, to which it joins at Annagh Bridge. The short watercourses (2.6km length) river flows in a loosely north-south direction, to the west of the wind farm site. The lowermost c.1km of the river forms a boundary of the Blackwater River SAC (002170)
- **Awbeg River (west)** (18A09): the Awbeg River (west branch) is the major watercourse associated with the proposed Annagh project. The Awbeg flows in a loosely north-west-south-east direction and joins the River Blackwater south of Castletownroche, approx. 37.5km downstream of the proposed wind farm site. Much of the river's course is located within the Blackwater River SAC (002170)
- **Oakfront River** (18O02): the Oakfront River is a small, historically straightened tributary of the Awbeg, which it joins approx. 1.3km south of the bridge at Coolcaum (aquatic site A5). The Oakfront drains an area north of the proposed wind farm and flows through the centre of the site in a loosely north-south direction. The lowermost 1.3km of the river forms part of the Blackwater River SAC (002170)

In vicinity of the wind farm site, the TDR crosses the following watercourse:

- **Rathnacally Stream** (18R32): the Rathnacally Stream is a small, historically straightened tributary of the Awbeg River (east branch), which adjoins the main (western) branch of the

Awbeg at Scart Bridge. The TDR crosses this watercourse via a local road bridge at Rathnacally, near Ardnageehy Cross Roads (**TDR node 10.5**)

The GCR crosses the Rathnacally Stream at the L1322 local road crossing at Rathnacally (GCR-WCC1). The proposed crossing methodology for this location is via horizontal directional drilling (HDD).

The watercourses and aquatic surveys sites in the vicinity of Annagh wind farm are typically small, lowland depositing channels (FW2; Fossitt, 2000) which have been historically straightened and deepened as part of arterial drainage works (see **section 4** for more details). Land use practices in the wider survey area are dominated by agricultural pasture (CORINE 231) with localised pockets of broadleaved forests (311) and, less so, coniferous forests (312).

Predominantly, the watercourses flow over Visean limestone & calcareous shale, with Tournaisian limestone to the east and Namurian shale, sandstone, siltstone & coal to the north of the proposed site (Geological Survey of Ireland data).

3.4 EPA water quality data (existing data)

The following outlines the available water quality data for the watercourses in context of the proposed wind farm project. Only recent water quality (i.e. since 2018) is summarised below. There was no existing EPA biological monitoring data available for the Fiddane Stream (EPA code: 18F19), Ardglass River (18A23), Milltown Stream (18M57), Oakfront River (18O02) or Rathnacally Stream (18R32).

Please note that biological water quality analysis was undertaken as part of this study, with the results presented in the **section 4** and **Appendix C** of this report.

3.4.1 Awbeg River water quality

The Awbeg River (EPA code: 18A09) is the most significant watercourse draining the proposed wind farm site (downstream connectivity only, to the south of the site). Survey site A3 is located at the confluence of the Ardglass River and Awbeg River at Annagh Bridge.

In the vicinity of the survey area, there is a total of two EPA biological monitoring stations on the Awbeg which have been recently monitored (since 2018). The uppermost of these (station code: RS18A090400) is located at survey site A3 (Annagh Bridge). This site achieved Q2-3 (poor status) water quality in 2018 and thus failed to meet target good status (≥Q4) as set out under Water Framework Directive (2000/60/EC). However, station RS18A050550 (L1320 road crossing), located approx. 4km downstream of survey site A3 achieved Q4 (good status) water quality in 2018.

The WFD River Waterbodies Risk upstream of Annagh Bridge (Awbeg (Buttevant) (West)_020), the Awbeg (including the Ardglass River) was ‘at risk’ according to the EPA. Downstream of this point the River Waterbodies Risk for the Awbeg (Buttevant)_010 sub-catchment, which included the Awbeg River, Oakfront River, Milltown Stream and Rathnacally Stream, was ‘under review’ at the time of survey. The River Waterbody WFD Status for this sub-catchment in 2013-2018 period was ‘good’.

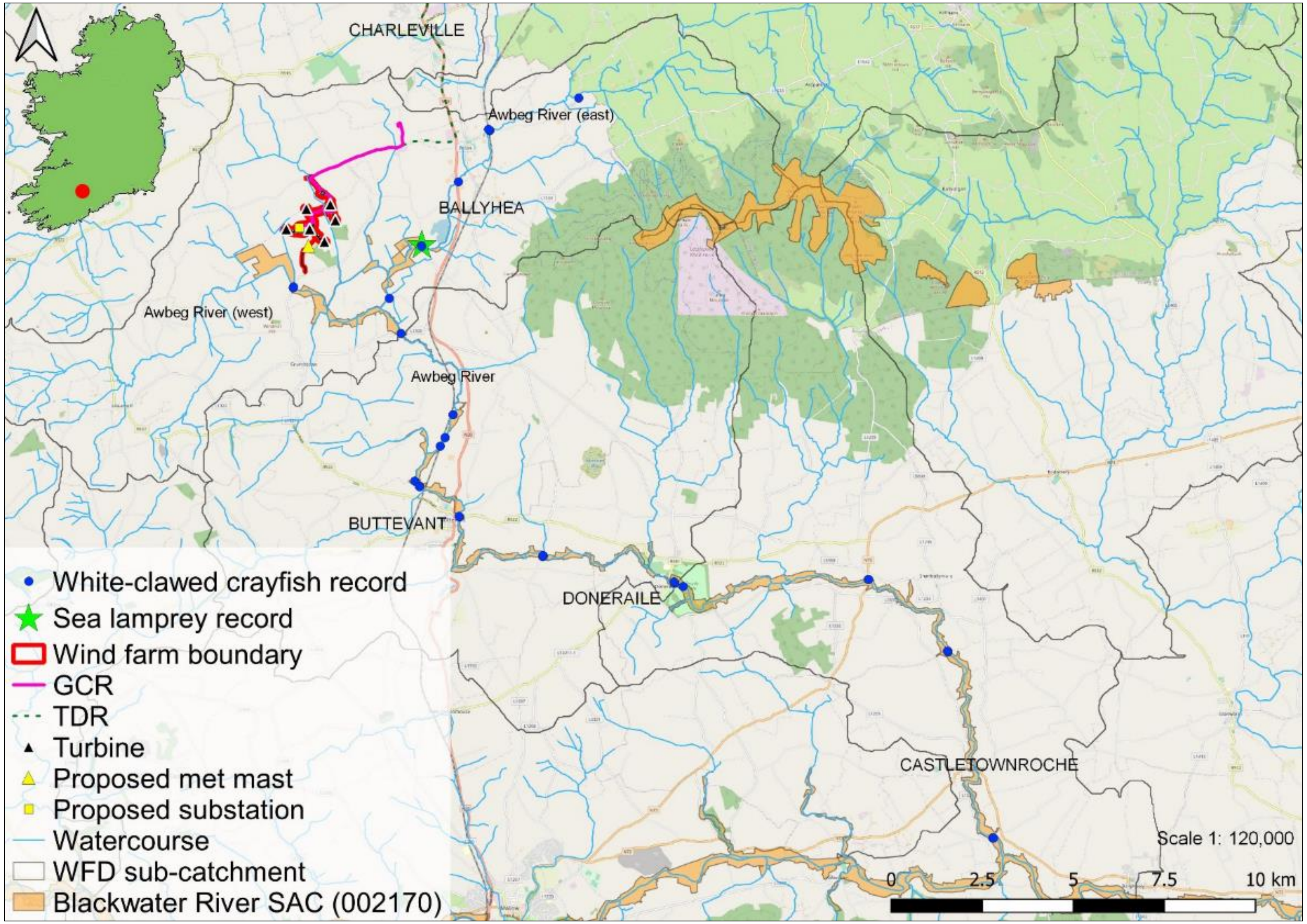


Figure 3.1 Distribution of white-clawed crayfish and sea lamprey records in the vicinity of the proposed wind farm (source: NPWS/NBDC data)

4. Results of aquatic surveys

The following section summarises each survey site in terms of aquatic habitats, physical characteristics and overall value for fish, white-clawed crayfish, freshwater pearl mussel and macrophyte communities. Biological water quality (Q-sample) results are also summarised for each site. Habitat codes are according to Fossitt (2000). Scientific names are provided at first mention only. Sites were surveyed in September 2020, with environmental DNA (eDNA) analysis carried out in April 2021. Please refer to **Appendix A** (fisheries assessment report), **Appendix B** (freshwater pearl mussel report), **Appendix C** (Q-sample results) and **Appendix D** (eDNA analysis) for more detailed results. An evaluation of the aquatic ecological importance of each survey site based on these aquatic surveys is provided and summarised in **Table 4.1**.

4.1 Aquatic survey site results

4.1.1 Site A1 – Fiddane Stream

Site A1 was located on the Fiddane Stream (18F19), immediately upstream of the Ardglass River confluence. The stream represented a small, narrow drainage channel (FW4) that averaged <1m wide and 0.1m deep. Flow was imperceptible at the time of survey (stagnant channel), with stagnant pool habitat to a maximum of 0.2m. The stream was considered a non-perennial watercourse at the survey location. The stream had been historically straightened and deepened, with varying bankfull heights of 1-2m. The substrata were composed of exclusively of deep silt, often >0.3m in depth. Livestock poaching was evident throughout the survey site. Riparian shading was high given a mature treeline dominated by ash (*Fraxinus excelsior*) and sycamore (*Acer psuedoplatanus*) with often dense bramble (*Rubus fruticosus* agg.), ivy (*Hedera helix*) and fern scrub. Tunnelling was frequent, with abundant woody debris instream, causing regular, significant blockages to flow. Consequently, macrophyte growth was limited to only occasional marginal fool's watercress (*Apium nodiflorum*).

Site A1 was not of fisheries value, with no fish recorded via electro-fishing (**Appendix A**). Whist localised ponding of water to 0.2m depth was present in several locations during the survey, the channel showed evidence of seasonal drying and was, therefore, not capable of supporting resident fish. The site had no suitability for white-clawed crayfish and none were recorded. The site had no suitability for freshwater pearl mussel given low flows, heavy siltation and its diminutive nature.

Site A1 was not suitable for Q-sampling during the survey period due to its shallow depth and lack of flow. Thus, it was not possible to assess biological water quality at this site.

The aquatic ecological evaluation of site A1 was of **Local importance (lower value)** (**Table 4.1**).

Plate 4.1 Representative image of site A1 on the Fiddane Stream, September 2020

4.1.2 Site A2 – Ardglass River, Annagh Bogs

Site A2 was located on the middle reaches of the Ardglass River (18A23) approx. 0.5km downstream from site A1. The river had been extensively straightened and over-deepened, historically, with a 1.5-2m wide channel with a deep U-shaped profile and 2-2.5m bankfull heights. The river represented a drainage channel (FW4), with an imperceptible flow at the time of survey. The channel averaged 0.7-0.8m deep with a bed composed exclusively of deep silt (often >0.5m in depth). The banks were heavily overgrown with dense bramble-dominated scrub (WS1). To the east was Annagh Bogs, an area of wet grassland (GS4), with coniferous plantation (WD4) adjoining to the west. Terrestrial encroachment of the channel was often high. Instream macrophyte coverage was very high, with abundant reed canary grass (*Phalaris arundinacea*) in addition to common duckweed (*Lemna minor*) and water mint (*Mentha aquatica*). As a result, open water areas were sparse. Common water starwort (*Callitriche stagnalis*) was occasional in more open areas of channel.

Three-spined stickleback (*Gasterosteus aculeatus*) was the only species recorded during electro-fishing at site A2 (**Appendix A**). The site was not of value for salmonids or lamprey given the heavily-silted, heavily-vegetated and low flow nature of the channel. Whilst some low suitability existed for European eel, none were recorded. The site had poor suitability for white-clawed crayfish and none were recorded. The site had no suitability for freshwater pearl mussel given low flows, heavy siltation and its diminutive nature (**Appendix B**).

Biological water quality, based on Q-sampling, was calculated (tentatively) as **Q2-3 (poor status)** (**Appendix C**). No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded via Q-sampling.

The aquatic ecological evaluation of site A2 was of **Local importance (lower value)** (**Table 4.1**).

Plate 4.2 Representative image of site A2 on the Ardglass River, September 2020

4.1.3 Site A3 – Awbeg River, Annagh Bridge

Site A3 was located at the confluence of the Awbeg River (18A09) and Ardglass River, near Annagh Bridge. The Ardglass adjoined the Awbeg via a poorly accessible pipe culvert under the local road (leading to a large pool) and a deeply-cut, heavily-silted channel of 6-7m in width and 1.5-2m deep leading to the main river. The Ardglass had been extensively straightened and over-deepened throughout (both upstream and downstream of the confluence). Similarly, the Awbeg in the vicinity of Annagh Bridge had also been historically straightened and deepened. The river featured 100% deep glide which averaged 1.5->2m in depth and 8-10m in width, with steep margins. The substrata were dominated by deep silt throughout. The site was bordered by improved agricultural grassland (GA1) and an extensive area of wet grassland (historical floodplain) to the east, downstream of the bridge. Scrub comprising bramble, nettle, reed canary grass, great willowherb (*Epilobium hirsutum*) and rank grasses bordered the river. Given the typically low flows and heavily-silted nature of the site, macrophyte growth was high. Channel margins supported frequent stands of branched bur-reed (*Sparganium erectum*), abundant reed canary grass and occasional lesser water parsnip (*Berula erecta*). Common duckweed was frequent throughout.

Three fish species were recorded via electro-fishing from site A3 at the Awbeg-Ardglass confluence (**Appendix A**). Brown trout were the most frequently recorded, with a low density of adults recorded (*n*=10, the highest density of trout recorded at any survey site). European eel and three-spined stickleback were also present in low numbers. The site was not considered of value as a salmonid or lamprey spawning habitat given high siltation rates and its historically drained nature. However, holding habitat was good. The site was of some moderate value as a nursery although no juvenile salmonids were recorded (recruitment likely impacted by siltation). Despite abundant silt deposits, no lamprey ammocoetes were recorded. European eel habitat was good overall given frequent instream macrophyte refugia. The site had some good suitability for white-clawed crayfish although none were recorded via sweep netting or hand-searching. However, eDNA analysis of a water sample at Scart Bridge (3.2km downstream) indicated the presence of white-clawed crayfish in the Awbeg at and or upstream of Scart Bridge (see section 4.3). The site had no suitability for freshwater pearl mussel given heavy siltation (**Appendix B**).

Site A3 was not suitable for Q-sampling during the survey period due to its considerable depth and slow-flowing glide and pool habitat. Thus, it was not possible to assess biological water quality at this site (however, refer to section 3.4.1 for existing water quality data).

Given the location of the site (Awbeg and Ardglass channels) within the Blackwater River SAC (002170), the aquatic ecological evaluation of site A3 was of **international importance** (**Table 4.1**).

Plate 4.3 Representative image of site A3 at the Awbeg River (right)-Ardglass River (left) confluence at Annagh Bridge, September 2020 (facing downstream)

Plate 4.4 Representative image of the Ardglass River (right) upstream of site A3, September 2020

4.1.4 Site B1 – Milltown Stream, Milltown

Site B1 was located on the upper reaches of the Milltown Stream (18M57). The semi-natural lowland depositing watercourse (FW2) averaged 1-1.5m wide and 0.1-0.2m deep. Upstream of the road crossing (single arch bridge), the stream had been straightened but not deepened with low habitat heterogeneity remaining. However, downstream, the stream retained some good natural features (meanders, large woody debris and an overall greater depth). Overall, the site was characterised by shallow glide and riffle (both 40%) with only limited shallow pool present. Given the shallow depth, the site was considered likely to suffer from partial drying in the summer months. The substrata were dominated by small cobble (50%) which were highly compacted/bedded, although finer gravel fractions were also present locally. However, these were often heavily silted. The small (unnamed) stream adjoining the site immediately upstream of the bridge was evidently contributing to siltation pressures. Some limited small boulder habitat was present in the vicinity of the bridge. Silt accumulations were present (high clay fractions), usually in association with macrophyte beds. The riparian zone supported dense bramble scrub downstream of the bridge with a small block of wet woodland of willow and alder with Scot's pine (*Pinus sylvestris*), sitka spruce (*Picea sitchensis*), hawthorn, ivy, meadowsweet (*Filipendula ulmaria*), iris and nettle. Improved grassland (GA1) bordered the site on the south bank and upstream. In terms of macrophytes, the site featured heavy instream growth of fool's watercress (40%) with iris (*Iris pseudacorus*) encroachment also frequent downstream of the bridge.

Three-spined stickleback and European eel were the only species recorded via electro-fishing (**Appendix A**). Despite some suitability in terms of nursery and spawning habitat, the site did not support salmonids at the time of survey (possibly due to low flow pressures, seasonally). Although some localised soft sediment accumulations were present, no lamprey ammocoetes were recorded. European eel habitat was moderate overall, with some locally good habitat present in deeper pool areas. The site had some moderate suitability for white-clawed crayfish although none were recorded. The site had no suitability for freshwater pearl mussel given seasonal fluctuations and siltation pressures (**Appendix B**).

Biological water quality, based on Q-sampling, was calculated as **Q3 (poor status)** (**Appendix C**). No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded via Q-sampling.

Given the presence of European eel, the aquatic ecological evaluation of site B1 was of **Local importance (higher value)** (**Table 4.1**).

Plate 4.5 Representative image of site B1 on the Milltown Stream, September 2020

4.1.5 Site B2 – Oakfront River, Cooliney Bridge

Site B2 was located on the upper reaches of the Oakfront River (18O02) approx. 0.6km downstream from its confluence with the Milltown Stream. At Cooliney Bridge, adjacent to the proposed grid cable route, the river had been extensively straightened and deepened historically for approx. 450m, with limited natural features remaining downstream of the bridge. Upstream, the river was more semi-natural although straightening was still evident. The river averaged a consistent 2.5m with little depth variation (0.2-0.3m). Shallow glide predominated (70%) with occasional riffles (20%) and very limited shallow pool (max. 0.4m). The substrata were dominated by cobble and small boulder (60%), which were largely bedded and compacted. Finer gravel fractions were present locally but these were limited in extent (more frequent upstream). Sand and silt accumulations were scattered. Overall, siltation was low but moderate locally (i.e. near bridge). The river was bordered on both banks by intensive agricultural grassland (GA1) with narrow riparian buffers (<2m). Shading was relatively high with intermittent immature treelines of willow, hawthorn and alder (evidently a mature treeline was cleared in the recent past). The riparian zone supported a low diversity and low cover of common species such as nettle, speedwell species (*Veronica* spp.), non-native montbretia (*Crocosmia x crocosmiiflora*) and rank grasses. Instream macrophytes were limited to occasional fool's watercress along channel margins. The bryophyte community was poorly developed with limited *Hygroamblystegium* sp. present on some instream boulder and cobble.

Low densities of brown trout, European eel, three-spined stickleback and *Lampetra* sp. ammocoetes were recorded via electro-fishing at site B2 (**Appendix A**). The site was of poor value for salmonids given poor hydromorphology, compaction of substrata and siltation pressures. Some moderate eel nursery habitat was present. Lamprey spawning habitat was present but limited in extent and silted. Some limited larval habitat was present immediately downstream of the bridge. The site had some low suitability for white-clawed crayfish although none were recorded. The site had no suitability for freshwater pearl mussel given historical straightening and siltation pressures (**Appendix B**).

Biological water quality, based on Q-sampling, was calculated as **Q3 (poor status)** (**Appendix C**). No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded via Q-sampling.

Given the presence of brown trout, European eel and *Lampetra* sp. ammocoetes, the aquatic ecological evaluation of site B1 was of **Local importance (higher value)** (**Table 4.1**).

Plate 4.6 Representative image of site B2 on the Oakfront River, facing upstream to Cooliney Bridge, September 2020

4.1.6 Site B3 – Oakfront River, Milltown

Site B3 on the Oakfront River was located approx. 1km downstream from site B2 and approx. 150m upstream of the proposed internal road GCR crossing (WH-HF5). The river averaged 2-2.5m wide with depths ranging from 0.2-0.3m. Locally deeper pool/slacks were present, to a maximum of 0.5m. The stream had been extensively straightened historically although some limited natural features by way of meanders were present upstream and downstream. Bankfull heights were 1-2m, with natural scouring frequent (especially on meanders, **Plate 4.7**). The profile was dominated by shallow glide (80%) with limited pool and occasional riffle (10%). Unlike the channel upstream and downstream of the survey site (heavily silted), the substrata were dominated by fine and medium gravels (50%) with occasional cobble and small boulder in faster areas. Sand was frequent (20%). However, the substrata were moderately bedded and silted (moderate siltation). The site was bordered by improved agricultural grassland (GA1) to the east) and wet grassland (GS4) to the west, with bramble scrub and a mature alder/ash/hawthorn treeline along the west bank. The liverwort *Conocephalum conicum* was present on muddy banks. Given moderate shading, macrophytes were limited to marginal reed canary grass and occasional fool's watercress in open areas. Some branched bur reed (*Sparganium erectum*) was also present downstream of the proposed crossing. Filamentous algae was present but rare (<1% cover).

Low densities of brown trout, European eel and *Lampetra* sp. ammocoetes were recorded via electro-fishing at site B3, in addition to higher numbers of three-spined stickleback (**Appendix A**). The site was of moderate nursery value to salmonids with poorer quality spawning and holding habitat present (nevertheless, much improved over site B2 upstream). European eel habitat was moderate given the shallow depth and lack of instream refugia. Larval lamprey habitat was present locally although this was sub-optimal. Salmonid and lamprey spawning habitat as present but impacted by siltation. The site had some low suitability for white-clawed crayfish although none were recorded. The site had no suitability for freshwater pearl mussel given historical straightening and siltation pressures (**Appendix B**).

Biological water quality, based on Q-sampling, was calculated as **Q2-3 (poor status)** (**Appendix C**). No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded via Q-sampling.

Given the presence of brown trout, European eel and *Lampetra* sp. ammocoetes, the aquatic ecological evaluation of site B3 was of **Local importance (higher value)** (**Table 4.1**).

Plate 4.7 Representative image of site B3 on the Oakfront River, September 2020 (facing downstream towards small meander)

4.1.7 Site B4 – Oakfront River, Springfort

Site B4 on the Oakfront River was located approx. 0.5km downstream from site B3 and 220m downstream of the proposed GCR crossing. The river averaged 2.5m wide with depths ranging from 0.2-0.3m. Locally deeper pool/slacks were present, to a maximum of 0.4m. As with upstream sites, the stream had been extensively straightened historically although some limited natural features by way of meanders were present (some good recovery of riparian areas also). Bankfull heights were 1-2m. The profile was dominated by swift, shallow glide (60%) with limited pool and occasional riffle (30%). The substrata were dominated by fine and medium gravels (50%) with occasional cobble (30%) and frequent sand (20%). Larger cobble and boulders were rare. However, the substrata were moderately bedded and silted (moderate siltation), although the faster flows had reduced siltation over upstream and downstream sites. Natural bank erosion was evident with some cattle poaching locally. The site was bordered by improved agricultural grassland (GA1) and adjoined a coniferous block (WD4) on the east bank (with alder buffer). The site was relatively highly shaded (not excessive) with a mature treeline and hedgerow mosaic of alder, ash and hawthorn, with an understory dominated by bramble scrub. The liverwort *Conocephalum conicum* was present on muddy banks. Given moderate shading, macrophytes were limited to occasional fool's watercress in open areas and some limited lesser water parsnip instream.

Low densities of brown trout, European eel and three-spined stickleback were recorded via electro-fishing at site B4 (**Appendix A**). The site was of moderate nursery value to salmonids with some good quality spawning habitat present (better than upstream site B3). Lamprey spawning habitat was available despite siltation pressures, though ammocoete habitat was sub-optimal (compacted sediment). European eel habitat was moderate given the presence of instream refugia such as scoured/undercut banks and large woody debris. Larval lamprey habitat was present locally although this was sub-optimal. Salmonid and lamprey spawning habitat as present but impacted by siltation. The site had some low suitability for white-clawed crayfish although none were recorded. The site had no suitability for freshwater pearl mussel given historical straightening and siltation pressures (**Appendix B**).

A kingfisher nest (that appeared recently used) was recorded under overhanging scrub in a steep muddy bank on the west bank of the river (ITM 550749, 617484) (Plate 4.9).

Biological water quality was not calculated at this site given the close proximity to site B3.

Given the presence of brown trout, European eel and a kingfisher nest, the aquatic ecological evaluation of site B4 was of **Local importance (higher value)** (**Table 4.1**).

Plate 4.8 Representative image of site B4 on the Oakfront River, September 2020

Plate 4.9 Steep muddy bank with kingfisher nest at site B4 (nest obscured underneath ivy scrub)

4.1.8 Site B5 – Oakfront River, bridge at Coolcaum

Site B5 was located on the lower reaches of the Oakfront River, at a local road crossing, approx. 1.2km downstream of site B4. Downstream of the bridge, the site was located within the Blackwater River SAC (002170) site. The lowland depositing watercourse (FW2) has been extensively straightened and over-deepened historically as part of flood relief works. A flood embankment was present on the west bank downstream of the bridge. The flood embankment was colonised by low-lying scrub comprising abundant nettle, reed canary grass, hogweed, creeping thistle, occasional bramble and rank grasses. The east bank was adjoined by intensive agricultural grassland (GA1) with no riparian buffer (farmed to edge). Coniferous afforestation (WD4) adjoined upstream (west bank). The river featured very little habitat heterogeneity with dredged deep glide >1.2m deep throughout and near vertical, low-lying banks. The site comprised 100% deep glide (shallower upstream of bridge). The site was heavily silted. The substrata was dominated by silt (70%) with some compacted, bedded cobble and medium to coarse gravels underneath. There was little exposed gravel. Some sand was present marginally upstream of the bridge (also high silt component). Sediment accumulations with some lamprey potential (see below) were present in association with limited instream macrophyte beds. Macrophyte growth was limited to occasional lesser water parsnip with occasional patches of common water starwort (*Callitriche stagnalis*). Reed canary grass and fool's watercress lined much of the channel margins.

Low densities of brown trout, European eel, three-spined stickleback and a single *Lampetra* sp. ammocoete were recorded via electro-fishing at site B5 (**Appendix A**). Site B5 provided poor salmonid habitat overall given heavy siltation, although predominant deep glide did offer some suitability for larger adults and European eel. Lamprey habitat was moderate overall, with an absence of suitable spawning substrata due to siltation. The site had some moderate suitability for white-clawed crayfish given instream refugia and soft banks for burrowing although none were recorded. The site had no suitability for freshwater pearl mussel given historical straightening and heavy siltation pressures (**Appendix B**).

Biological water quality, based on Q-sampling, was calculated as **Q3 (poor status)** (**Appendix C**). No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded via Q-sampling.

Given the location of the site downstream of the bridge within the Blackwater River SAC (002170), the aquatic ecological evaluation of site A3 was of **international importance** (**Table 4.1**). Upstream of the bridge, the site was considered of **local importance (higher value)** given the presence of brown trout and *Lampetra* sp.

Plate 4.9 Representative image of site B5 on the Oakfront River, September 2020 (facing downstream into Blackwater River SAC).

4.1.9 Site C1 – Rathnacally Stream, Clashganniv

Site C1 was located on the uppermost reaches of the Rathnacally Stream (18R32), at a local road crossing. The stream represented a small, heavily-modified drainage channel (historically straightened and deepened) with stagnant water at the time of the survey. The channel was evidently seasonal (dries out frequently) and downstream of the field boundary the channel merged into two dry ditches. The channel was heavily scrubbed over and buried in a dense hawthorn hedgerow. The bank heights were low at 0.6m. The bed comprised exclusively of deep silt. Some small pockets of standing water existed upstream of the road crossing, near a residential property entrance. These pools supported water 0.2m deep with high levels of terrestrial encroachment from wild angelica (*Angelica sylvestris*) and yellow iris (*Iris pseudacorus*). Macrophytes were limited to occasional fool's watercress.

The channel had no inherent value for fish, white-clawed crayfish or freshwater pearl mussel due to the absence of flows, heavy siltation and the site's evidently seasonal nature. No fish were recorded via electro-fishing.

Site C1 was not suitable for Q-sampling during the survey period due to its shallow depth and lack of flow. Thus, it was not possible to assess biological water quality at this site.

The aquatic ecological evaluation of site C1 was of **Local importance (lower value)** (**Table 4.1**).

Plate 4.10 Representative image of site C1 on the upper Rathnacally Stream, September 2020 (channel heavily overgrown).

4.1.10 Site C2 – Rathnacally Stream, bridge at Rathnacally

Site C2 on the Rathnacally Stream (18R32) was located at a local road (L1322) and proposed GCR and TDR crossing point (GCR-WCC1), approx. 1.2km downstream of site C1. The small lowland depositing stream (FW2) averaged 1.5m wide and 0.4m deep, although the channel was often shallower and narrower, particularly upstream. The bank heights were low at 0.75m and the stream exhibited historical straightening and deepening. The profile was dominated by deep glide (90%) and pool (10%), with frequent instream blockage (terrestrial plant encroachment, refuse, large woody debris etc.). The riparian zone comprised a mixture of dense scrub (e.g. bramble, hedge bindweed) and rank grasses. The treeline adjoining the stream comprised of mature ash, sycamore and sitka spruce with blackthorn (*Prunus spinosa*), hawthorn and ivy in the understory. The adjoining land uses were of heavily improved grassland (GA1). The substrata comprised small amounts of cobble, occasional coarse and medium gravels but was dominated by silt with a high clay fraction. The silt formed a bed c.0.3m deep over the majority of the coarse substrata. The very heavily-modified stream habitat did not contain any macrophytes apart from marginal fool's watercress with lesser amounts of watercress (*Nasturtium officinale*).

Three-spined stickleback was the only fish species recorded via electro-fishing from site C2 (**Appendix A**). The slow-flowing site was considered too heavily modified and silted to support a healthy fish population fish and the deep silt/clay bed was considered too compacted to support lamprey ammocoetes. The site had some very low suitability for white-clawed crayfish, albeit none were recorded. The site had no suitability for freshwater pearl mussel given historical straightening and heavy siltation pressures (**Appendix B**).

Biological water quality, based on Q-sampling, was calculated as **Q2 (bad status)** (**Appendix C**). No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded via Q-sampling.

The aquatic ecological evaluation of site C2 was of **Local importance (lower value)** (**Table 4.1**).

Plate 4.11 Representative image of site C2 on the Rathnacally Stream, September 2020 (downstream of road crossing).

4.1.11 Site C3 – Rathnacally Stream, bridge at Ballynadrideen

Site C3 on the Rathnacally Stream (18R32) was located at a local road, approx. 1.5km downstream of site C2. The small lowland depositing stream (FW2) had been historically straightened upstream of the bridge but retained more semi-natural features downstream, where the stream was located within the Blackwater River SAC site. The small, lowland depositing watercourse (FW2) averaged 2.0m wide and 0.3m deep, with localised pool to 0.7m downstream of the bridge. The bank heights were low at 0.6m. The profile was dominated by deep glide (80%), riffle (10%) and pool (10%) by surface area over the survey reach, with deeper glide predominating downstream of the bridge and shallower glide and riffle upstream. The substrata were dominated by sand and silt covering 50% surface area of the bed. The remaining fractions comprised small boulder, coarse, medium and fine gravels (50%). Downstream of the bridge, the silt formed a bed

0.3m deep and covered large areas of the substrata. The riparian zone supported hedgerows and treelines adjoining domestic gardens upstream (GA2) and downstream of the road crossing. These were composed primarily of hawthorn, elder (*Sambucus nigra*), ash, sycamore and scattered sitka spruce (*Picea sitchensis*) with bramble in the understories. The adjoining land uses were of heavily improved grassland (GA1). The heavily-modified stream habitat did not contain any macrophytes apart from marginal fool's watercress.

Three-spined stickleback and European eel were the only fish species recorded via electro-fishing from site C3 (**Appendix A**). The slow-flowing site had been extensively straightened historically and was considered too heavily modified to support a healthy fish population. Salmonids were absent, despite some superficial suitability (riffle, glide and pool habitat). Evidently, siltation and water quality pressures had impacted the stream's ability to support salmonids (as per upstream). The deep silt/clay bed was considered too compacted to support lamprey ammocoetes, with none recorded. Suitability for European eel was moderate overall, although only a single juvenile was captured. The site had some moderate suitability for white-clawed crayfish given the presence of refugia and suitable burrowing habitat (clay banks). However, none were recorded. The site had no suitability for freshwater pearl mussel given historical straightening and heavy siltation pressures (**Appendix B**).

Biological water quality, based on Q-sampling, was calculated as **Q3 (poor status)** (**Appendix C**). No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded via Q-sampling.

Given the location of the site (downstream of the bridge) within the Blackwater River SAC (002170), the aquatic ecological evaluation of site C3 was of **international importance** (**Table 4.1**).

Plate 4.12 Representative image of site C3 on the Rathnacally Stream, September 2020 (facing downstream from bridge).

4.2 Biological water quality (macro-invertebrates)

No rare or protected macro-invertebrate species (according to national red lists) were recorded in the biological water quality samples taken from *n*=7 sites across the Fiddane Stream, Ardglass River, Milltown Stream, Oakfront River and Rathnacally Stream (**Figure 4.1, Appendix C**). All samples failed to meet the good status (≥Q4) requirements of the European Union Environmental Objectives (Surface Waters) (Amendment) Regulations 2019 and the Water Framework Directive (2000/60/EC).

The majority of samples achieved Q2-3 or Q3 (poor status) given the absence of EPA group A (sensitive) species and paucity of group B (less sensitive) species. The Group B cased caddis *Limnephilus* sp. was only present in small numbers at sites B1 (Milltown Stream) and B5 (Oakfront River). The dominance of group C species such as *Baetis rhodani, Gammarus duebeni* and *Limnius volckmari* and or group D *Asellus aquaticus* and *Radix balthica,* along with the presence of group E species (e.g. *Tubificid* sp.) reduced the Q-rating to that of poor status in the majority of samples. Site C2 on the Rathnacally Stream (proposed GCR and TDR crossing, GCR-WCC1) achieved Q2 (bad status) given the dominance of group D *Asellus aquaticus* and E species such as *Chironomus* sp., in addition to very heavy siltation.

4.3 eDNA analysis

Composite water samples collected from both the Awbeg River (east branch) (sample C0269) and Awbeg River west branch, immediately upstream of east branch confluence; sample C0277) (**Figure 2.2**) returned a positive result for white-clawed crayfish eDNA (10 of 12 and 2 of 12 qPCR replicates, respectively) (**Appendix D**). These test results were considered as evidence of the species' presence within the vicinity of Annagh wind farm, i.e. present at and or upstream of the sampling locations in the east and west branches of the Awbeg River. These results suggest a higher frequency of crayfish in the eastern branch of the Awbeg River, which is in keeping with available data and personal observations of high densities upstream of Ballyhea Cross Roads.

Given the absence of crayfish recorded using traditional survey methodologies (i.e. hand-searching, sweep netting, examination of otter spraints) at the *n*=11 aquatic survey sites, these results may indicate cryptically low populations of white-clawed crayfish within the vicinity of Annagh wind farm. It is considered that the habitat quality for crayfish has been significantly reduced given historical arterial drainage (removed bed material, higher compaction etc.) and ongoing siltation pressures.

A negative result for crayfish plague was returned for the two sample sites i.e. crayfish plague eDNA was not detected or was present below the limit of detection in a series of 12 qPCR replicates (0 positive replicates out of 12) (**Appendix D**). To date, crayfish plague has not been recorded in the wider Munster Blackwater catchment (inclusive of the Awbeg River).

4.4 Aquatic ecological evaluation

An aquatic ecological evaluation of each survey site was based on the results of electro-fishing, white-clawed crayfish, freshwater pearl mussel and biological water quality surveys (**Table 4.1**). Brown trout, *Lampetra* sp., European eel and three-spined stickleback were the only fish species recorded via electro-fishing. No salmonids or lamprey were recorded in the Fiddane Stream, Ardglass River or Rathnacally Stream. There was no suitability for freshwater pearl mussel. No white-clawed crayfish were recorded during the aquatic surveys using traditional methodologies. However, eDNA analysis revealed the species' presence in the Awbeg River (west branch) at or upstream of Scart Bridge and in the Awbeg River (east branch) at or upstream of the road crossing at Caherconnor.

Biological water quality was calculated as Q2-3 or Q3 across all *n*=7 sampling sites (**Appendix C**). Thus, all sites failed to achieve the (≥Q4) good status requirements of the European Union Environmental Objectives (Surface Waters) (Amendment) Regulations 2019 and the Water Framework Directive (2000/60/EC).

During freshwater pearl mussel surveys (**Appendix B**), otter signs (spraint) were recorded on the Awbeg River at Scart Bridge and the L1320 road bridge, as well as the Awbeg River (east branch) bridge at Caherconnor. An active otter holt was recorded near the Awbeg-Oakfront confluence (ITM 550754, 615085).

No examples of Annex I habitat 'Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation [3260] ('floating river vegetation') were recorded at the aquatic survey sites.

Sites A3 (Awbeg River), B5 (Oakfront River) and C3 (Rathnacally Stream) were considered of **international importance** given their location within the Blackwater River SAC (002170).

Sites B2, B3 and B4 on the Oakfront River, as well as site B1 on the connected Milltown Stream, were evaluated as **local Importance (higher value)** given the presence of salmonid, European eel and or *Lampetra* sp. populations and the presence of a kingfisher nest (site B4).

Sites A1 (Fiddane Stream), A2 (Ardglass River) and the remaining sites on the Rathnacally Stream (C1 & C2) were evaluated as l**ocal importance (lower value)** given their poor or absent fisheries value due to extensive historical modifications, heavy siltation, poor water quality (≤Q3) and or evident seasonality.

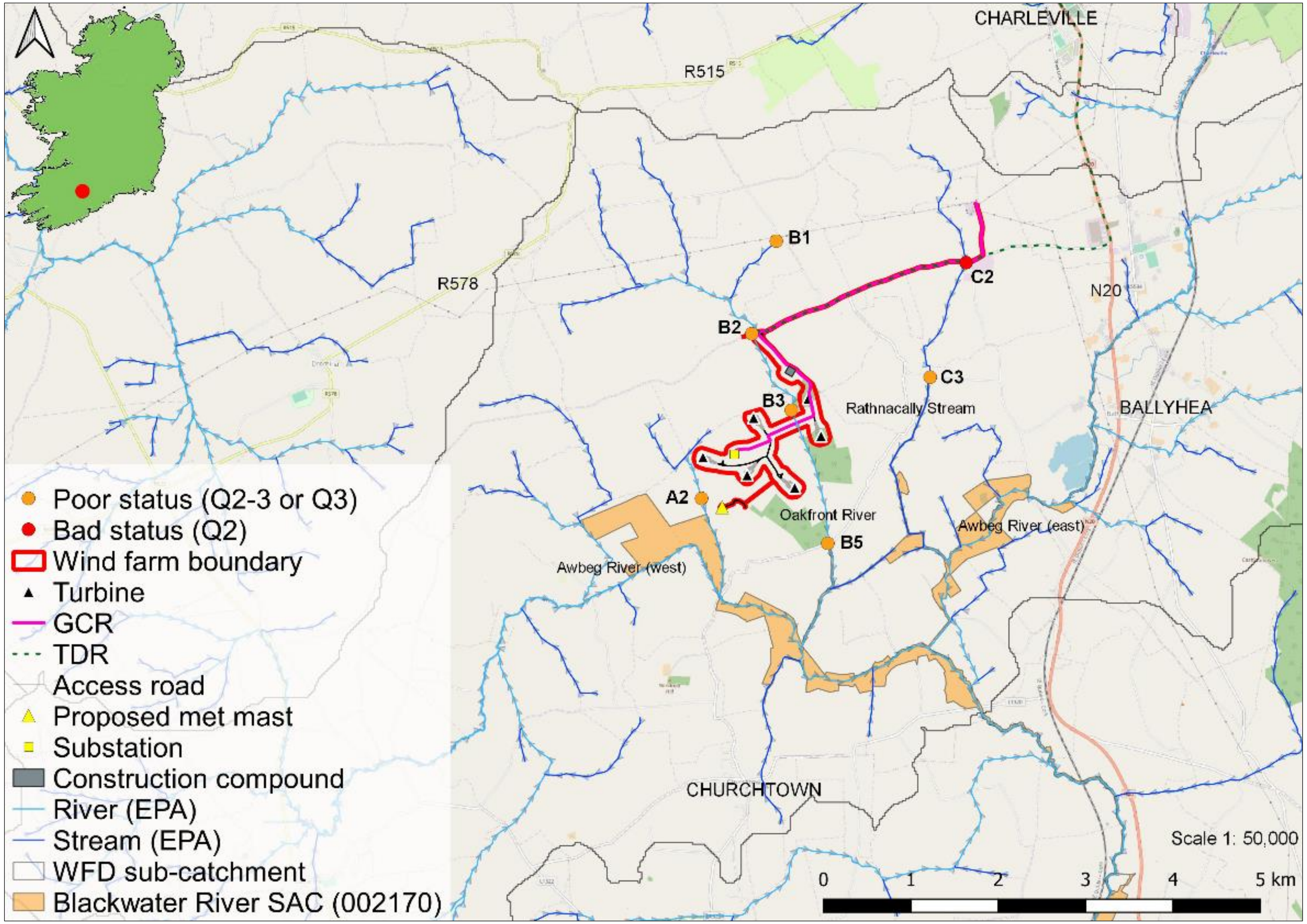


Figure 4.1 Biological water quality at *n*=7 sites in the vicinity of the proposed Annagh wind farm project, September 2020

Table 4.1 Aquatic ecological evaluation summary of the survey sites according to NRA (2009) criteria

Site no.	Watercourse	EPA code	Evaluation of importance	Rationale summary
A1	Fiddane Stream	18F19	Local importance (lower value)	No fisheries value (no fish recorded); biological water quality not assessed due to unsuitability; no other aquatic species or habitats of high conservation value
A2	Ardglass River	18A23	Local importance (lower value)	Poor fisheries value, three-spined stickleback recorded via electro-fishing; Q2-3 (poor status) water quality; no other aquatic species or habitats of high conservation value
A3	Awbeg River, Annagh Bridge	18A09	**International importance**	Located within Blackwater River SAC (002170); moderate quality salmonid and European eel value; brown trout, European eel & three-spined stickleback recorded via electro-fishing; biological water quality not assessed due to unsuitability; white-clawed crayfish eDNA present at and or upstream of Scart Bridge; no other aquatic species or habitats of high conservation value
B1	Milltown Stream	18M57	**Local importance (higher value)**	Moderate quality salmonid habitat but none present; European eel & three-spined stickleback recorded via electro-fishing; Q3 (poor status) water quality; no other aquatic species or habitats of high conservation value
B2	Oakfront River, Cooliney Bridge	18O02	**Local importance (higher value)**	Poor quality salmonid habitat, moderate lamprey habitat; brown trout, *Lampetra* sp., European eel & three-spined stickleback recorded via electro-fishing; Q3 (poor status) water quality; no other aquatic species or habitats of high conservation value
B3	Oakfront River	18O02	**Local importance (higher value)**	Moderate quality salmonid habitat, moderate quality lamprey habitat; brown trout, *Lampetra* sp., European eel & three-spined stickleback recorded via electro-fishing; Q2-3 (poor status) water quality; no other aquatic species or habitats of high conservation value
B4	Oakfront River	18O02	**Local importance (higher value)**	Moderate quality salmonid nursery & spawning habitat, moderate quality lamprey habitat; brown trout, European eel & three-spined stickleback recorded via electro-fishing; biological water quality not assessed; kingfisher nest recorded; no other aquatic species or habitats of high conservation value European eel present

Site no.	Watercourse	EPA code	Evaluation of importance	Rationale summary
B5	Oakfront River, bridge at Coolcaum	18O02	**International importance**	Located within Blackwater River SAC (002170) downstream of the bridge; poor quality salmonid habitat, moderate quality lamprey habitat; brown trout, *Lampetra* sp., European eel & three-spined stickleback recorded via electro-fishing; Q3 (poor status) water quality; no other aquatic species or habitats of high conservation value
C1	Rathnacally Stream	18R32	Local importance (lower value)	No fisheries value (seasonal drainage channel); no fish recorded via electro-fishing; biological water quality not assessed due to unsuitability; no other aquatic species or habitats of high conservation value
C2	Rathnacally Stream	18R32	Local importance (lower value)	Low fisheries value; three-spined stickleback recorded via electro-fishing; Q2 (bad status) water quality; no other aquatic species or habitats of high conservation value
C3	Rathnacally Stream	18R32	**International importance**	Located within Blackwater River SAC (002170); moderate quality salmonid and lamprey habitat; European eel & three-spined stickleback recorded via electro-fishing; Q3 (poor status) water quality; no other aquatic species or habitats of high conservation value

[1] Kingfisher are protected under Annex I of the EU Birds Directive (79/409/EEC, as amended 2009/147/EC) and are Amber-listed (medium conservation concern) in Ireland according to the Birds of Conservation Concern of Ireland (BoCCI; Gilbert et al., 2021)

*** Conservation value:** Atlantic salmon (*Salmo salar*), sea lamprey (*Petromyzon marinus*), brook lamprey (La*mpetra planeri*), river lamprey (*Lampetra fluviatilis*), white-clawed crayfish (*Austropotamobius pallipes*) and otter (*Lutra lutra*) are listed under Annex II of the Habitats Directive [92/42/EEC]. Atlantic salmon, river lamprey, white-clawed crayfish and otter are also listed under Annex V of the Habitats Directive [92/42/EEC]. Otters, along with their breeding and resting places, are also protected under provisions of the Irish Wildlife Acts 1976 to 2021. European eel are 'critically endangered' according to most recent ICUN red list (Pike et al., 2020) and listed as 'critically engendered' in Ireland (King et al., 2011). With the exception of the Fisheries Acts 1959 to 2019, brown trout have no legal protection in Ireland.

5. Potential impacts

As with any construction project, wind farm developments and associated infrastructure have the potential to cause significant negative impacts on water dependant species and habitats that fall within the footprint of the project or maintain downstream hydrological connectivity. The proposed Annagh Wind Farm drains the Awbeg [Buttevant]_SC_010 river sub-catchment and shares downstream hydrological connectivity with the Blackwater River SAC (site code: 002170). To elucidate potential impacts resulting from the proposed wind farm project, detailed surveys of physical and riparian habitats, and assessments of fish stocks (electro-fishing), fisheries habitat, white-clawed crayfish (including eDNA, freshwater pearl mussel, otter and biological water quality (Q-sampling) were undertaken in September 2020 and April 2021 (eDNA only).

The principle impacts from the proposed project on the aquatic environment are expected to occur during the construction phase where access track construction, concrete pouring for turbine bases and watercourse crossings are required. Ongoing operational activities including the maintenance of the turbines and infrastructure are considered unlikely to result in significant impacts on the receiving aquatic environment due to more localised footprints and the absence of direct disturbance to habitats.

The conventional source-pathway-target model was applied to assess potential impacts to downstream aquatic receptors as a result of the proposed project. This was evaluated by establishing the closest downstream watercourses and likely pathways for direct or indirect effects. The nearest hydrological distances from the aforementioned infrastructure to receiving watercourses are summarised in **Table 5.1.**

The proposed turbine delivery route (TDR) and grid connection route (GCR) travels predominantly along the existing road and utilises existing bridge and culvert structures over various watercourses. The crossing of the Rathnacally Stream on the L1322 (GCR-WCC1) will be via horizontal directional drilling (HDD), located approx. 1.5km upstream of the Blackwater River SAC (002170). The Oakfront Stream will be crossed at a single location (WF-HF5) via a single span, pre-cast concrete bridge. These proposed watercourse crossings are summarised in Chapter 3 and Chapter 10 (section 10.6.4). Within the proposed site boundary, new access tracks will be required and these will also convey the GCR.

The potential impacts of the proposed project are outlined below for the 'do-nothing' scenario and construction, operation and decommissioning phases (as applicable) of the Annagh wind farm project. These are the potential impacts that could potentially occur in the absence of mitigation measures. The summary of potential impacts, magnitude, duration, likelihood and whether it is of a direct or indirect nature is provided in **Table 5.1**.

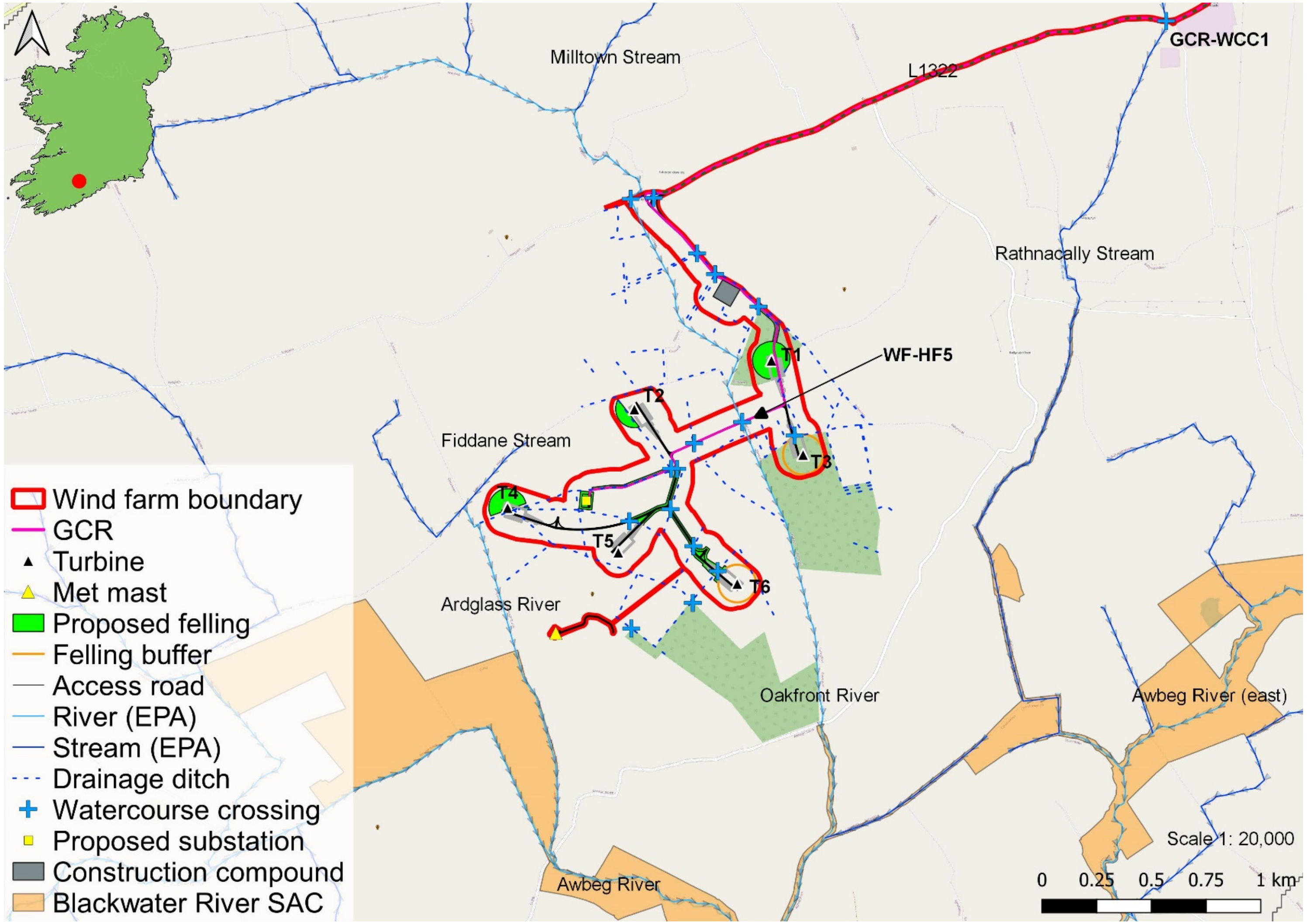


Figure 5.1 Location of the proposed Annagh wind farm project, Co. Cork showing proposed infrastructure

5.1 'Do nothing' scenario

If the proposed wind farm project does not go ahead then the land in the vicinity of the site will continue to be used for agricultural pasture and commercial forestry activities. The 'do-nothing' approach would result in water quality, hydrological regimes and the aquatic ecology of the receiving watercourses remaining consistent with the emergent baseline (i.e. pre-development). The majority of the aquatic survey sites achieved poor status (i.e. Q2-3 or Q3), with no sites meeting target good status (≥Q4) (**Appendix C**). Significant pressures such as eutrophication and siltation would continue to pose a threat to water quality within the wider catchment.

5.2 Potential construction phase impacts

The principle impacts from the proposed project on the aquatic environment are expected to occur during the construction phase. Primarily, these risks relate to water pollution and or contamination via siltation (suspended solids), hydrocarbons, concrete etc. The Construction Environmental Management Plan (CEMP), which details the construction methodology, has been developed to minimise the requirement for in-stream works and to reduce the risk of potential contamination and water pollution. Potential impacts relating specifically to hydrology are dealt with in Chapter 10 (Hydrology and Water Quality). The potential impacts relating to specific construction-phase activities on the aquatic environment are discussed in detail below.

5.2.1 Potential impacts during tree felling

Localised tree felling will be required in the vicinity of turbines T1, T2, T3, T4, and T6 hardstand areas, the substation (and associated access track) and along the access tracks to T1, T4 and T6; see **Figure 5.1**). It is estimated that 12.6ha of existing broadleaf forestry will be felled to facilitate development of the proposed wind farm infrastructure (e.g., turbine hardstands, substation compound, associated access tracks and bat felling buffers). There are potential source-receptor pathways from felling areas to both the Ardglass River and Oakfront River.

In light of the location of these felling areas in relation to surface water features (i.e. drainage ditches) and watercourses (**Figure 5.1**), there is potential for felling to contribute to the increase in site run-off, as outlined in section 10.4.2 of chapter 10. This may impact sensitive aquatic ecological receptors through mobilisation of sediment and or nutrients (especially phosphorus), resulting in impacts to both water quality and aquatic habitat (e.g., smothering fish spawning substrata). The release of nutrients to watercourses can also come from brash if material is left within close proximity to receiving watercourses (riparian zone) or if it is incorrectly managed (e.g. not replaced as required when used for off-road plant). However, it is noted that nutrient leaching would be less severe in a lowland setting with broadleaf-dominated forestry where little or no fertilisation has occurred than, for example, an upland conifer plantation which was heavily fertilised. The overall felling area proposed is small (12.6ha) when compared to commercial conifer clear-felling operations taking place within the catchment nearby (primarily the Ballyhoura Mountains). Considering these factors together, the potential for impacts associated with nutrient run-off or leaching is relatively low.

Tree felling operations require trafficking of heavy machinery which can lead to pollution of watercourses due to spillage of fuels and hydrocarbons. Exposure of soil and subsoil following vehicle tracking, skidding and extraction methods also has the potential to release nutrients to surface waters, posing a risk to aquatic ecosystems and species, including aquatic qualifying interests of the downstream-connecting Blackwater River SAC (002170). There is also a risk that machinery associated with tree felling could act as a vector for introducing or dispersing non-native invasive species, which may spread along nearby watercourses.

Whilst tree felling in the vicinity of all turbines poses a potential risk to water quality and aquatic receptors given the existing site drainage network, the greatest risk of impact to aquatic sensitivities from felling was identified at turbine T4, whose felling area is located <15m from a drainage channel with connectivity to the Ardglass River (felling area located c.65m direct distance from Ardglass River). This drainage channel also adjoins (to the south) an area of wet grasslands/marsh (GS4/GM1), which may increase the potential hydrological connectivity to the receiving watercourse. The felling area for the proposed site substation is located <20m from the existing drainage channel network which shares downstream hydrological connectivity with the Ardglass River (approx. 500m instream distance from substation). Similarly, the proposed felling along the existing access track to the substation area is located directly adjacent to the drainage channel network, which provides potential (indirect) hydrological connectivity to the Ardglass River (approx. 530m instream distance). The Ardglass River is a heavily-modified watercourse (straightened, deepened, heavily silted with poor flows) and supported three-spined stickleback, with no other species or habitats of conservation value greater than local importance (lower value) present. However, the Ardglass River shares hydrological connectivity with the Blackwater River SAC (002170), located approx. 0.6km downstream of the aforementioned drainage channel network confluence west of turbine T4. Thus, there is potential for tree felling to impact qualifying interests such as otter, lamprey species and white-clawed crayfish.

The proposed 2.1ha felling area in the vicinity of turbine T1 is located c.70m (shortest over-land distance) from the Oakfront River. Whilst potential hydrological connectivity (via existing drainage network) is poor, and although an existing forestry plantation buffer exists between the turbine location and the river, the close proximity of felling to the Oakfront River presents a risk to sensitive aquatic receptors and the Blackwater River SAC located approx. 1.8km downstream.

Although hydrological connectivity is relatively poor, the proposed felling area (2.6ha) associated with turbine T3 is located <160m from the Oakfront River via the drainage channel network. This may serve as a more significant source-receptor pathway during periods of heavy rainfall/higher water levels. The Oakfront River supported brown trout, *Lampetra* sp. and otter. Therefore, there is potential for tree felling activities to impact these sensitive aquatic receptors and their habitats via water quality impacts (eutrophication, sedimentation), in addition to the Blackwater River SAC (002170), located approx. 1.4km downstream from the potential drainage channel confluence. The remaining felling areas in the vicinity of turbines T2, and T6 are located >200m from riverine watercourses and share poor/limited hydrologically connectivity to these watercourses via the existing drainage channel network.

Potential hydrological and water quality impacts as a result of tree felling and felling activities are further considered in section 10.4.2 of chapter 10.

Given the close proximity of and potential hydrological connectivity of the Ardglass River and Oakfront River to tree felling areas, potential impacts to aquatic ecology, in the absence of mitigation, are assessed as being **likely moderate negative, short-term and at the local scale[1].**

With regards the downstream-connecting Blackwater River SAC (002170), potential impacts to aquatic qualifying interests are considered as **likely significant negative, short-term and at the scale of the European site**.

5.2.2 Potential impacts during access track construction

It is proposed to construct approximately 4.5km of new internal access tracks and 0.1km length of turning heads, and carry out upgrades to c.0.4km of existing agricultural tracks to facilitate site access and construction activities. New access tracks and upgrade of existing tracks have the potential to contribute to the increase in surface water run-off and cause more localised water quality impacts through sediment- and nutrient-laden run-off, including from tree felling areas associated with new tracks. Works leading to erosion of the river banks/bed could result in the release of suspended solids. This may impact sensitive aquatic ecological receptors in receiving watercourses through mobilisation of sediment and or contaminants, as well as additional erosion, resulting in impacts to both water quality and aquatic habitat. Details on the projected increase are provided in section 10.4.2 of chapter 10.

Access track construction will also require localised tree felling, primarily in the vicinity of turbines T1and T6. Potential impacts on aquatic ecological receptors from tree felling required for access track construction are the same as those outlined above in section 5.2.1.

As outlined in section 10.6 of chapter 10, the drainage system for the existing tracks and roads will largely be retained. It is proposed to upgrade approximately 0.4km of existing agricultural roads. All track widening will be undertaken using clean uncrushable stone with a minimum of fines.

Road drainage will be over the edge, where the surface runoff will be collected in swales and dispersed via diffuse outfalls. Swales will be connected to settlement ponds at the end of the swale.

These activities have the potential to convey suspended solids and contaminants (e.g., nutrients, hydrocarbons) to receiving watercourses.

There will be one new access track crossing over the Oakfront River and 13 no. crossings over the field and forestry drains identified during the site visits. These access track crossings are detailed in section 10.6.4 and Table 10.9 of chapter 10, and shown in **Figure 5.1** above. The proposed crossing structure over the Oakfront River (WF-HF5) is a single span, pre-cast concrete bridge, approx. 1.6km instream distance from the Blackwater River SAC (002170). Foundations are to be

[1] i.e. at the river sub-catchment scale

set back 2.5m from the river bank. The Oakfront River was found to support brown trout, European eel, *Lampetra* sp., three-spined stickleback, kingfisher and otter. Water quality was of poor status (Q2-3 or Q3) in September 2020.

For small crossings over the field and forestry drains, pre-cast box culverts are proposed. Manmade agricultural and forest drains will be crossed using 450mm diameter pipes. Where cross drains are to be provided to convey the drainage across the track, the minimum sizes of these cross drains are 300 mm diameter pipes.

Given the close proximity of and potential hydrological connectivity of access track construction to the Oakfront River and (less so) the Ardglass River, potential impacts to aquatic ecology, in the absence of mitigation, are assessed as being **likely moderate negative, short-term and at the local scale.**

With regards the downstream-connecting Blackwater River SAC (002170), potential impacts to qualifying interests are considered as **likely significant negative, short-term and at the scale of the European site**.

5.2.3 Potential impacts during turbine base and met mast construction

The construction of 6 no. wind turbines (with a transformer at each turbine and associated hardstand areas) and 1 no. met mast will include construction activity, large-scale earthworks, drainage and pouring of concrete. The 6 no. turbines have been positioned at a minimum distance of c.120m (measured along flow paths) from the riverine watercourses draining the site (i.e. Ardglass River and Oakfront River). The proposed met mast is located approx. 200m north-west (over-land) from the nearest potential hydrological pathway (i.e. Ardglass River).

The greatest threat to aquatic ecology from turbine base construction (based on site topography and the layout of surface water features) was impacts to water quality identified at turbines T3 and T4 which are located approx. 130m and 170m from the Ardglass River and Oakfront River, respectively (indirect connectivity via drainage ditches). Although the aquatic ecological evaluation of the heavily-modified Ardglass River was considered of local importance (lower value) only, the Oakfront River supported brown trout, European eel, *Lampetra* sp., three-spined stickleback, kingfisher and Blackwater River SAC qualifying interest otter. Both the Ardglass and Oakfront Rivers share downstream hydrological connectivity with the Awbeg River and Blackwater River SAC (002170), with the shortest hydrological distances from proposed turbine infrastructure to the European site being 0.7km and 1.4km, respectively (via surface water drains and the rivers). The Awbeg is known to support a range of aquatic qualifying interest species and habitats, including otter, Atlantic salmon, lamprey species and white-clawed crayfish. No crayfish were recorded via traditional surveys in the vicinity of the proposed wind farm. However, eDNA sampling detected cryptically low levels of white-clawed crayfish at and or upstream of Scart Bridge, located downstream of the wind farm site (3.2km hydrological distance to turbine hardstand T3). The earthworks required to facilitate turbine base construction may liberate nutrients and increase the sediment load of surface water run-off, potentially impacting water quality and aquatic sensitivities (e.g. fish, macro-invertebrates, otter, white-clawed crayfish) in adjacent and downstream watercourses, including the Oakfront River, Ardglass River, Awbeg

River and Blackwater River SAC (002170). Thus, given the proximity and hydrological connectivity of turbines T3 and T4 to these receiving watercourses (see **Table 5.1** for distances), there exists a risk of water quality impacts to aquatic receptors via siltation, nutrient run-off and pollution associated with turbine base construction.

Wet concrete poured for turbine bases, met mast construction or rinsing of truck chutes on-site could lead to contamination of receiving waters via surface water run-off. Concrete and other cement-based products are highly alkaline and corrosive and can have significant negative impacts on water quality and aquatic biota, including Atlantic salmon, lamprey, otter and white-clawed crayfish.

Heavy machinery required for turbine base and met mast construction may also lead to pollution of nearby receiving watercourses due to spillage of fuels and hydrocarbons. Haul tracks crossing the Oakfront River or passing close to sites drainage channel network could allow the migration of silt-laden run-off into adjacent watercourses via surface water pathways (e.g. wheel rutting). Accidental spillage during refuelling of construction plant with petroleum hydrocarbons can cause significant pollution risk to surface waters and aquatic ecology. It is also a nutrient supply for adapted micro-organisms, which can rapidly deplete dissolved oxygen in surface waters, resulting in death of aquatic organisms.

There is also a risk that machinery required for construction could act as a vector for introducing or dispersing non-native invasive species, which may spread along nearby watercourses. However, no invasive species were identified in the vicinity of the proposed turbines or site access tracks and the geographical separation of same from adjacent watercourses would reduce this risk considerably.

It is noted that there is little direct connectivity between the turbine locations or met mast site and the receiving watercourses draining the site (i.e. considerable geographic separation), so the risk of silt-laden surface water run-off to watercourses is greatly reduced. However, given the close proximity of turbines T3 and T4 from receiving riverine watercourses and the proximity of the proposed met mast from surface water drains (see **Table 5.1** for details), potential impacts to aquatic ecology resulting from turbine and met mast construction do exist and are considered **likely moderate negative, short-term and in the local context,** in the absence of mitigation.

At its shortest distance, the Blackwater River SAC (002170) is located approx. 0.7km and 1.4km downstream of wind farm site infrastructure respectively (via surface water drains and the Ardglass and Oakfront Rivers). Potential impacts to local populations of qualifying interest Atlantic salmon, lamprey species, white-clawed crayfish and otter and Annex I habitats are considered **likely significant negative, short-term and in context of the European site**, in the absence of mitigation.

5.2.4 Potential impacts resulting from site drainage

The construction phase may result in significant changes or alterations to the existing drainage network within the wind farm boundary, which may increase sediment and nutrient loads to receiving watercourses within, adjoining or draining the site. No alterations to existing drainage are proposed or expected outside of the wind farm boundary (e.g. along the TDR or grid connection route). As outlined in Chapter 10 (section 10.4.6), there are several watercourse (drain) crossings to be installed for the wind farm access tracks. Track widening will involve slight relocation of existing roadside drains. For small crossings over the field and forestry drains, pre-cast box culverts are proposed. Manmade agricultural and forest drains will be crossed using 450mm diameter pipes. Where cross drains are to be provided to convey the drainage across the track, the minimum sizes of these cross drains are 300mm diameter pipes. Culverting may increase surface water run-off (flow) to the receiving Ardglass River and Oakfront River, mobilising and increasing siltation rates and exacerbating the risk of other water quality impacts (e.g., eutrophication).

Site drainage, including silt traps and stilling ponds, will be put in place in parallel with construction, such that excavation for new infrastructure will have functional drainage system in place. Inappropriate management of the carrying out of these modifications could result in blockages of existing roadside drainage and drainage swales, which may both increase the risk of water contamination to adjacent watercourses via siltation, fuel spillages etc., as well as cause alterations in the existing hydrology of the wider site. Inappropriate management of the excavated material associated with construction (e.g. inadequate silt fences on drainage channels or ponds alongside access/haul tracks) could also lead to loss of suspended solids to surface waters.

Whilst the on-site drainage network was not of value to sensitive aquatic receptors (e.g. salmonids, lamprey, white-clawed crayfish), inappropriate sizing of pipework or blockages could impede flows, particularly during heavy rainfall events. Local flooding or surface water ponding could result, potentially resulting in the release of suspended solids to receiving watercourses or altering local hydrology. The significance of the effect of the increase in site run-off as a result of the proposed project has been assessed as “not significant” on receiving waters because estimated increases in the peak run-off is low compared to the flows of receiving waters (chapter 10). Further consideration to site drainage and the potential for hydrological impacts are considered in section 10.6 of chapter 10.

The temporary construction compound, located in agricultural pasture to the north-east extent of the site, poses a risk to water quality of the Oakfront River given the potential drainage channel source-receptor pathways present in close proximity (c.185m). Whilst set-back from the drainage network, inappropriate management of surface water run-off to the interceptor drain and stilling pond could lead to aquatic ecological impacts. Potential impacts to hydrology resulting from site drainage of the temporary construction compound are outlined in section 10.6.6 of chapter 10.

Given the likely small-scale of site drainage-related events due to geographic separation and limited surface water pathways to receiving watercourses, potential impacts to aquatic ecology resulting from alterations to/inadequate site drainage management are considered **likely moderate negative, short-term and in the local context**, in the absence of mitigation.

Potential impacts to Blackwater River SAC (002170) qualifying interest species and habitats are considered **likely significant negative, short-term and in context of the European site**, in the absence of mitigation.

5.2.5 Potential impacts during GCR installation (HDD and excavations)

The proposed underground grid connection cable route (GCR), which is approx. 6km in length, follows to-be-constructed access tracks and local public roads to connect to the existing Charleville 110Kv substation in the townland of Rathnacally, 2.8km north-east of the wind farm site entrance. The cable ducts will be placed in the carriageway of the public road network, whilst along internal site tracks, the cable ducts will be installed above proposed pre-cast concrete pipe culverts at drainage crossing points (see section 10.6.4 of chapter 10). The proposed grid connection trench will be up to 600mm wide (1040mm wide in flat formation) and up to 1200mm deep. Where the proposed grid connection cable route encounters minor culverts, the ducts will be installed above or below the culvert depending on its depth in accordance with construction methodologies outlined in the CEMP. Excavation of the GCR trenching presents a potential risk to water quality from silt and hydrocarbons during construction. There is a potential impact, in the absence of mitigation measures, of sediment-laden run-off in surface water from the ground surface surrounding the cable trench. Wheel rutting from machinery could allow the migration of silt-laden run-off into adjacent watercourses via surface water pathways. Along the on-site access tracks, concrete (lean-mix) will be used as backfill around the ducting with excavated material used on top. Concrete has a high pH and presents a potential significant risk to the aquatic environment. Underground cabling can potentially provide a preferential flow path for surface water.

In addition to crossing 6 no. drainage channels, there will be a requirement for 2 no. riverine watercourse crossings along the GCR in total. These are on the Rathnacally Stream (GCR-WCC1) and Oakfront River (WF-HF5). The crossing of the Rathnacally Stream on the L1322 will be via horizontal directional drilling (HDD), located approx. 1.5km upstream of the Blackwater River SAC (002170). There is a risk of surface water quality impacts on the Oakfront River and the downstream Awbeg River and Blackwater River SAC (002170) during HDD and groundworks associated with potential directional drilling. Watercourses crossed by directional drilling are at risk of suspended solid releases, hydrocarbon pollution and escapement of drilling lubricants (e.g. bentonite). The release of suspended solids would negatively affect fish populations, invertebrates and other water-dependant species, such as otter and kingfisher. Suspended solids can damage fish spawning substrata through the blocking of interstitial spaces, preventing oxygen diffusion and effecting egg/larval development, or directly smothering attaching and burrowing invertebrates, causing mortalities and changes to fish and invertebrate community composition at the local scale. An increase in suspended solids can also have negative effects on instream flora through a reduction in light penetration and habitat heterogeneity, thus altering overall aquatic ecology. It is proposed that directional drilling under the existing L1322 road bridge will be undertaken to prevent direct impacts on the Rathnacally Stream. However, there is a risk of indirect impacts from sediment-laden run-off during the launch pit and reception pit excavation works. It should be noted that the Rathnacally Stream and downstream-connecting Awbeg River, already suffer from significant siltation and water quality pressures.

The water quality of the riverine watercourses within the vicinity of the proposed wind farm project are already compromised (bad to poor status, Q2 to Q3; **Appendix C**), with significant siltation and eutrophication pressures. These pressures would appear to have precluded salmonids and lamprey species from the Rathnacally Stream and Ardglass River (none recorded during electro-fishing surveys), and inhibited populations in the Oakfront River. Additional release of suspended solids and or nutrients as a result of the construction, operational and or decommissioning phases could cause further impacts to aquatic qualifying interest species and habitats of the Blackwater River SAC (002170).

To avoid instream works, the Oakfront River will be crossed by a single span, pre-cast concrete bridge (cable ducts to be incorporated into proposed pre-cast concrete structure), located approx. 1.6km upstream of the Blackwater River SAC (002170). However, there remains potential for the release of silt or contaminants (e.g. hydrocarbons) to the Oakfront River and downstream-connecting Blackwater River SAC (002170) due to vegetation/bank clearance/excavation works and construction/plant activity. As above, it should be noted that the Oakfront River and downstream-connecting Awbeg River, already suffer from significant siltation and water quality pressures.

Potential impacts to aquatic ecology of the receiving riverine watercourses, in the absence of mitigation, are assessed as being **likely moderate negative, short-term and at the local scale**.

With regards the downstream-connecting Blackwater River SAC (002170), potential impacts to aquatic qualifying interests are considered as **likely significant negative, short-term and at the scale of the European site**.

5.2.6 Potential impacts during turbine delivery (TDR)

In addition to turbine construction, the delivery of turbines and associated materials has the potential to impact water quality of watercourses crossed during transport. The turbine delivery route (TDR) will follow the existing road network and will run for 80km from the port of Foynes, Co. Limerick via the N69, M20, N20 and L1322 to the north-eastern extent of the site, near Cooliney Bridge.

Modifications along the TDR will involve the temporary removal of street furniture and removal of some vegetation in addition to the temporary local widening at bends using hardcore material. Within the vicinity of the wind farm site, the TDR will cross a single watercourse, namely the Rathnacally Stream at a local road crossing on the L1322 (GCR-WCC1). This crossing is located approx. 1.5km upstream (by water) of the Blackwater River SAC (002170). Although no instream works are proposed to this existing watercourse crossing, hedgerow trimming and wall lowering will be required to facilitate oversail. Given the close proximity of works to the watercourse, there is a low but potential risk of water quality impacts from sediment-laden run-off and or nutrient escapement resulting from vegetation removal. There is also a low risk of water quality impacts resulting from fuel spillage (hydrocarbons) from associated plant machinery in vicinity of the road crossing.

Potential impacts to aquatic ecology resulting from turbine delivery are considered **likely moderate negative, short-term and in the local context**, in the absence of mitigation.

Impacts to the downstream-connecting Blackwater River SAC (002170) are considered as **likely not significant, short-term and at the scale of the European site**.

Table 5.1 Summary of construction phase impacts to aquatic ecological receptors (pre-mitigation)

Activity	Nearest downstream connecting watercourse(s) (direct down-slope distance from activity)	Sensitive aquatic receptor(s)	Aquatic ecological impacts	Potential impact significance
Tree felling	**Ardglass River** (c.120m from T4 via a drainage channel) **Oakfront River** (c.160m from T3 via a drainage channel)	Salmonids (Atlantic salmon & brown trout), European eel, *Lampetra* sp., common frog, otter, kingfisher, white-clawed crayfish; Blackwater River SAC aquatic qualifying interests (≤1.4km downstream)	Release of suspended solids, contaminants and or nutrients (water quality impacts); mortality of aquatic invertebrates & fish eggs; eutrophication and impacts to downstream fish, otter, kingfisher, invertebrates & water quality; spread of invasive species along watercourses	*All downstream aquatic habitats & species:* **Likely moderate negative, short-term and in the local context** *All downstream aquatic qualifying interests of Blackwater River SAC (002170):* **Likely significant negative, short-term and in context of the European site**
Access track construction	**Oakfront River** (crossed by single span bridge (WF-HF5), c.1.4km instream distance from Blackwater River SAC) **13 no. drainage channels** (crossed by access tracks – see section 10.6.4 of chapter 10)	Salmonids (Atlantic salmon & brown trout), European eel, *Lampetra* sp., common frog, otter, kingfisher, white-clawed crayfish; Blackwater River SAC aquatic qualifying interests	Release of suspended solids, contaminants and or nutrients (water quality impacts); mortality of aquatic invertebrates & fish eggs; eutrophication and impacts to downstream fish, otter, kingfisher, invertebrates & water quality; spread of invasive species along watercourses	*All downstream aquatic habitats & species:* **Likely moderate negative, short-term and in the local context** *All downstream aquatic qualifying interests of Blackwater River SAC (002170):* **Likely significant negative, short-term and in context of the European site**
Turbine base and met mast construction	**<u>Turbine bases:</u>**	Salmonids (Atlantic salmon & brown trout),	Release of suspended solids, contaminants and or nutrients (water quality impacts); mortality of	*All downstream aquatic habitats & species:*

Activity	Nearest downstream connecting watercourse(s) (direct down-slope distance from activity)	Sensitive aquatic receptor(s)	Aquatic ecological impacts	Potential impact significance
	Ardglass River (c.130m from T4 via a drainage channel, 0.7km from Blackwater River SAC) **Oakfront River** (c.170m from T3 via a drainage channel, 1.4km from Blackwater River SAC) **Drainage channels** (numerous small drains in footprint of hardstands) **Met mast:** **Ardglass River** (c.200m from met mast)	European eel, *Lampetra* sp., common frog, otter, kingfisher, white-clawed crayfish; Blackwater River SAC aquatic qualifying interests	aquatic invertebrates & fish eggs; eutrophication and impacts to downstream fish, otter, kingfisher, invertebrates & water quality; spread of invasive species along watercourses	**Likely moderate negative, short-term and in the local context** *All downstream aquatic qualifying interests of Blackwater River SAC (002170):* **Likely significant negative, short-term and in context of the European site**
Site drainage (incl. crossing/culverting of drainage channels)	**Ardglass River** (various source-receptor pathways via drainage channels) **Oakfront River** (various source-receptor pathways via drainage channels)	Salmonids (Atlantic salmon & brown trout), European eel, *Lampetra* sp., common frog, otter, kingfisher, white-clawed crayfish; Blackwater River SAC aquatic qualifying interests	Increase in flow rates (surface water run-off); changes to rates of erosion & deposition in receiving watercourses; impacts to aquatic habitats and water quality	*All downstream aquatic habitats & species:* **Likely moderate negative, short-term and in the local context** *All downstream aquatic qualifying interests of Blackwater River SAC (002170):* **Likely significant negative, short-term and in context of the European site**

Activity	Nearest downstream connecting watercourse(s) (direct down-slope distance from activity)	Sensitive aquatic receptor(s)	Aquatic ecological impacts	Potential impact significance
Grid connection route (GCR)	**Rathnacally Stream** (crossed at GCR-WCCC1 via HDD on L1322 road) **Oakfront River** (crossed at WF-HF5 via single span pre-cast concrete bridge) **6 no. drainage channels** (crossed by GCR via box culvert– see section 10.6.4 and Table 10.9 of chapter 10)	Salmonids (Atlantic salmon & brown trout), European eel, *Lampetra* sp., common frog, otter, kingfisher, white-clawed crayfish; Blackwater River SAC aquatic qualifying interests	Release of suspended solids, contaminants and or nutrients (water quality impacts); mortality of aquatic invertebrates & fish eggs; eutrophication and impacts to downstream fish, otter, kingfisher, invertebrates & water quality; spread of invasive species along watercourses	*All downstream aquatic habitats & species:* **Likely moderate negative, short-term and in the local context** *All downstream aquatic qualifying interests of Blackwater River SAC (002170):* **Likely significant negative, short-term and in context of the European site**
Turbine delivery route (TDR)	**Rathnacally Stream** (crossed at GCR-WCCC1 on L1322 road, 1.5km upstream of Blackwater River SAC)	European eel; downstream Blackwater River SAC aquatic qualifying interests	Release of contaminants (water quality impacts); spread of invasive species along watercourses	*All downstream aquatic habitats & species:* **Likely moderate negative, short-term and in the local context** *All downstream aquatic qualifying interests of Blackwater River SAC (002170):* **Likely not significant negative, short-term and in context of the European site**

5.3 Potential operational phase impacts

Operational wind farms are not normally considered to have the potential to significantly impact on the aquatic environment. The main risk to watercourses is via water quality impacts, when oils and lubricants are used on the site (e.g. infrastructure maintenance). If such substances leaked from the turbines or maintenance areas or were disposed of inappropriately, there is a risk of water contamination and subsequent impacts to aquatic ecology. However, the likelihood of this occurring is very low, and the potential significance of this impact can be mitigated through effective mitigation and appropriate management.

Increases in the surface water run-off volume as a result of less-permeable surfaces of the wind farm (e.g. hardstands, access tracks etc.) are predicted to be <1% of the average daily/monthly volume in comparison to the baseline pre-development conditions (section 10.6 of chapter 10). Thus, no significant operational phase impacts are predicted as a result of increases in surface water run-off.

The overall estimated increase in the unmitigated peak runoff due to the wind farm is 0.174 m^3/s (or 0.20 %) for a 1 in 100 years storm event (Chapter 10, section 10.4.2). Therefore, the slight predicted increase in surface water run-off during the lifetime of the wind farm project is not anticipated to impact slow-swimming fish species, such as European eel or *Lampetra* sp., in receiving watercourses and is considered negligible.

Due to the natural 'grassing-over' the drainage swales and revegetation of other exposed surfaces, and the non-intrusive nature of site operations, there is a negligible risk of sediment release to the watercourses during the operational stage.

Spills of any oil or fuels (hydrocarbons) from site vehicles onto access tracks may leach to adjacent watercourses. However, this is unlikely to be a significant impact considering the low volumes of vehicular traffic involved in typical wind farm operations. During the operation stage, small quantities of oil will be used in cooling the transformers associated with the facility. A back-up generator at the sub-station may be used (and refuelled). There is, therefore, a potential for small oil spills which may enter surface waters and cause impacts to aquatic ecology. Upgrading of the site track/road network within the wind farm boundary could present the risk of silt-laden run-off resulting from excavations required for underground cable maintenance.

Potential operational phase impacts on aquatic ecology are considered **likely slight negative, short-term and in the local context**, in the absence of mitigation.

Given the downstream-connectivity from the wind farm site and associated infrastructure (GCR, sub-stations, access tracks etc.), potential impacts to aquatic qualifying interest species and habitats of the Blackwater River SAC (002170) are considered **likely not significant negative, short-term and in context of the European site**, in the absence of mitigation.

5.4 Potential decommissioning phase impacts

Decommissioning activities of the Annagh Wind Farm project will take place in a similar fashion to the construction phase. Potential impacts will be similar to the construction phase but on a reduced scale. The decommissioning phase poses similar risks of potential effects vis-á-vis the construction phase. However, with suitable planning and provision of adequate mitigation, potential negative impacts on the receiving aquatic environment during decommissioning can be minimised. The decommissioning phase is described in Chapter 3 and these works will be subject to a decommissioning plan, to be agreed with Cork County Council. A decommissioning plan can be found in the CEMP.

There would be increased trafficking and an increased risk of disturbance to underlying soils at the wind farm, during the decommissioning phase, in this instance, leading to the potential for silt laden run-off entering receiving watercourses from the wheels of vehicles (i.e. wheel-rutting).

Any such potential impacts would be likely to be less than during the construction stage as the drainage swales would be fully mature and would provide additional filtration of run-off. Any diesel or fuel oils stored on main wind farm site will be bunded.

For access tracks and turbine foundations it is proposed that they are left in place and covered with local topsoil and re-vegetated. Removal of this infrastructure would result in considerable disruption to the local environment in terms of an increased possibility of sedimentation. It is considered that leaving the turbine foundations hardstanding areas in-situ will cause less environmental damage than removing them.

Grid connection cables will be left in the ground, therefore no potential impacts to aquatic ecology during the decommissioning stage are likely to occur.

Potential decommissioning phase impacts on aquatic ecology are considered **likely slight negative, short-term and in the local context**, in the absence of mitigation.

Potential impacts to aquatic qualifying interest species and habitats of the Blackwater River SAC (002170) are considered **likely not significant negative, short-term and in context of the European site**, in the absence of mitigation.

5.5 Potential cumulative impacts

There is the potential for cumulative impacts to occur to aquatic ecological receptors during the construction and operational phases of the proposed Annagh wind farm.

Cumulative impact from an aquatic ecology point of view can only occur if assessed developments are hydrologically linked. The major developments which are in the same sub-basin and within 10km from the proposed wind farm are listed and evaluated in section 8.5.5 of Chapter 8 and section 10.9 of chapter 10. Of these, Boolard wind farm, Rathnacally wind farm and two separate solar farm developments are located within the Awbeg (Buttevant)_010 and Oakfront_010 sub-basins and therefore share hydrological linkage with the proposed Annagh wind farm project.

The potential for impacts to aquatic ecology from wind farms is primarily during the construction phase, and relate principally to water quality impacts. Both the Boolard and Rathnacally wind farm developments are operational and have themselves been assessed as 'not significant' in terms of potential impacts to water quality. Therefore, there is not considered any potential for the operation of these developments to contribute towards significant in-combination impacts with the current project.

Solar farm (2) is located approximately 1km south-east of the proposed wind farm site, in the Awbeg (Buttevant)_010 sub-basin, and is hydrologically linked to it. The potential impacts to water quality and hydrology of this solar farm development has been assessed as 'not significant'. Given the absence of overlapping infrastructure between this and the current project, there is there is not considered any potential for significant in-combination impacts on aquatic ecology.

Solar farm (1) is located approximately 0.1km north of the proposed Annagh wind farm site and is hydrologically linked to it. The environmental impact assessment screening report of the solar farm concluded that there will be no significant environmental impact as a result of the development. The grid connection for this solar farm overlaps with that proposed for Annagh Wind Farm and will also cross the Rathnacally Stream at watercourse crossing GCR-WCC1 (unnamed bridge on L1322). However, the solar farm grid connection is scheduled to be constructed first, with the cable ducts to be installed in the bridge deck. The GCR for Annagh wind farm is to cross the Rathnacally Stream via HDD (as outlined in section 5.2.5). Whilst the potential for in-combination impacts to water quality will be reduced through scheduling divergence and differing crossing methodologies, a risk of cumulative impacts nevertheless exists, in the absence of mitigation.

While it is difficult to quantify the level of impact with certainty, in-combination effects are considered likely, in the absence of mitigation. These would include the increased release of sediment and, in particular, nutrients to receiving watercourses. The risk of such impacts would, for example, greatly increase if such works were taking place during the winter months or times of very high rainfall. Due to the already compromised water quality of the majority of watercourses draining the proposed project site (e.g. predominantly poor status; **section 4.2, Appendix C**), further significant impacts to these could be likely. This would be of particular concern to the downstream-connecting Awbeg River and Blackwater River SAC (002170). In the absence of mitigation, a **significant negative, short-term cumulative impact** on the European site is considered likely. Potential cumulative impacts on aquatic ecology are considered **likely slight negative, short-term and in the local context**, in the absence of mitigation.

6. Mitigation measures

6.1 Construction phase mitigation

Construction phase mitigation for hydrology should follow that outlined in section 10.7 of Chapter 10, and the mitigation measures outlined should be adhered to in conjunction with those outlined in this section. Construction phase mitigation measures for aquatic ecology predominantly involve the preservation of water quality.

All measures for the protection of water quality within the proposed project site, as detailed in the CEMP, will also protect the aquatic ecology and fisheries value of downstream watercourses. The measures adopted within the CEMP (including recommendations from Inland Fisheries Ireland) will ensure effective protection of aquatic ecological interests downstream of the proposed project, particularly the habitats supporting sensitive aquatic species and with connectivity to the Blackwater River SAC (002170).

6.1.1 Mitigation measures for tree felling

Localised tree felling will be required in the vicinity of turbine T1, T2, T3, T4 and T6 hardstand areas, the substation (and associated access track) and along the access tracks to T1and T6 (see **Figure 5.1**). It is estimated that 12.6ha of existing broadleaf forestry will be felled to facilitate development of the proposed wind farm infrastructure (e.g., turbine hardstands, substation compound and associated access tracks). There are potential source-receptor pathways from felling areas to both the Ardglass River and Oakfront River.

Whilst no specific mitigation exists for the felling of broadleaf forestry, the installation of buffer zones adjacent to the aquatic zone are particularly important adjacent to the Ardglass River and adjoining drainage channel located near turbine T4 (c.130m shortest instream distance) and the Oakfront River and associated drainage channel near turbine T3 (c.160m shortest instream distance). Given the close proximity of felling areas to receiving watercourses and potential source-receptor pathways (i.e. drainage channels), a minimum buffer zone for felling areas of 15m will be applied. Check dams/silt fences will be required within the drainage channels adjoining the Ardglass and Oakfront Rivers (i.e. those providing hydrological connectivity from felling areas to receiving watercourses). Drains and silt traps will be maintained throughout all felling works, ensuring that they are clear of sediment build-up and are not severely eroded. Broadleaf brash mats will be used to support vehicles on soft ground and mineral soils erosion and avoiding the formation of rutted areas, in which surface water ponding can occur. Brash mat renewal will take place when they become heavily used and worn. Provision will be made for brash mats along all off-road routes, to protect the soil from compaction and rutting. Where there is risk of severe erosion occurring, extraction will be suspended during periods of high rainfall.

To ensure tree clearance methodology that reduces the potential for sediment and nutrient run-off, the construction methodology will follow the specifications set out in the following best guidance documents:

- DAFM (2019). Standards for Felling and Reforestation;

- Forestry Service (2000a). Forest Service Forestry and Water Quality Guidelines;
- Forestry Service (2000b). Forest Harvesting and Environmental Guidelines;

Additional mitigation measures for the protection of aquatic ecology and receptors during felling activities will follow those outlined in section 10.7.1.2 and 10.7.1.6 of Chapter 10 (e.g. minimum buffer zone widths along watercourses).

Given the sensitivity of aquatic ecological receptors in the Ardglass River, Oakfront River and downstream-connecting Blackwater River SAC (002170) (e.g. salmonids, lamprey species, kingfisher, otter, white-clawed crayfish), it is recommended to undertake felling in the spring period to facilitate the sowing of grass seeds post-harvest to aid sediment filtration and nutrient absorption, using native grass species *Holcus lanatus* and *Agrostris capilaris* (DAFM, 2018). Machine operations must not take place in the 48-hour period before predicated heavy rainfall, during heavy rainfall or in the 48-hour period following heavy rainfall (DAFM, 2018). Removal of branch lop-and-top and other debris (brash) from felling areas within 20m of drainage channels will reduce nutrient seepage immediately post-felling and in the proceeding years after felling has occurred (DAFM, 2019).

In the presence of mitigation measures, potential impacts to aquatic ecology resulting from tree felling are considered **likely slight negative, short-term and in the local context**.

Potential impacts to qualifying interest species and habitats of the downstream-connecting Blackwater River SAC (002170) are considered **likely not significant and short-term in in context of the European site,** in the presence of mitigation.

6.1.2 Mitigation measures for access track construction

It is proposed to construct approximately 4.5km of new internal access tracks and 0.1km of turning heads, and carry out upgrades to c.0.4km of existing agricultural tracks (including bend widening) to facilitate site access and construction activities. All track widening will be undertaken using clean uncrushable stone with a minimum of fines to reduce the risk of suspended solid releases to receiving watercourses.

Still traps will be placed in the new roadside swales. Proposed new tracks will be drained as via roadside swales with stilling ponds at the end of the swale. These grassed swales will serve to detain flow and reduce the velocities of surface water flows. The swales will be 0.3 m deep with a bottom width of 0.5 m and side slope of 1 in 3. The swales will be constructed in accordance with CIRIA C698 Site Handbook for the Construction of SuDS which can be used in conjunction with CIRIA C753 The SuDS Manual. Where roadside drains are laid at slopes greater than 2%, check dams will be provided.

Mitigation measures to protect site hydrology and water quality are provided in section 10.6 and 10.7.1 of chapter 10. These include measures to reduce or prevent surface water run-off, suspended solids, hydrocarbons, site wastewater, cement and nutrients escaping to receiving surface waters. The mitigation measures proposed will reduce potential direct and indirect impacts from the construction of access tracks. The risk of water quality impacts to receiving watercourses via siltation or nutrient release will be further reduced through siltation management as detailed in the CEMP.

The 13 no. surface water drains within the site boundary to be crossed by access tracks during the construction phase will be via precast box culverts (refer to section 10.6.4 of chapter 10). Silt Protection Controls (SPCs) are proposed at the location of the drain crossings. It is recommended that the SPCs will consist of a minimum of silt traps containing filter stone and filter material staked across the width of the swales and upstream of the outfall to any watercourse.

In the presence of mitigation measures, potential impacts to aquatic ecology resulting from access track construction are considered **likely slight negative, short-term and in the local context**.

Potential impacts to qualifying interest species and habitats of the downstream-connecting Blackwater River SAC (002170) are considered **likely not significant and short-term in in context of the European site,** in the presence of mitigation.

6.1.3 Mitigation measures for turbine base and met mast construction

The greatest threat to aquatic ecology from turbine base construction (based on site topography and the layout of surface water features) are impacts to water quality identified at turbines T3 and T4 which are located approx. 130m and 170m from the Ardglass River and Oakfront River, respectively (indirect connectivity via drainage ditches). Both the Ardglass and Oakfront Rivers share downstream hydrological connectivity with the Awbeg River and Blackwater River SAC (002170), with the shortest hydrological distances to the European site being 0.7km and 1.4km, respectively (via surface water drains and the rivers).

Please refer to section 10.6 of Chapter 10 for detailed mitigation measures for site drainage and silt attenuation to prevent impacts to the water quality of downstream watercourses during the construction phase. These include measures to prevent run-off erosion from vulnerable areas and consequent sediment release into nearby watercourses to which the proposed development site discharges. The mitigation measures proposed will reduce potential direct and indirect impacts from the construction of the turbine foundations/hardstands. The risk of water quality impacts to receiving watercourses via siltation or nutrient release will be further reduced through siltation management as detailed in the CEMP.

In the presence of mitigation measures, potential impacts to aquatic ecology resulting from turbine base and met mast construction are considered **likely slight negative, short-term and in the local context**.

Potential impacts to qualifying interest species and habitats of the downstream-connecting Blackwater River SAC (002170) are considered **likely not significant and short-term in in context of the European site,** in the presence of mitigation.

6.1.4 Mitigation measures for site drainage

Permanent roadside drainage will be installed as part of the construction stage. This will include the use of interceptor drains, swales, check dams and stilling ponds. These measures will buffer site run-off during periods of high rainfall by retaining the water until the storm hydrograph has receded. The proposed locations of the stilling ponds are provided in the Surface Water Management Plan (SWMP) contained in Appendix 10.3 and in the Planning Drawings. Silt fencing will be provided at strategic locations (See section 10.7 in Chapter 10 Hydrology and water Quality) to further protect watercourses during the construction phase.

Site drainage, including silt traps and stilling ponds, will be put in place in parallel with construction, such that excavation for new infrastructure will have functional drainage system in place. The stilling ponds will remain in place during construction phase. The stilling ponds will drain diffusely overland, over existing vegetated areas, within the site boundary. The stilling ponds will be back-filled and the swales that were connected to them will be re-connected to the outfall once construction is completed. Silt Protection Controls (SPCs) are proposed at the location of all drain crossings. SPCs will consist of a minimum of silt traps containing filter stone and filter material staked across the width of the swales and upstream of the outfall to any watercourse.

As outlined in section 5.2.4, It is noted that there is little direct connectivity between the development area and the riverine watercourses draining the site (i.e. heavily vegetated drainage channels connecting to the Ardglass River and Oakfront River), so the risk of silt-laden surface water run-off to receiving watercourses is greatly reduced, even in the absence of mitigation. However, detailed mitigation measures to protect water quality (which include but are not limited to sediment run-off control and management of concrete and aquatic buffer zones) in respect of site drainage are outlined in Chapter 10 and the CEMP.

Please refer to section 10.6 of Chapter 10 for detailed mitigation measures for site drainage and silt attenuation to prevent impacts to the water quality of downstream watercourses during the construction phase.

In the presence of mitigation to protect water quality, potential impacts to aquatic ecology resulting from alterations to/inadequate site drainage management are considered **likely slight negative, short-term and in the local context**.

Potential impacts to qualifying interest species and habitats of the downstream-connecting Blackwater River SAC (002170) are considered **likely not significant and short-term in in context of the European site,** in the presence of mitigation.

6.1.5 Mitigation measures for GCR installation

In addition to the crossing on 6 no. drainage channels, there will be a requirement for 2 no. riverine watercourse crossings along the GCR in total. These are on the Rathnacally Stream (GCR-WCC1) and Oakfront River (WF-HF5).

The crossing of the Rathnacally Stream on the L1322 will be via horizontal directional drilling (HDD), located approx. 1.5km upstream of the Blackwater River SAC (002170). Mitigation measures relating to water quality preservation are outlined in detail in section 10.7 of chapter 10. These measures will also serve to protect sensitive aquatic ecological receptors and Blackwater River SAC (002170) qualifying interest species and habitats. Although no-instream works are proposed, the drilling works will only be completed during a dry period between July and September (as required by Inland Fisheries Ireland for in-stream works) to avoid the salmonid spawning season and sensitive life stage period. A pre-construction otter survey will be undertaken in the vicinity of GCR-WCC1 and WF-HF5 to ensure than no breeding or resting areas are located within 150m (no holts recorded in these locations to date during otter surveys but pre-construction surveys will be undertaken to reconfirm the findings of the EIAR). Should an otter breeding (holt) or resting area (couch) be detected, a derogation licence would need to be obtained from the NPWS to facilitate drilling works.

Excavation of the grid route trench will require excavation of soils/subsoils which has the potential to impact the water quality and aquatic habitat of receiving watercourses. Excavated spoil emanating from the cut trenches, where appropriate (i.e. when trenching within private tracks or the public road verge) will be used to back-fill the trenches. Any excess will be disposed of off-site, at an appropriate licenced facility. All excavated material emanating from trenches within the public road network will be disposed at an appropriate licenced facility. Mitigation measures to prevent the escapement of suspended solids to receiving watercourses (e.g. silt fences, interceptor drains, stilling ponds, drain blocking etc.) are outlined in section 10.7 of chapter 10 and the CEMP. On the Rathnacally Stream, silt fences will also be constructed in the vicinity of the excavated areas on the stream banks to prevent siltation of the adjacent watercourse. An Ecological Clerk of Works (ECoW) will monitor both turbidity and observe the riverbed during the drilling process to detect any leakage (frac-out) of drilling fluid. Should this leakage be observed, works will cease immediately. If drilling fluids are required, a biodegradable fluid that is non-toxic to aquatic life, such as CLEARBORE, shall be used rather than bentonite.

The GCR crossing of the Oakfront River (WF-HF5) will be via a single span, pre-cast concrete bridge. This will avoid the requirement for instream works. Nevertheless, installation will only be completed during a dry period between July and September (as required by Inland Fisheries Ireland for in-stream works) to avoid the salmonid spawning season and sensitive life stage period. Potential releases of sediment-laden surface run-off as a result of bank clearance works to facilitate bridge installation/access will be mitigated against through the water quality mitigation measures applicable throughout the site (see section 10.7 of chapter 10 and the CEMP).

Further mitigation measures in relation to the grid connection cable route (including the spread of invasive species) are outlined in the CEMP and will be fully implemented.

In the presence of mitigation measures, potential impacts to aquatic ecology resulting from GCR installation are considered **likely slight negative, short-term and in the local context**.

Potential impacts to qualifying interest species and habitats of the downstream-connecting Blackwater River SAC (002170) are considered **likely not significant and short-term in in context of the European site,** in the presence of mitigation.

6.1.6 Mitigation measures for turbine delivery route

The TDR will cross the Rathnacally Stream at a local road crossing on the L1322 (GCR-WCC1). This crossing is located approx. 1.5km upstream (by water) of the Blackwater River SAC (002170). There are no instream works required at the bridge structure to facilitate turbine delivery, although hedgerow trimming and wall lowering will be required to facilitate oversail. These minor, localised works could in the absence of mitigation cause impacts to the water quality of the receiving Rathnacally Stream and downstream Blackwater River SAC (002170).

Mitigation measures relating to water quality preservation are outlined in detail in section 10.7 of Chapter 10 and in the CEMP. These measures, which include but are not limited to silt fences, roadside drain blocking, refuelling protocols and spoil disposal, will also serve to protect sensitive aquatic ecological receptors and Blackwater River SAC (002137) qualifying interests such as Atlantic salmon, lamprey species, otter and white-clawed crayfish.

In terms of hydrology and water quality, the significance of the effect of the works associated with TDR onto the receiving waters has been assessed as “not significant” (section 10.7.3 of chapter 10).

In the presence of mitigation measures, potential impacts to aquatic ecology resulting from turbine delivery are considered **likely not significant, short-term and in the local context**.

Potential impacts to qualifying interest species and habitats of the downstream-connecting Blackwater River SAC (002170) are considered **likely not significant and short-term in in context of the European site,** in the presence of mitigation.

6.2 Operational phase mitigation

The primary impact to aquatic ecology resulting from the operational phase of the proposed wind farm is an increase in surface water run-off from hardstand areas, access tracks and other reduced-permeability surfaces, thus potentially impacting water quality and site drainage/hydrology. However, the overall estimated increase in the unmitigated peak runoff due to the wind farm is 0.174 m^3/s (or 0.20 %) for a 1 in 100 years storm event (Chapter 10, section 10.4.2). Therefore, the slight predicted increase in surface water run-off during the lifetime of the wind farm project (compared with baseline conditions, pre-development) is not anticipated to impact slow-swimming fish species, such as European eel or *Lampetra* sp., in receiving watercourses and is considered negligible.

In light of this slight increase, potential impacts to receiving watercourses are considered unlikely, even pre-mitigation. Nonetheless, mitigation measures (including interceptor drains, check dams, settlement ponds) will be implemented to reduce this risk even further. Mitigation for the maintenance regime respective of hydrology and water quality is outlined in section 10.7.4 of chapter 7. These measures will also serve to protect sensitive aquatic receptors.

Due to the natural 'grassing-over' the drainage swales and revegetation of other exposed surfaces, and the non-intrusive nature of site operations, there will be a further reduction in the risk of sediment release to the watercourses during the operational stage.

In the presence of mitigation, potential operational phase impacts on aquatic ecology are considered **likely imperceptible negative, short-term and in the local context**.

Given the downstream-connectivity from the wind farm site and associated infrastructure (GCR, sub-stations, access tracks etc.), potential impacts to aquatic qualifying interest species and habitats of the Blackwater River SAC (002170) are considered **likely not significant negative, short-term and in context of the European site**, in the presence of mitigation.

6.3 Decommissioning phase mitigation

In relation to aquatic ecology, the same mitigation measures will apply for the decommissioning phase as for the construction phase. In the event of decommissioning of the Annagh wind farm, the access tracks may be used in the decommissioning process. Mitigation measures applied during decommissioning activities will be similar to those applied during construction but will be of reduced magnitude.

It is proposed that turbine foundations and hardstand areas should be left in place and covered with local soil/topsoil to revegetate at the decommissioning stage. It is considered that leaving the turbine foundations, access tracks and hardstand areas in-situ will cause less environmental damage than removing them. The grid connection ducting and substation will be left in situ as part of the national grid, therefore no potential impacts during decommissioning stage are likely to occur. Hence no mitigation measures are required.

Moreover, due to the relatively long life of wind farm infrastructure, it is likely that a revised/updated environmental assessment will be required at the time of decommissioning to account for any changes in baseline conditions at the wind farm site, and potential changes is assessment guidelines and legislation.

In the presence of mitigation, potential decommissioning phase impacts on aquatic ecology are considered **likely slight negative, short-term and in the local context**, in the absence of mitigation.

Potential impacts to aquatic qualifying interest species and habitats of the Blackwater River SAC (002170) are considered **likely not significant negative, short-term and in context of the European site**, in the presence of mitigation.

7. Residual impacts

The residual impacts on aquatic ecology resulting from Annagh wind farm project are summarised in **Table 7.1** below, using the impact assessment criteria outlined in Section 2.1.

The layout and design of the proposed Annagh wind farm has taken the aquatic ecology of the existing environment into consideration. The limitation of indirect impacts arising from water quality pollution events such as siltation and run-off of suspended solids will significantly reduce the potential for impacts affecting aquatic ecological interests within the vicinity of the proposed project. Provided all mitigation measures are implemented in full, no significant residual impacts on the local aquatic ecology or integrity of the Blackwater River SAC (002170) are expected from the project.

Overall, the proposed Annagh wind farm project will have a **likely moderate to significant negative, short-term impact** on sensitive aquatic receptors in the **local scale context** during the construction phase, in the absence of mitigation (see Table 5.1). Potential impacts to the aquatic qualifying interest species and habitats of the Blackwater River SAC (002170) in the absence of mitigation, are considered **likely significant negative, short-term and in context of the European site**, with the exception of impacts from the TDR which was assessed as being **likely not significant negative, short-term and in context of the European site.**

However, through the implementation of the mitigation measures outlined in **Section 6 above,** section 10.6 and 10.7 of Chapter 10 and the CEMP, residual impacts to aquatic species and habitats are considered to be **likely slight negative to not significant, short-term and in the local context.**

For the Blackwater River SAC (002170), the impacts to aquatic qualifying interest species and habitats are considered **likely not significant, short-term and in the context of the European site**.

Table 7.1 Summary of residual impacts to aquatic ecological receptors (post-mitigation)

Activity	Nearest downstream connecting watercourse(s) (direct down-slope distance from activity)	Sensitive aquatic receptor(s)	Aquatic ecological impacts	Potential impact significance
Tree felling	**Ardglass River** (c.120m from T4 via a drainage channel) **Oakfront River** (c.160m from T3 via a drainage channel)	Salmonids (Atlantic salmon & brown trout), European eel, *Lampetra* sp., common frog, otter, kingfisher, white-clawed crayfish; Blackwater River SAC aquatic qualifying interests (≤1.4km downstream)	Release of suspended solids, contaminants and or nutrients (water quality impacts); mortality of aquatic invertebrates & fish eggs; eutrophication and impacts to downstream fish, otter, kingfisher, invertebrates & water quality; spread of invasive species along watercourses	*All downstream aquatic habitats & species:* **Likely slight negative, short-term and in the local context** *All downstream aquatic qualifying interests of Blackwater River SAC (002170):* **Likely not significant, short-term and in context of the European site**
Access track construction	**Oakfront River** (crossed by single span bridge (WF-HF5), c.1.4km instream distance from Blackwater River SAC) **13 no. drainage channels** (crossed by access tracks – see section 10.6.4 of chapter 10)	Salmonids (Atlantic salmon & brown trout), European eel, *Lampetra* sp., common frog, otter, kingfisher, white-clawed crayfish; Blackwater River SAC aquatic qualifying interests	Release of suspended solids, contaminants and or nutrients (water quality impacts); mortality of aquatic invertebrates & fish eggs; eutrophication and impacts to downstream fish, otter, kingfisher, invertebrates & water quality; spread of invasive species along watercourses	*All downstream aquatic habitats & species:* **Likely slight negative, short-term and in the local context** *All downstream aquatic qualifying interests of Blackwater River SAC (002170):* **Likely not significant, short-term and in context of the European site**
Turbine base and met mast construction	**<u>Turbine bases:</u>** **Ardglass River**	Salmonids (Atlantic salmon & brown trout), European eel, *Lampetra* sp., common frog, otter, kingfisher, white-clawed	Release of suspended solids, contaminants and or nutrients (water quality impacts); mortality of aquatic invertebrates & fish eggs; eutrophication and impacts to downstream fish, otter, kingfisher,	*All downstream aquatic habitats & species:* **Likely slight negative, short-term and in the local context**

Activity	Nearest downstream connecting watercourse(s) (direct down-slope distance from activity)	Sensitive aquatic receptor(s)	Aquatic ecological impacts	Potential impact significance
	(c.130m from T4 via a drainage channel, 0.7km from Blackwater River SAC) **Oakfront River** (c.170m from T3 via a drainage channel, 1.4km from Blackwater River SAC) **Drainage channels** (numerous small drains in footprint of hardstands) **<u>Met mast:</u>** **Ardglass River** (c.200m from met mast)	crayfish; Blackwater River SAC aquatic qualifying interests	invertebrates & water quality; spread of invasive species along watercourses	*All downstream aquatic qualifying interests of Blackwater River SAC (002170):* **Likely not significant, short-term and in context of the European site**
Site drainage (incl. crossing/culverting of drainage channels)	**Ardglass River** (various source-receptor pathways via drainage channels) **Oakfront River** (various source-receptor pathways via drainage channels)	Salmonids (Atlantic salmon & brown trout), European eel, *Lampetra* sp., common frog, otter, kingfisher, white-clawed crayfish; Blackwater River SAC aquatic qualifying interests	Increase in flow rates (surface water run-off); changes to rates of erosion & deposition in receiving watercourses; impacts to aquatic habitats and water quality	*All downstream aquatic habitats & species:* **Likely slight negative, short-term and in the local context** *All downstream aquatic qualifying interests of Blackwater River SAC (002170):* **Likely not significant, short-term and in context of the European site**

Activity	Nearest downstream connecting watercourse(s) (direct down-slope distance from activity)	Sensitive aquatic receptor(s)	Aquatic ecological impacts	Potential impact significance
Grid connection route (GCR)	**Rathnacally Stream** (crossed at GCR-WCCC1 via HDD on L1322 road) **Oakfront River** (crossed at WF-HF5 via single span pre-cast concrete bridge) **6 no. drainage channels** (crossed by GCR via box culvert – see section 10.6.4 and Table 10.9 of chapter 10)	Salmonids (Atlantic salmon & brown trout), European eel, *Lampetra* sp., common frog, otter, kingfisher, white-clawed crayfish; Blackwater River SAC aquatic qualifying interests	Release of suspended solids, contaminants and or nutrients (water quality impacts); mortality of aquatic invertebrates & fish eggs; eutrophication and impacts to downstream fish, otter, kingfisher, invertebrates & water quality; spread of invasive species along watercourses	*All downstream aquatic habitats & species:* **Likely slight negative, short-term and in the local context** *All downstream aquatic qualifying interests of Blackwater River SAC (002170):* **Likely not significant, short-term and in context of the European site**
Turbine delivery route (TDR)	**Rathnacally Stream** (crossed at GCR-WCCC1 on L1322 road, 1.5km upstream of Blackwater River SAC)	European eel; Blackwater River SAC aquatic qualifying interests	Release of contaminants (water quality impacts); spread of invasive species along watercourses	*All downstream aquatic habitats & species:* **Likely not significant , short-term and in the local context** *All downstream aquatic qualifying interests of Blackwater River SAC (002170):* **Likely not significant, short-term and in context of the European site**

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9. Appendix A – fisheries assessment report

Please see accompanying fisheries assessment report

Fisheries assessment of Annagh wind farm, Co. Cork

Prepared by Triturus Environmental Ltd. for Fehily Timoney & Company

October 2021

Please cite as:

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Table of contents

1. Introduction

1.1 Background

Triturus Environmental Ltd. were contracted by Fehily Timoney & Company to undertake a baseline fisheries assessment of numerous watercourses in the vicinity of the proposed Annagh wind farm, located near Charleville, Co. Cork (**Figure 1.1**).

The survey was undertaken to establish baseline fisheries data used in the preparation of the EIAR for the proposed project, which includes a proposed wind turbine layout, turbine delivery route (TDR) and associated grid connection route (GCR) alignment (**Figure 2.1**). In order to gain an accurate overview of the existing and potential fisheries value of the riverine watercourses within the vicinity of the proposed project, a catchment-wide electro-fishing survey across *n*=11 sites was undertaken (**Table 2.1; Figure 2.1**). Electro-fishing helped to identify the importance of the watercourses as nurseries and habitats for salmonids, lamprey and European eel (*Anguilla anguilla*), as well as other species, and helped to further inform impact assessment and any subsequent mitigation for the project.

Triturus Environmental Ltd. made an application under Section 14 of the Fisheries (Consolidation) Act, 1959 as substituted by Section 4 of the Fisheries (Amendment) Act, 1962, to undertake a catchment-wide electro-fishing survey in the vicinity of the proposed Annagh wind farm. Permission was granted on Friday 24th July 2020 and the survey was undertaken on Wednesday 2nd and Thursday 3rd September 2020.

1.2 Fisheries asset of the survey area

The proposed survey sites were located on numerous watercourses within the Awbeg [Buttevant]_SC_010 river sub-catchment near Charleville, Co. Cork. The survey area also overlapped with the (Munster) Blackwater *Margaritifera* sensitive area (**Figure 1.1**). The survey watercourses shared downstream hydrological connectivity with the Blackwater River SAC (site code: 002170), to the south of the survey area. Fisheries survey sites were present on the Fiddane Stream (EPA code: 18F19), Ardglass River (18A23), Milltown Stream (18M57), Oakfront River (18O02) and Rathnacally Stream (18R32) (**Table 2.1**).

The Awbeg River is a major tributary of the (Munster) River Blackwater, flowing for some 50km south-westerly from its source in the Ballyhoura Mountains through Buttevant and Doneraile before joining the River Blackwater near Castletownroche. Recreational brown trout fishing is popular along this river, although their growth rates have been noted as slow due to relatively low average water temperatures (O'Reilly, 2009; Kelly et al. 2013). The river is known to support Atlantic salmon (*Salmo salar*), brown trout (*Salmo trutta*), European eel (*Anguilla anguilla*), lamprey (*Lampetra* sp.), stone loach (*Barbatula barbatula*) and, in the lower reaches, the non-native dace (*Leuciscus leuciscus*) (Kelly et al., 2009, 2013). The Awbeg is also one of few sites in county Cork to support a significant population of white-clawed crayfish (*Austropotamobius pallipes*). Historically, the Awbeg was arterially drained and currently achieves poor (Q3) to moderate status (Q3-4) water quality throughout much of its length (EPA data).

Fisheries data for the other watercourses within the survey area was not available at the time of survey.

2. Methodology

2.1 Fish stock assessment (electro-fishing)

A single anode Smith-Root LR24 backpack (12V DC input; 300V, 100W DC output) was used to electro-fish sites on watercourses in the vicinity of the proposed Annagh wind farm on Wednesday 2nd and Thursday 3rd September, following notification to Inland Fisheries Ireland (Macroom) and under the conditions of a Department of Communications, Climate Action & Environment (DCCAE) license. Both river and holding tank water temperature was monitored continually throughout the survey to ensure temperatures of 20°C were not exceeded, thus minimising stress to the captured fish due to low dissolved oxygen levels. A portable battery-powered aerator was also used to further reduce stress to any captured fish contained in the holding tank.

Salmonids, European eel and other captured fish species were transferred to a holding container with oxygenated fresh river water following capture. To reduce fish stress levels, anaesthesia was not applied to captured fish. All fish were measured to the nearest millimetre and released in-situ following a suitable recovery period.

As three primary species groups were targeted during the survey, i.e. salmonids, lamprey, and eel, the electro-fishing settings were tailored for each species. By undertaking electro-fishing using the rapid electro-fishing technique (see methodology below), the broad characterisation of the fish community at each sampling reach could be determined as a longer representative length of channel can be surveyed. Electro-fishing methodology followed accepted European standards (CEN, 2003) and adhered to best practice (e.g. CFB, 2008).

The catchment-wide electro-fishing (CWEF) survey was undertaken across *n*=11 sites (see **Table 2.1, Figure 2.1**).

Table 2.1 *n*=11 electro-fishing survey site locations in the vicinity of the proposed Annagh wind farm project, Co. Cork.

Site no.	Watercourse	EPA code	Location	X (ITM)	Y (ITM)
A1	Fiddane Stream	18F19	Annagh Bogs	549427	617248
A2	Ardglass River	18A23	Annagh Bogs	549606	616770
A3	Awbeg River	18A09	Annagh Bridge	549823	615649
B1	Milltown Stream	18M57	Milltown	550461	619714
B2	Oakfront River	18O02	Cooliney Bridge	550181	618654
B3	Oakfront River	18O02	Milltown	550651	617869
B4	Oakfront River	18O02	Springfort	550775	617421
B5	Oakfront River	18O02	Bridge at Coolcaum	551050	616256
C1	Rathnacally Stream	18R32	Clashganniv	552439	620511
C2	Rathnacally Stream	18R32	Bridge at Rathnacally	552633	619468
C3	Rathnacally Stream	18R32	Bridge at Ballynadrideen	552222	618157

2.1.1 Salmonids and European eel

For salmonid species and European eel, as well as other incidental species, electro-fishing was carried out in an upstream direction for a 10-minute CPUE, an increasingly common standard approach for wadable streams (Matson et al., 2018). A total of approx. ≥75-100m channel length was surveyed at each site, where feasible, in order to gain a better representation of fish stock assemblages. At certain, more minor watercourse sites or sites with limited access, it was more feasible to undertake electro-fishing for a 5-minute CPUE. Discrepancies in fishing effort (CPUE) between sites are accounted for in the subsequent results section (**Table 3.1**).

Relative conductivity of the water at each site was checked in-situ with a conductivity meter and the electro-fishing backpack was energised with the appropriate voltage and frequency to provide enough draw to attract salmonids and European eel to the anode without harm. For the high conductivity waters of the sites (most draining calcareous geologies) a voltage of 210-230v, frequency of 40-45Hz and pulse duration of 3.5ms was utilised to draw fish to the anode without causing physical damage.

2.1.2 Lamprey

Electro-fishing for lamprey ammocoetes was conducted using targeted box quadrat-based electro-fishing (as per Harvey & Cowx, 2003) in objectively suitable areas of sand/silt, where encountered. As lamprey take longer to emerge from silts and require a more persistent approach, they were targeted at a lower frequency (30Hz) burst DC pulse setting which also allowed detection of European eel in sediment, if present. Settings for lamprey followed those recommended and used by Harvey & Cowx (2003), APEM (2004) and Niven & McAuley (2013). Using this approach, the anode was placed under the water's surface, approx. 10–15 cm above the sediment, to prevent immobilising lamprey ammocoetes within the sediment. The anode was energised with 100V of pulsed DC for 15-20 seconds and then turned off for approximately five seconds to allow ammocoetes to emerge from their burrows. The anode was switched on and off in this way for approximately two minutes. Immobilised ammocoetes were collected by a second operator using a fine-mesh hand net as they emerged.

Lamprey species were identified to species level, where possible, with the assistance of a hand lens, through external pigmentation patterns and trunk myomere counts as described by Potter & Osborne (1975) and Gardiner (2003).

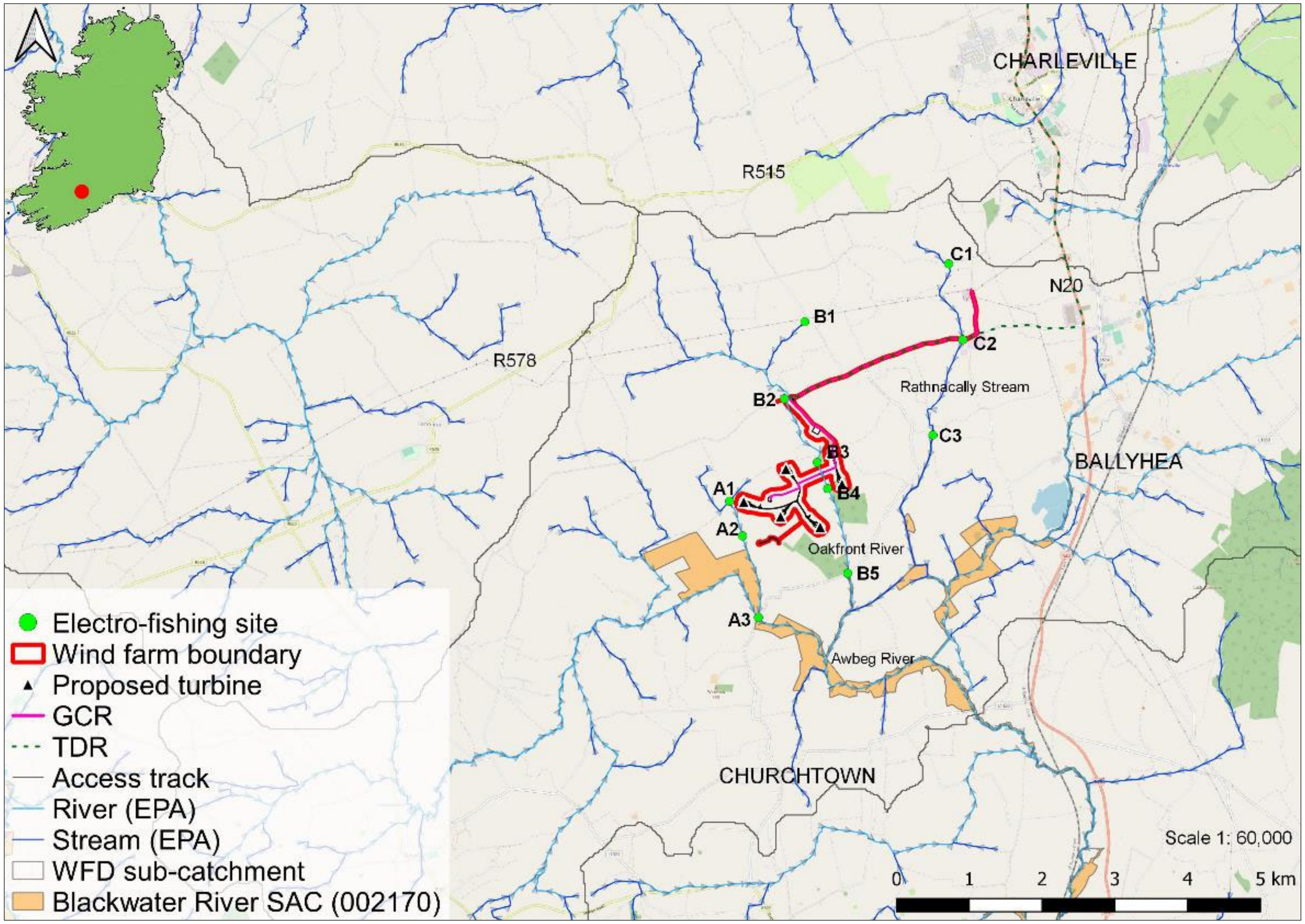

Figure 2.1 Location overview of the *n*=11 electro-fishing sites in vicinity of the proposed Annagh wind farm, Co. Cork

2.2 Fisheries habitat

2.2.1 Salmonid habitat

Fisheries habitat quality for salmonids was assessed using the Life Cycle Unit method (Kennedy, 1984; O'Connor & Kennedy, 2002) to map the *n*=11 riverine sites as nursery, spawning and holding habitat, by assigning quality scores to each type of habitat. Those habitats with poor quality substrata, shallow depth and a poorly defined river profile receive a higher score. Higher scores in the Life Cycle Unit method of fisheries quantification are representative of poorer value, with lower scores being more optimal despite this appearing counter-intuitive.

Table 2.1 Life Cycle Unit scoring system for salmonid nursery, spawning and holding habitat value (as per Kennedy, 1984 & O'Connor & Kennedy, 2002)

Habitat quality	Habitat score	Total score (three components)
Poor	4	12
Moderate	3	9-11
Good	2	6-8
Excellent	1	3-5

2.2.2 Lamprey habitat

Lamprey habitat evaluation for each survey site was undertaken using the Lamprey Habitat Quality Index (LHQI) scoring system, as devised by Macklin et al. (2018). The LHQI broadly follows a similar rationale as the Life Cycle Unit score for salmonids. Those habitats with a lack of soft, largely organic sediment areas for ammocoete burrowing, shallow sediment depth (<10cm) or compacted sediment nature receive a higher score. Higher scores in this index are thus of poorer value (in a similar fashion to the salmonid Life Cycle Unit Index), with lower scores being more optimal. Overall scores are calculated as a simple function of the sum of individual habitat scores.

Larval lamprey habitat quality as well as the suitability of adult spawning habitat is assessed based on the information provided in Maitland (2003) and other relevant literature (e.g. Gardiner, 2003). Unlike the salmonid Life Cycle Unit index, holding habitat for adult lamprey is not assessed owing to their different migratory and life history strategies, and that electro-fishing surveys routinely only sample larval lamprey.

The LHQI scoring system provides additional information compared to the habitat classification based on the observations of Applegate (1950) and Slade et al. (2003), which deals specifically with larval (sea) lamprey settlement habitat. Under this scheme, habitat is classified into three different types: preferred (Type 1), acceptable (Type 2), and not acceptable for larvae (Type 3) (Slade et al. 2003). Type 1 habitat is characterized by soft substrate materials usually consisting of a mixture of sand and fine organic matter, often with some cover over the top such as detritus or twigs in areas of deposition. Type 2 habitat is characterized by substrates consisting of shifting sand with little if any organic matter and may also contain some gravel and cobble (lamprey may be present but at much lower densities than Type 1). Type 3 habitat consists of materials too hard for larvae to burrow including bedrock and highly compacted sediment. This classification can also be broadly applied to other lamprey species ammocoetes, including *Lampetra* species.

Table 2.2 Lamprey Habitat Quality Index (LHQI) scoring system for lamprey spawning and nursery habitat value (Macklin et al., 2018).

Habitat quality	Habitat score	Total score (two components)
Poor	4	8
Moderate	3	6-7
Good	2	3-5
Excellent	1	2

2.2.3 General fisheries habitat

A broad appraisal / overview of the upstream and downstream habitat at each site was also undertaken to evaluate the wider contribution to salmonid and lamprey spawning and general fisheries habitat. River habitat surveys and fisheries assessments were also carried out utilising elements of the approaches in the River Habitat Survey Methodology (Environment Agency, 2003) and Fishery Assessment Methodology (O'Grady, 2006) to broadly characterise the river sites (i.e. channel profiles, substrata etc.).

2.3 Biosecurity

A strict biosecurity protocol following the Check-Clean-Dry approach was employed during the survey. Equipment and PPE used was disinfected with Virkon® between survey sites to prevent the transfer of pathogens and/or invasive species between survey areas. Particular cognisance was given to preventing the introduction or spread of crayfish plague (*Aphanomyces astaci*) given the known presence of a healthy white-clawed crayfish population throughout the Awbeg catchment. As per best practice, surveys were undertaken at sites in a downstream order (i.e. uppermost site surveyed first etc.) to prevent the upstream mobilisation of invasive propagules and pathogens. Any invasive species recorded within or adjoining the survey area were geo-referenced.

3. Results

A catchment-wide electro-fishing survey of *n*=11 sites in the vicinity of the proposed Annagh wind farm was conducted on Wednesday 2nd and Thursday 3rd September 2020 following notification to Inland Fisheries Ireland (Macroom). The results of the survey are discussed below in terms of fish population structure, population size and the suitability and value of the surveyed areas as nursery and spawning habitat for salmonids, European eel and lamprey species. Scientific names are provided at first mention only.

3.1 Fish stock assessment (electro-fishing)

3.1.1 Site A1 – Fiddane Stream

No fish were recorded during electro-fishing at site A1 on the Fiddane Stream, located along the wind farm site boundary, immediately upstream of the Ardglass River confluence. The historically straightened site represented a heavily-silted, stagnant drainage ditch (FW4) and was not of fisheries value. Whist localised ponding of water to 0.2m was present in several locations during the survey, the channel showed evidence of seasonal drying and was, therefore, not capable of supporting resident fish. Fisheries potential improved further down the catchment (i.e. Ardglass River).

Plate 3.1 Representative image of site A1 on the Fiddane Stream (no fish recorded via electro-fishing).

3.1.2 Site A2 – Ardglass River, Annagh Bogs

Three-spined stickleback (*Gasterosteus aculeatus*) was the only species recorded during electro-fishing at site A2 on the Ardglass River. The river had been extensively straightened and deepened, historically and resembled a drainage ditch habitat (FW4) with an imperceptible flow at the time of survey. The river at this location (and for much of its length) was heavily-vegetated and supported a low density of both juveniles and adult stickleback.

The site was of no value for salmonids or lamprey given the heavily-silted, heavily-vegetated and low flow nature of the channel. Whilst some low suitability existed for European eel, none were recorded.

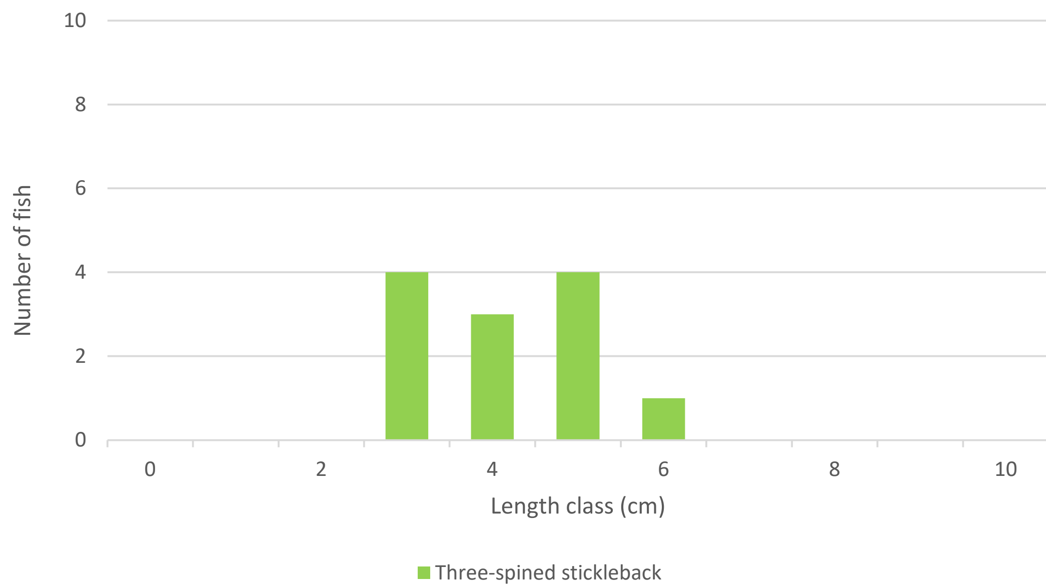

Figure 3.1 Fish stock length distribution recorded via electro-fishing at site A2 on the Ardglass River, September 2020.

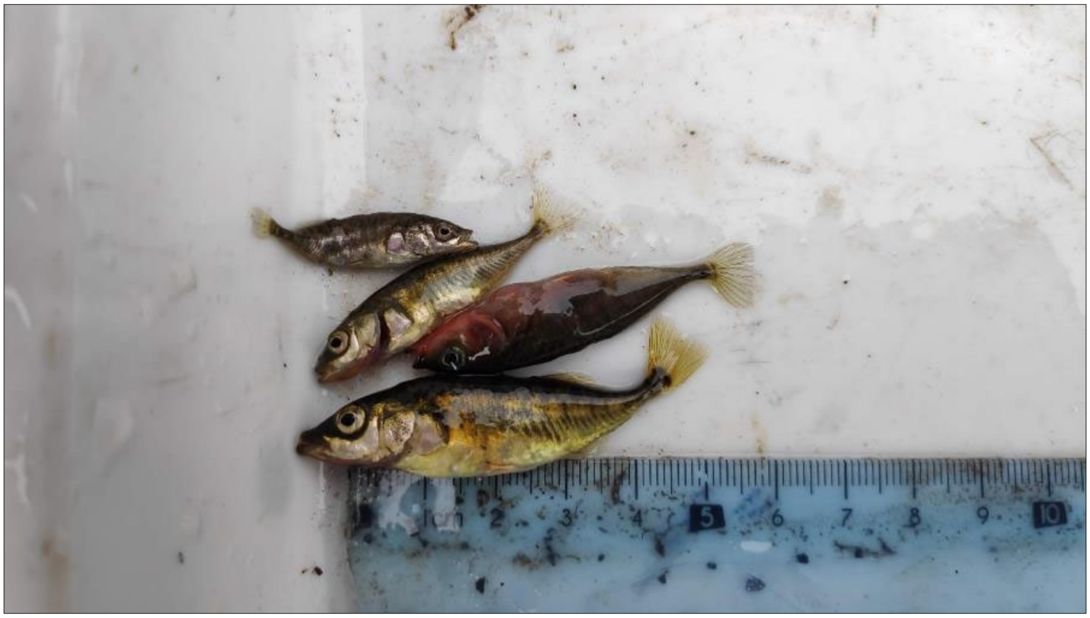

Plate 3.2 Three-spined stickleback recorded from site A2 on the Ardglass River, September 2020.

3.1.3 Site A3 – Awbeg River, Annagh Bridge

Three fish species were recorded via electro-fishing from site A3 at the Awbeg-Ardglass confluence (**Figure 3.2**). Brown trout were the most frequently recorded, with a low density of adults recorded (*n*=10). This was the highest density of trout recorded at any survey site. No juvenile trout were captured. European eel and three-spined stickleback were also present in low numbers.

The slow-flowing site was not considered of value as a salmonid spawning area given high siltation rates and its historically drained nature (i.e. deepened, straightened channel with heavy siltation). However, holding habitat was good given the predominance of deep glide and pool, often >1.5m in depth. The site was of some moderate value as a nursery although no juvenile salmonids were recorded (recruitment likely impacted by siltation). Despite abundant silt deposits, no lamprey ammocoetes were recorded, possibly reflecting typically low flows at this site. Lamprey spawning habitat was absent. European eel habitat was good overall given frequent instream macrophyte refugia.

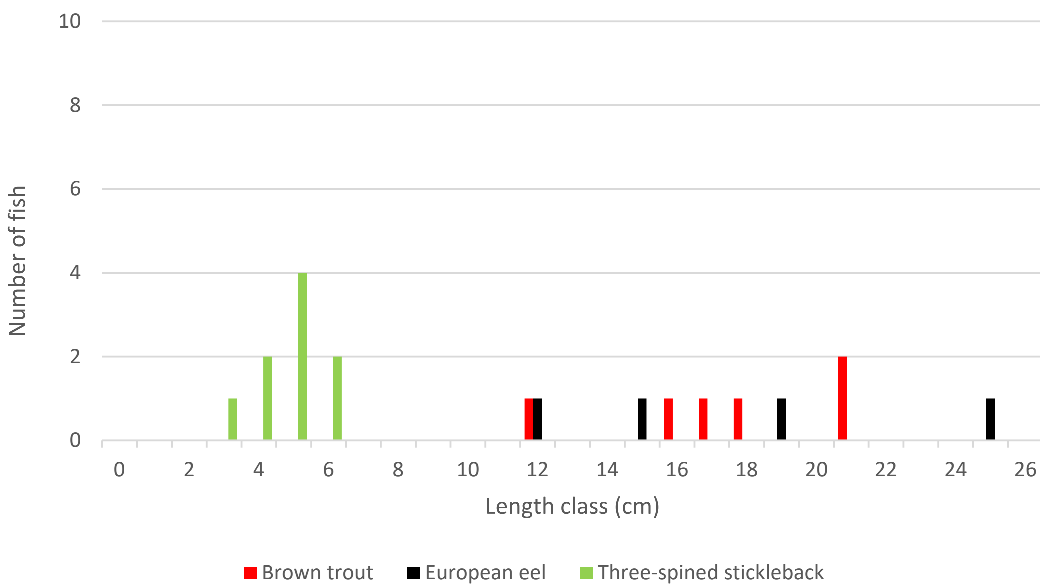

Figure 3.2 Fish stock length distribution recorded via electro-fishing at site A3 on the Awbeg River, September 2020.

Plate 3.3 Small adult brown trout recorded from site A3 on the Awbeg River, September 2020.

3.1.4 Site B1 – Milltown Stream, Milltown

Two fish species were recorded from site B1 on the uppermost reaches of the Milltown Stream (**Figure 3.3**). Low numbers of three-spined stickleback were captured along with a single juvenile European eel.

Despite some physical suitability, the site did not support salmonids at the time of survey. Overall salmonid habitat was impacted by siltation pressures, upstream historically straightening and the shallow nature of the small stream, which resulted in moderate salmonid nursery and spawning habitat. Instream macrophyte growth and riparian tunnelling were both high. There was some evidence that the stream was exposed to seasonal low flows or partial-drying which further impacted the site's fisheries value. Despite the presence of some localised soft sediment accumulations (in association with instream macrophytes), no lamprey ammocoetes were recorded. European eel habitat was moderate overall, with some locally good habitat present underneath the bridge structure (i.e. boulder refugia in deeper pool area).

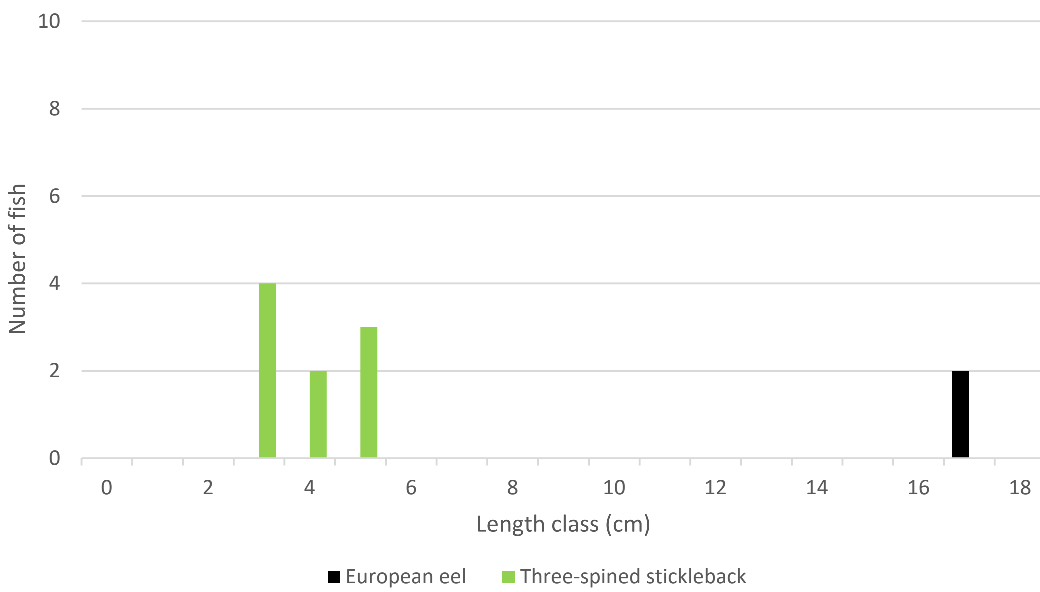

Figure 3.3 Fish stock length distribution recorded via electro-fishing at site B1 on the Milltown Stream, September 2020.

Plate 3.4 Representative image of site B1 on the Milltown Stream

3.1.5 Site B2 – Oakfront River, Cooliney Bridge

A total of four fish species were recorded from site B2 on the Oakfront River (**Figure 3.4**). Three-spined stickleback dominated the site (*n*=33), the highest density of any survey site (0.147 fish per m^2). A low number of European eel were recorded along with a single juvenile brown trout. A low density of *Lampetra* sp. ammocoetes (likely brook lamprey, *Lampetra planeri*) were present in shallow, superficial soft sediment near the bridge (ford crossing).

Downstream of the road bridge, the site had been extensively straightened and deepened historically and was evidently a poor nursery for salmonids despite some superficial suitability. However, compaction and or siltation of the bed in addition to poor profile heterogeneity reduced the overall value of the site. Some moderate eel habitat was present (nursery), with the better refugia in vicinity and underneath the bridge structure. Lamprey spawning habitat was present but limited in extent and silted. Some limited larval habitat was present immediately downstream of the bridge, in a marginal slack associated with a farm access crossing/cattle drink. Whilst the silt accumulations here were shallow (mostly <5cm and with high clay fractions), the area on the east bank supported a low number of ammocoetes (2m^2 fished, 3 ammocoetes recorded.). Stickleback were abundant in marginal macrophytes in this same area.

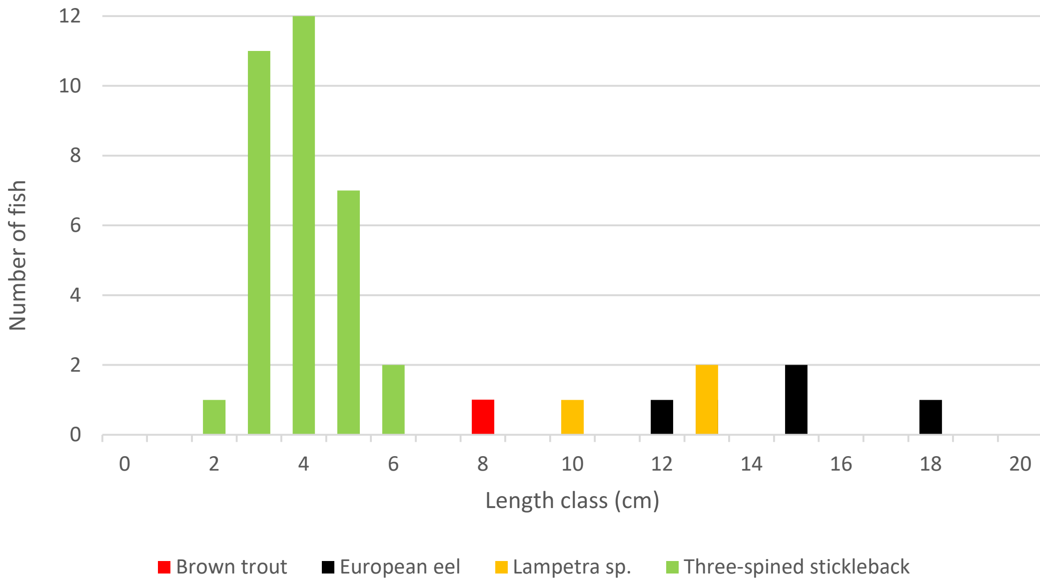

Figure 3.4 Fish stock length distribution recorded via electro-fishing at site B2 on the Oakfront River, September 2020.

Plate 3.5 Lamprey (*Lampetra* sp.) ammocoetes recorded from site B2 on the Oakfront River at Cooliney Bridge, September 2020.

3.1.6 Site B3 – Oakfront River, Milltown

A total of four fish species were recorded from site B3 on the Oakfront River (**Figure 3.5**). Three-spined stickleback dominated the site (*n*=21). A low number of brown trout were recorded, with both juveniles and small adults present. A low density of *Lampetra* sp. ammocoetes (likely brook lamprey) and European eel were also recorded.

The site was of moderate value to salmonids overall, supporting a small brown trout population. Whilst some good nursery habitat features were present (swift glide etc.), the spawning and holding value of the site was moderate, at best, due to bedding/compaction of the gravel and cobble substrata and an overall shallow depth with few pools. Nevertheless, salmonid habitat was much improved over site B2 upstream. Eel habitat was moderate given shallow depth and lack of instream refugia although juveniles were present at low densities. Larval lamprey habitat was present locally although sub-optimal (compacted, lots of sand, shallow depth).

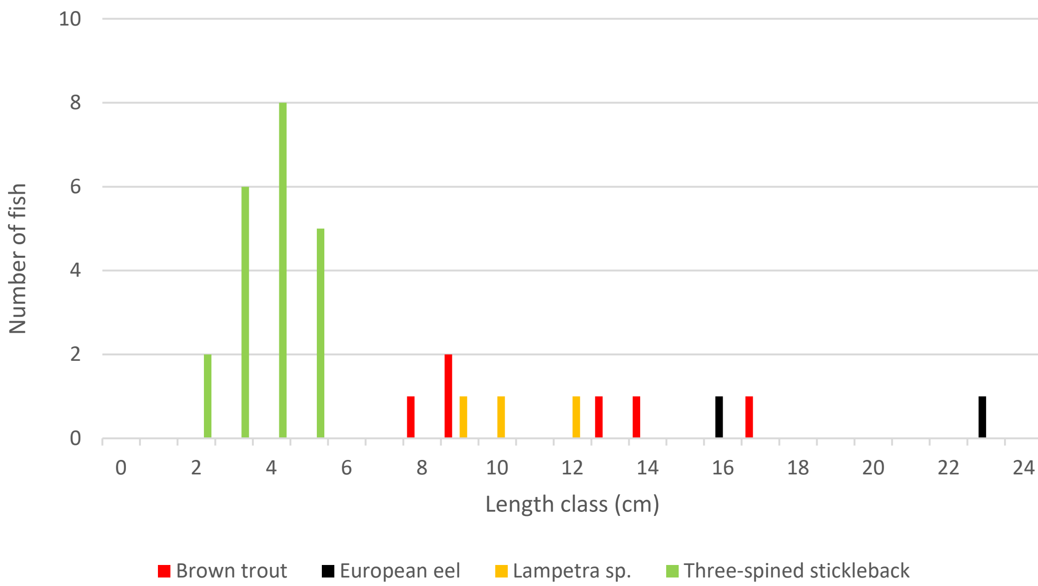

Figure 3.5 Fish stock length distribution recorded via electro-fishing at site B3 on the Oakfront River, September 2020.

3.1.7 Site B4 – Oakfront River, Springfort

A total of three fish species were recorded from site B4 on the Oakfront River, located approx. 475m downstream from site B3 (**Figure 3.6**). The overall density of fish was low - a small number of three-spined stickleback (*n*=8) and brown trout (*n*=3) were present alongside two European eel. Unlike upstream sites, no *Lampetra* sp. ammocoetes were recorded.

The site was a moderate value salmonid nursery although the number of brown trout recorded were less than expected for the river type (likely due to siltation pressures, substrata compaction etc.). Spawning habitat was good, locally although deeper holding habitat for adults was sparse. Larval lamprey habitat was present locally although sub-optimal (compacted, sand-dominated, shallow depth) – no ammocoetes were recorded. Lamprey spawning was good physically despite siltation pressures. Eel habitat was moderate given the presence of instream refugia such as scoured/undercut banks and large woody debris. Juvenile eels were present at low densities.

Figure 3.6 Fish stock length distribution recorded via electro-fishing at site B4 on the Oakfront River, September 2020.

Plate 3.6 Representative image of site B4 on the Oakfront River, September 2020.

3.1.8 Site B5 – Oakfront River, bridge at Coolcaum

A total of four fish species were recorded from site B5 on the Oakfront River (**Figure 3.7**). As with site B4 (1.2km) upstream, the overall density of fish at the historically straightened and deepened site was low. A low number of three-spined stickleback and European eel were recorded with a single small adult brown trout. A single, particularly large *Lampetra* sp. ammocoete (15.2cm TL) was also recorded near the bridge crossing (Plate 3.7).

The fisheries value of the site was much reduced given historical drainage (straightening and deepening), although the site provided some moderate quality eel and larval lamprey habitat. Overall salmonid habitat was poor, apart from some good deep glide holding habitat. Lamprey habitat was moderate overall, with an absence of suitable spawning substrata. However, some heavily silted gravels were present upstream of the road bridge. The silt-dominated river bed was considered sub-optimal for larval lamprey although a single ammocoete was recorded. European eel habitat was good overall given deep glide and pool with scoured/undercut banks and macrophyte refugia.

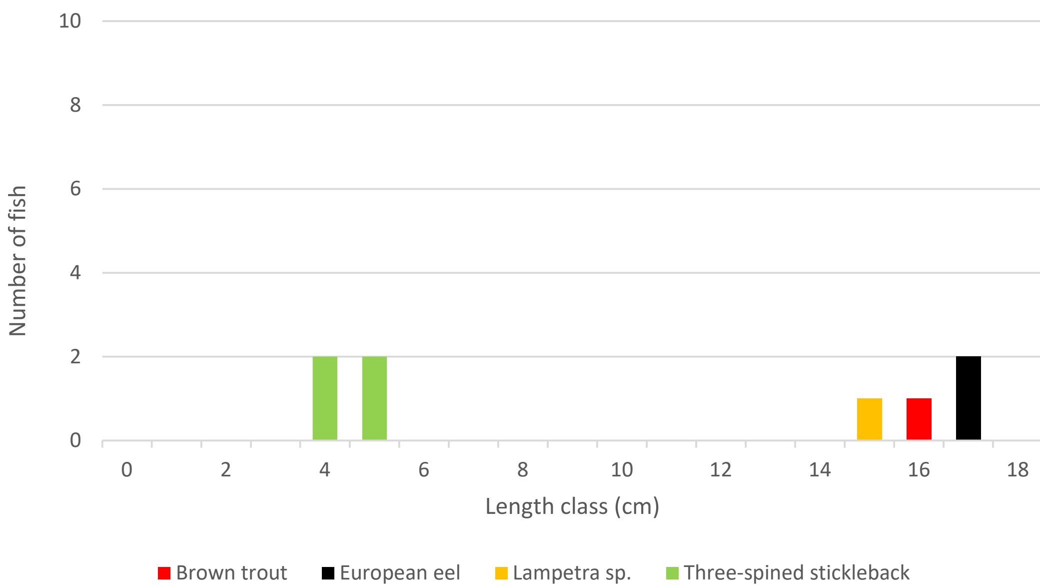

Figure 3.7 Fish stock length distribution recorded via electro-fishing at site B5 on the Oakfront River, September 2020.

Plate 3.7 A single, particularly large *Lampetra* sp. ammocoete (likely brook lamprey due to size) recorded from site B5 on the Oakfront River, September 2020.

3.1.9 Site C1 – Rathnacally Stream, Clashganniv

No fish were recorded via electro-fishing at site C1 on the upper reaches of the Rathnacally River. The small drainage channel site (FW4) had been historically straightened and deepened. The site featured pools of stagnant water (0.2m deep max.) at the time of survey (no observable flow) and was not considered to be of fisheries value. Whist localised ponding of water was present the channel showed evidence of seasonal drying and was, therefore, not capable of supporting resident fish. Fisheries potential improved further downstream.

Plate 3.8 Representative image of site C1 on the Rathnacally Stream (stagnant water, no fish recorded via electro-fishing).

3.1.10 Site C2 – Rathnacally Stream, bridge at Rathnacally

Three spined stickleback were the only fish species recorded via electro-fishing at site C2 on the Rathnacally Stream, located approx. 1.2km downstream of site C1. The heavily-silted and modified site supported low numbers of both juveniles and adults (total *n*=11).

The slow-flowing site was considered too heavily modified to support a healthy fish population fish and the deep silt/clay bed was considered too compacted to support lamprey ammocoetes. Adjoining diffuse sources of pollution were evidently contributing to enrichment and very heavy siltation. These pressures also removed the potential for the stream to support salmonids, which were absent during the survey at this location. Furthermore, no European eel were recorded. Small numbers of stickleback were recorded from marginal macrophyte beds.

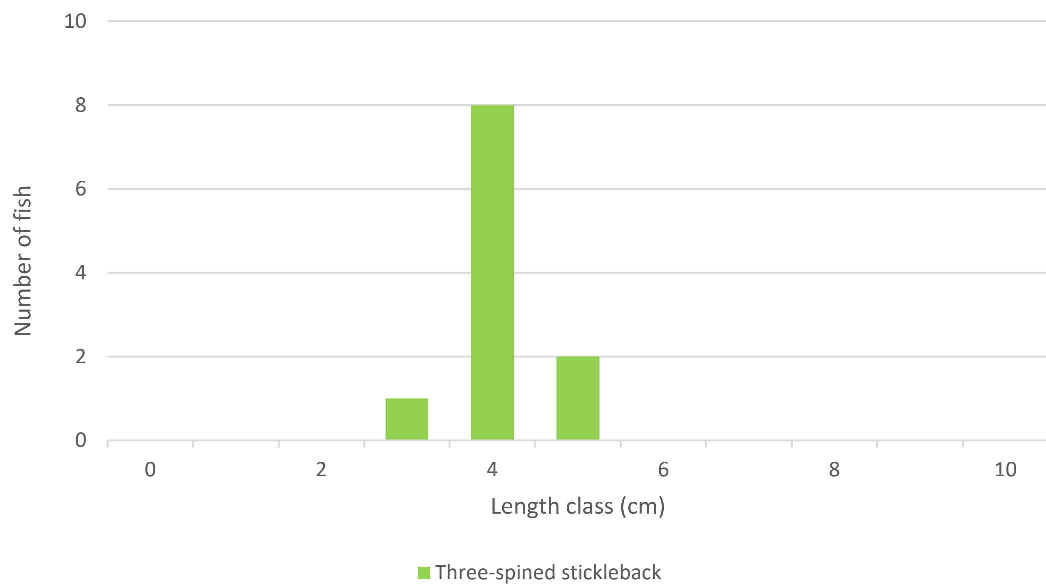

Figure 3.8 Fish stock length distribution recorded via electro-fishing at site C2 on the Rathncacally Stream, September 2020.

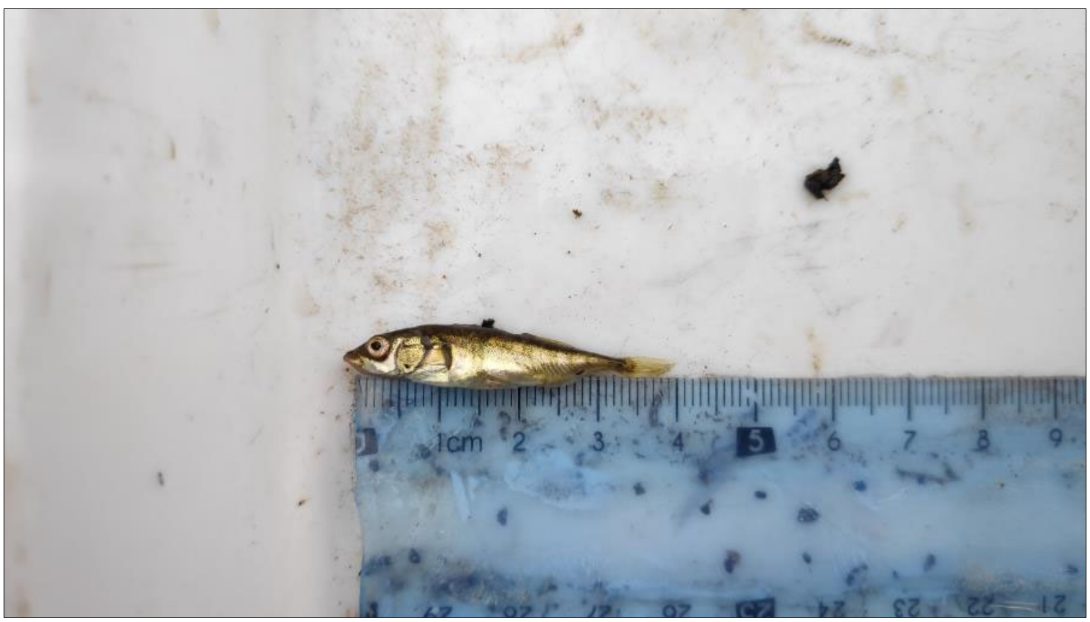

Plate 3.9 Representative image of three-spined stickleback recorded from site C2 on the Rathnacally Stream, September 2020.

3.1.11 Site C3 – Rathnacally Stream, bridge at Ballynadrideen

A total of two fish species were recorded from site C3 on the Rathnacally Stream, located at the boundary of the Blackwater River SAC site, approx. 1.5km downstream from site C2 (**Figure 3.9**). The overall density of fish was low, with three-spined stickleback dominating (*n*=20). A single European eel was also captured. Despite some habitat suitability, no *Lampetra* sp. ammocoetes were recorded.

The slow-flowing site had been extensively straightened historically and was considered too heavily modified to support a healthy fish population fish. Salmonids were absent, despite some superficial suitability (riffle, glide and pool habitat). Evidently, siltation and water quality pressures had impacted the stream's ability to support salmonids (as per upstream). The deep silt/clay bed was considered too compacted to support lamprey ammocoetes, with none recorded. Suitability for European eel was moderate overall (deep glide and instream refugia present), although only a single juvenile was captured.

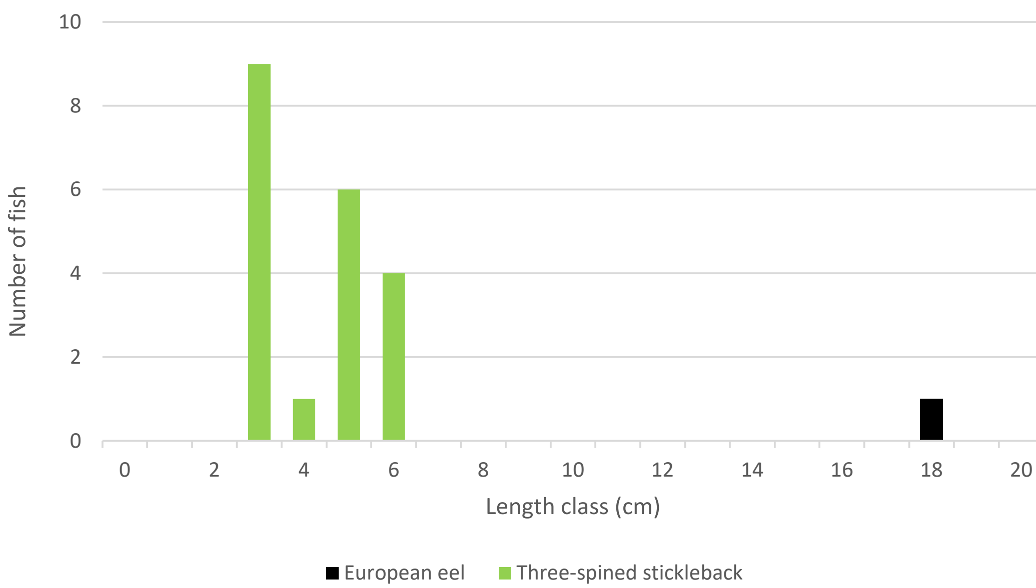

Figure 3.9 Fish stock length distribution recorded via electro-fishing at site C3 on the Rathncacally Stream, September 2020.

Plate 3.10 Juvenile European eel recorded from site C3 on the Rathnacally Stream, September 2020.

Table 3.1 Fish species densities per m^2 recorded at sites in the vicinity of Annagh wind farm via electro-fishing in September 2020. Values in **bold** represent the highest densities recorded for each species, respectively. * = no. *Lampetra* sp. per m^2 of targeted habitat

Site	Watercourse	CPUE (minutes)	Approx. area fished (m^2)	Fish density (number fish per m^2)			
				Brown trout	European eel	*Lampetra* sp.	Three-spined stickleback
A1	Fiddane Stream	5	22.5	0.000	0.000	0.000	0.000
A2	Ardglass River	10	130	0.000	0.000	0.000	0.092
A3	Awbeg River	10	112.5	**0.089**	**0.036**	0.000	0.053
B1	Milltown Stream	10	127.5	0.000	0.016	0.000	0.071
B2	Oakfront River	10	225	0.004	0.022	**0.67***	**0.147**
B3	Oakfront River	10	175	0.034	0.011	**0.67***	0.120
B4	Oakfront River	10	200	0.015	0.010	0.000	0.040
B5	Oakfront River	5	82.5	0.012	0.024	0.012	0.048
C1	Rathnacally Stream	5	20	0.000	0.000	0.000	0.000
C2	Rathnacally Stream	5	45	0.000	0.000	0.000	0.244
C3	Rathnacally Stream	10	140	0.000	0.007	0.000	0.143

3.2 Fisheries habitat

3.2.1 Salmonid habitat

The quality of salmonid habitat ranged from poor to good across the survey sites (**Table 3.2**) but was significantly impacted by siltation pressures in the vicinity of the proposed wind farm. Brown trout were recorded from a total of four sites, with no Atlantic salmon recorded.

Of the *n*=11 sites, only two offered good quality salmonid habitat according to Life Cycle Unit scores. These were sites B3 and B4 on the middle reaches of the Oakfront River, where small brown trout populations were present. Sites A3, B1, B2, B5 and C3 all offered moderate quality salmonid habitat only, given high siltation rates. Sites A1, A2, C1 and C2 scored as poor according to Life Cycle Unit scores but, in reality, offered no potential for salmonids given imperceptible or low flows, heavy siltation and or evident channel seasonality.

Table 3.2 Life Cycle Unit scores for salmonid habitat at the sites surveyed in the vicinity of the proposed Annagh wind farm, September 2020 (lower scores = superior habitat).

Site no.	Salmonid habitat value	Spawning	Nursery	Holding	Total score	Salmonids recorded
A1	Poor	4	4	4	**12**	No
A2	Poor	4	4	4	**12**	No
A3	Moderate	4	3	2	**9**	Yes
B1	Moderate	3	3	4	**10**	No
B2	Moderate	3	3	3	**9**	Yes
B3	Good	3	2	3	**8**	Yes
B4	Good	2	2	3	**7**	Yes
B5	Moderate	4	4	2	**10**	No
C1	Poor	4	4	4	**12**	No
C2	Poor	4	4	4	**12**	No
C3	Moderate	4	3	3	**10**	No

3.2.2 Lamprey habitat

The quality of lamprey habitat ranged from poor to good across the survey sites (**Table 3.3**) but, as with salmonid habitat, was significantly impacted by siltation pressures in the vicinity of the proposed wind farm. *Lampetra* sp. ammocoetes were recorded from a total of three sites (B2, B3 and B5), all on the Oakfront River.

Of the *n*=11 sites, only three offered good quality lamprey habitat according to Lamprey Habitat Quality Index scores. These were sites B2 and B3 on the middle reaches of the Oakfront River, where very low densities of ammocoetes were present (both 0.67 ammocoetes per m^2 of ammocoete habitat fished). Sites A3, B1, B5, C2 and C3 all offered moderate quality lamprey habitat only, primarily due to poor spawning habitat (high siltation rates) – however none of these sites were found to support lamprey. Sites A1, A2 and C1 scored as poor according to LHQI scores but, in reality, offered no potential for lamprey given imperceptible or low flows and or evident channel seasonality.

Table 3.3 Lamprey Habitat Quality Index (LHQI) scores for lamprey habitat at the sites surveyed in the vicinity of the proposed Annagh wind farm, September 2020 (lower scores = superior habitat).

Site no.	Lamprey habitat value	Spawning	Nursery	Total score	Lamprey recorded
A1	Poor	4	4	**8**	No
A2	Poor	4	4	**8**	No
A3	Moderate	4	2	**6**	No
B1	Moderate	3	3	**6**	No
B2	Good	3	2	**5**	**Yes**
B3	Good	3	2	**5**	**Yes**
B4	Good	2	3	**5**	No
B5	Moderate	4	3	**7**	**Yes**
C1	Poor	4	4	**8**	No
C2	Moderate	4	3	**7**	No
C3	Moderate	3	3	**6**	No

3.2.3 European eel habitat

European eel were recorded from a total of *n*=7 sites; A3 (Awbeg River), B1, B2, B3, B4 and B5 (Oakfront River) and C3 (Rathnacally Stream). All four survey sites on the Oakfront River supported eel, albeit in very low densities. In general, eel habitat was poor to moderate at best across the majority of survey sites, primarily due to siltation pressures, intermittent flows and sub-optimal habitat (e.g. lack of deep pool refugia, macrophyte beds etc.).

4. Discussion

4.1 Most valuable sites

4.1.1 Salmonids

In general, salmonid habitat in the vicinity of the proposed Annagh wind farm was poor due to historical drainage pressures, low or intermittent/seasonal flows and often excessive siltation. Whilst some better-quality salmonid habitat was present at sites B3 and B4 on the middle reaches of the Oakfront River, this was highly localised in areas of faster flow and the small brown trout populations recorded present were evidently at risk from significant siltation and water quality pressures in the catchment. The downstream-connecting Awbeg River is known to support a healthy population of both brown trout and Atlantic salmon, at least in the middle and lower reaches of the river.

Diffuse siltation is one of the greatest threats to salmonid populations, particularly in agricultural catchments such as that of the proposed Annagh wind farm. Sediment not only blocks interstitial spaces in substrata and limits oxygen supply to salmonid eggs (required for healthy embryonic project and successful hatching) but can also smother substrata, thus reducing available spawning habitat and impact macro-invertebrate communities on which salmonids feed (Soulsby et al., 2001; Walling et al., 2003; Louhi et al., 2008, 2011; Cocchiglia et al., 2012; Conroy et al., 2016; Davis et al., 2018; Kelly-Quinn et al., 2020). Sedimentation of salmonid habitat is a particular problem in Irish rivers flowing through agricultural catchments (Evans et al., 2006).

4.1.2 Lamprey

As with salmonid habitat, the quality of lamprey habitat was significantly impacted by siltation pressures in the vicinity of the proposed wind farm. *Lampetra* sp. ammocoetes were recorded from a total of three sites (B2, B3 and B5), all on the Oakfront River. However, these were present in very low densities (both 0.67 ammocoetes per m^2 of ammocoete habitat fished). Lamprey ammocoetes require the deposition of fine, organic rich sediment ≥5cm in depth in which to burrow and mature (Gardiner, 2003; Goodwin et al., 2008; Aronsuu & Virkkala, 2014). Whilst such habitat was widespread in the watercourses within the vicinity of the proposed wind farm, spawning habitat for adult lamprey was appreciably sparse and invariably of poor quality due to significant siltation pressures.

Owing to their relatively small morphologies, *Lampetra* species such as brook lamprey require clean, fine gravels in which to dig their redds (Lasne et al., 2010; Rooney et al., 2013; Dawson et al., 2015) although areas may also include fractions of sand, larger gravels, and cobble (Nika & Virbickas, 2010). Furthermore, at the beginning of dispersal, young *Lampetra* spp. larvae appear to favour and burrow in fine gravel substrata soon after hatching, until they are better able to burrow in soft sediment (Aronsu & Virkkala, 2014).

Larval lamprey distribution and settlement is passive and entirely regulated by local, dynamic hydrographical (flow) regimes (Hardisty & Potter 1971; Potter, 1980; King & Kelly, 2001). Thus, a paucity of suitable spawning sites (i.e. sources of larvae) can often counteract the presence of even widespread ammocoete burial habitat (i.e. soft sediment) and limit the success of local populations. This was exemplified at surveys sites on the Awbeg River (A3), Milltown Stream (B1), Rathnacally Stream (C2 and C3) and Oakfront River (B5), where, despite a presence of suitable ammocoete habitat none were recorded, presumably due to spawning habitat pressures within these watercourses.

4.1.3 European eel

On both a global and Irish scale, the European eel is listed as 'critically endangered' (Pike et al., 2020; King et al., 2011). European eel were recorded from a total of *n*=7 sites; A3 (Awbeg River), B1, B2, B3, B4 and B5 (Oakfront River) and C3 (Rathnacally Stream). All four survey sites on the Oakfront River supported eel, albeit in very low densities. In keeping with impacts to general fisheries habitat across the survey area, the quality of European eel habitat was also compromised primarily due to siltation pressures but also intermittent flows and sub-optimal habitat (e.g. lack of deep pool refugia, macrophyte beds etc. required as diurnal refugia; Laffaile et al., 2003). Nonetheless, even smaller channels with poor or little fisheries value overall can offer potential as European eel migratory pathways provided they maintain downstream connectivity to larger channels. (e.g. adult migration seawards, usually from September/October onwards).

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10. Appendix B – freshwater pearl mussel survey report

Please see accompanying fisheries assessment report

Freshwater pearl mussel (*Margaritifera margaritifera*) survey for Annagh wind farm, Co. Cork

Triturus

Prepared by Triturus Environmental Ltd. for Fehily Timoney & Company

October 2021

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Table of contents

1. Introduction

1.1 Background

Triturus Environmental Ltd. were contracted by Fehily Timoney & Company to undertake a baseline freshwater pearl mussel (*Margaritifera margaritifera*) survey of the watercourses in the vicinity of the proposed Annagh wind farm, located near Charleville, Co. Cork (**Figure 2.1, Table 2.1**).

The survey was undertaken in September 2020 to establish the presence/absence of freshwater pearl mussel in the vicinity of the proposed wind farm, thus informing impact assessment and mitigation for the project. The watercourses in vicinity of the project included the Awbeg River and numerous tributaries within the Awbeg [Buttevant]_SC_010 river sub-catchment, itself present within the wider Munster Blackwater catchment. The survey area overlapped with the Munster Blackwater *Margaritifera* sensitive area.

In the vicinity of the wind farm site, the Ardglass River (18A23), Milltown Stream (18M57), Oakfront River (18O02) and Rathnacally Stream (18R32) all shared downstream hydrological connectivity with the Blackwater River SAC (site code: 002170), to the south of the survey area. Freshwater pearl mussel are listed as a qualifying interest for this European site (NPWS, 2012) although it is the populations within the Allow, Licky and Munster Blackwater river sub-basins which are responsible for this designation (DEHLG, 2010) (i.e. not the Awbeg River).

1.2 Conservation status of freshwater pearl mussel in Ireland

The freshwater pearl mussel (*Margaritifera margaritifera*) is listed on the IUCN Invertebrate Red Data List as an 'endangered species' (Moorkens et al., 2018) according to the most recent status classification. It is also protected under the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention). Pearl mussel are protected by law in Ireland under the Wildlife Acts 1976 to 2018 (S.I. 112, 1990) and the species is listed on Annex II and Annex V of the EU Habitats Directive (92/43/EEC).

Three Article 17 reports have been prepared for pearl mussel (to report on national status as part of the requirements of the Habitats Directive) with the overall conservation status being considered as 'Bad' on three occasions (NPWS, 2008, 2013, 2019). During 2009, The European Communities Environmental Objectives (Freshwater Pearl Mussel) Regulations S.I. No. 296/2009 were created to establish environmental quality objectives for SAC pearl mussel populations, including the preparation of sub-basin management plans. These regulations set out conservation targets for pearl mussel, as shown in **Table 1.1** below.

1.3 Status of freshwater pearl mussel in the Munster Blackwater catchment

The Munster Blackwater catchment is the largest pearl mussel catchment encompassing over 2300km^2 in County Cork (SWRBD). The current conservation status of the pearl mussel population within the Blackwater River SAC is assessed as 'unfavourable', with numerous significant pressures to pearl mussel populations identified, including erosion, diffuse nutrient enrichment, field drainage and fish migration barriers. However, siltation is the greatest pressure within the catchment (Igoe & Murphy, 2015; DEHLG, 2010).

Whilst pearl mussels still may be relatively widespread in the Blackwater catchment, and there are still small localised areas with moderately high densities, the numbers have declined, and the population is composed entirely of aged adults with no evidence of recruitment for a considerable time (i.e. 20-30 years) (DEHLG, 2010). Regarding the population size of the catchment, the same document stated that, "*While it is likely to be considerably less than 10,000, it may even be reduced to the 100's. The prognosis for the population is very poor. Any measures towards the rehabilitation of juvenile mussel conditions are likely to be slow to achieve…*".

Table 1.1 Targets for sustainable pearl mussel population structure under the European Communities Environmental Objectives (Freshwater Pearl Mussel) Regulations 2009

Criterion	Target to pass	Notes
Numbers of live adults	No recent decline	Based on comparative results from the most recent surveys
Numbers of dead shells	<1% of population and scattered distribution	1% considered to be indicative of natural losses
Mussels shell length ≤65mm	At least 20% of populations ≤65mm in length	Field survey of 0.5 x 0.5 m quadrats must be carried out in suitable habitat areas for juveniles
Mussels shell length ≤30mm	At least 5% of populations ≤30mm in length	Field survey of 0.5 x 0.5m quadrats must be carried out in suitable habitat areas for juveniles

2. Methodology

2.1 Desktop review

A desktop survey of available pearl mussel data for the survey area and wider River Blackwater catchment was undertaken. This included a National Parks & Wildlife Service (NPWS) sensitive species data request for the Awbeg River and tributaries in the in vicinity of the proposed Annagh wind farm (issued January 20th 2021, received January 26th 2021). This helped to establish the presence of the nearest downstream mussel populations from the proposed project.

2.2 Freshwater pearl mussel surveys

The pearl mussel surveys were carried out on Tuesday 22nd September 2020 in bright weather, with good underwater visibility and under base flow conditions. This helped to maximise visibility of pearl mussel against dark substrata and also helped increase chances of detection when mussels are filtering in brighter conditions. The visual pearl mussel survey (stage 1 and stage 2) was carried out under Section 23 & 34 of the Wildlife Acts 1976 to 2018, licence number C201/2020, issued by the National Parks and Wildlife Service (NPWS) on the 15th September 2020. The survey methodology used was in accordance with the Stage 1 and 2 guidelines given by the NPWS in the Irish Wildlife Manual No. 12 (Anon., 2004) (guidelines currently being updated but unpublished at the time of survey). The surveys were also cognisant of the latest European-wide guidance for freshwater pearl mussel survey methodology (e.g. CEN, 2017; Boon et al., 2019).

Stage 1 presence-absence surveys were undertaken at a total of *n*=14 sites across the Ardglass River, Oakfront River, Rathnacally Stream and Awbeg River (**Table 2.1, Figure 2.1**) through a combination of bathyscope surveying and snorkelling techniques, dependant on local water depths and flow regimes. To maximise detection rates and efficiency, two operators worked in tandem, with one surveyor in-stream and one bank manager to collate data. As per best practice, surveys began downstream and worked upstream at each site to avoid silt and debris blocking the view of pearl mussels and to avoid damage to pearl mussels by trampling (i.e. because of better visibility). Notes were also taken on the aquatic habitat conditions and suitability for freshwater pearl mussels at each site, based on the criteria of Hastie et al. (2000) and Skinner et al. (2003).

2.3 Biosecurity

A strict biosecurity protocol following the Check-Clean-Dry approach was employed during the survey. Equipment and PPE used was disinfected with Virkon® between survey sites to prevent the transfer of pathogens and/or invasive species between survey areas. As per best practice, surveys were undertaken at sites in a downstream order (i.e. uppermost site surveyed first etc.) to prevent the upstream mobilisation of invasive propagules and pathogens.

Table 2.1 Location of the *n*=14 freshwater pearl mussel survey sites in the vicinity of Annagh wind farm, Co. Cork.

Site no.	Watercourse	EPA code	Location	X (ITM)	Y (ITM)
Ar1	Ardglass River	18A23	Annagh Bogs	549606	616770
O1	Oakfront River	18O02	Cooliney Bridge	550181	618654
O2	Oakfront River	18O02	Annagh North	550775	617421
O3	Oakfront River	18O02	Bridge at Coolcaum	551050	616256
O4	Oakfront River	18O02	0.5km d/s bridge at Coolcaum	551075	615737
A1	Awbeg River	18A09	Annagh Bridge	549823	615649
A2	Awbeg River	18A09	d/s Oakfront confluence	550751	614883
A3	Awbeg River	18A09	Scart Bridge	552200	615051
A4	Awbeg River (east branch)	18A08	Bridge at Caherconnor	552453	615374
A5	Awbeg River (east branch)	18A08	u/s Scart Bridge	552222	615075
A6	Awbeg River	18A09	L1320 road bridge	552780	614388
R1	Rathnacally Stream	18R32	Bridge at Rathnacally	552633	619468
R2	Rathnacally Stream	18R32	Ballnadrideen	552222	618157
R3	Rathnacally Stream	18R32	Awbeg River (east branch) confluence	552428	616052

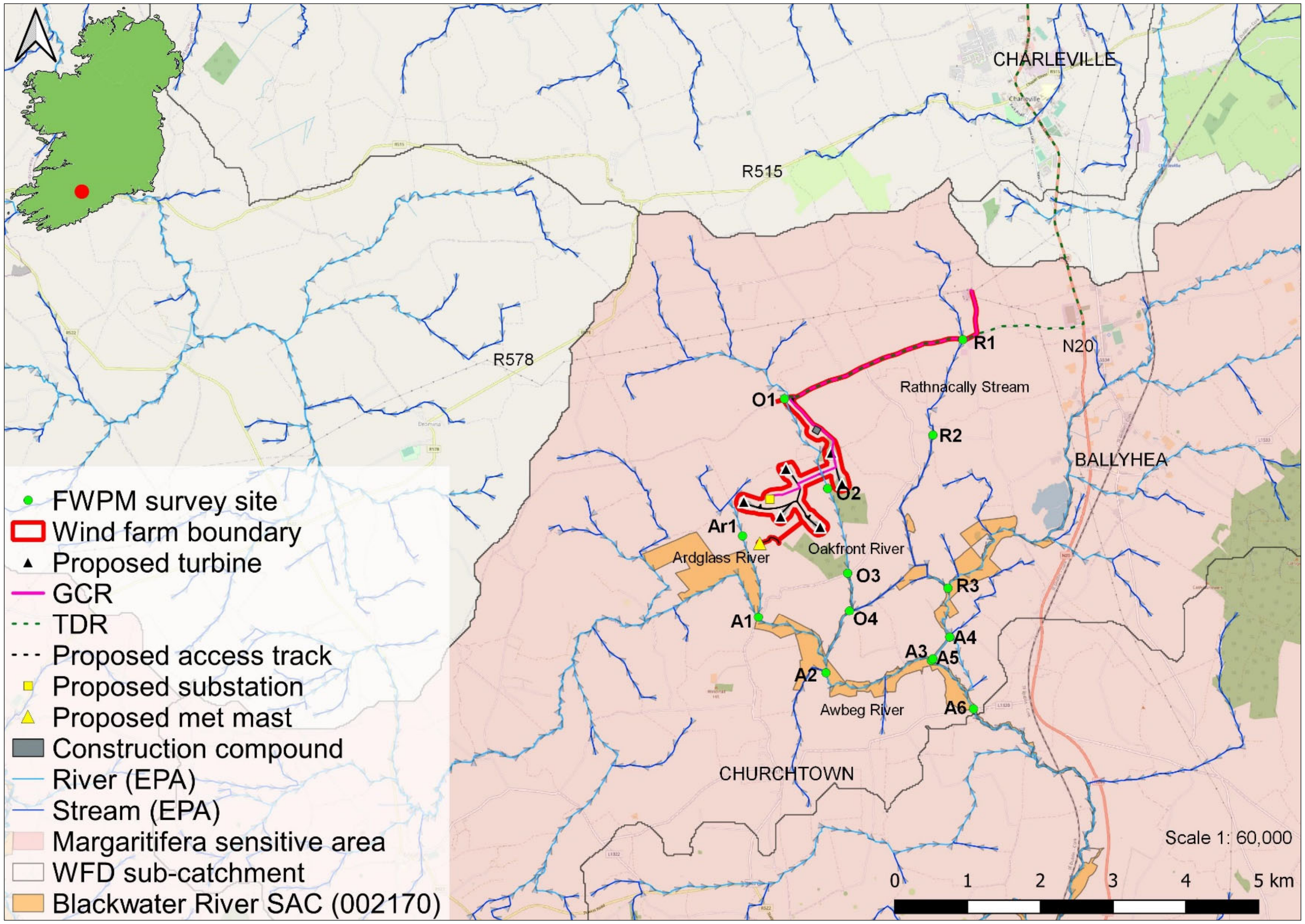

Figure 2.1 Overview of the proposed freshwater pearl mussel survey sites in the vicinity of Annagh wind farm near Charleville, Co. Cork.

3. Results

Freshwater pearl mussel surveys were undertaken on Tuesday 22nd September 2020. The results of the surveys are presented below in terms of the number of mussels recorded (live or dead), number of shells and overall pearl mussel suitability as well as general observations on the ecology of each site. The survey sites are summarised per river below and in more detail in **Appendix A**. Scientific names are provided at first mention only.

3.1 Desktop review

A desktop review revealed no known historical or contemporary freshwater pearl mussel records in the Ardglass River, Oakfront River, Rathnacally Stream or Awbeg River in the vicinity of the proposed Annagh wind farm project (NPWS sensitive species data request).

All survey areas shared downstream hydrological connectivity with or were located within the Blackwater River SAC (site code: 002170). Freshwater pearl mussel are listed as a qualifying interest for this European site (NPWS, 2012) although it is the populations within the Allow, Licky and Munster Blackwater river sub-basins which are responsible for this designation (DEHLG, 2010) (i.e. not the Awbeg River or vicinity of the proposed wind farm).

3.2 Site descriptions & pearl mussel habitat

3.2.1 Ardglass River (site Ar1)

No live or dead freshwater pearl mussels were recorded via bathyscope survey or snorkelling at site Ar1 on the Ardglass River (**Figure 3.1**). The Ardglass River flowed through an intensive agricultural landscape (improved grassland) and was heavily modified throughout its course (i.e. historically straightened and deepened). The small river represented a drainage channel habitat throughout its length. Arterial drainage had resulted in a narrow channel with very poor hydromorphology, low flows, high instream macrophyte coverage (often approaching 90%) and high levels of siltation. As such, there was no suitability for freshwater pearl mussel.

3.2.2 Oakfront River (sites O1, O2, O3 & O4)

No live or dead freshwater pearl mussels were recorded at a total of *n*=4 sites along the Oakfront River via bathyscope survey or snorkelling (**Figure 3.1**). The river flowed through an intensive agricultural landscape (improved grassland) and was heavily modified throughout its course (i.e. historically straightened and deepened). Arterial drainage had resulted in a channel with very poor hydromorphology and high levels of siltation (particularly excessive in the lower reaches, e.g. site O4). Whilst some better-quality habitat was present at faster-flowing sites O1 and O2 by way of exposed cobble and gravel substrata, these were bedded, compacted and moderately to heavily silted. There was no suitability for freshwater pearl mussel throughout the Oakfront River.

Plate 3.1 The straightened, deepened and heavily-silted Ardglass River near site Ar1

Plate 3.2 The extensively straightened Oakfront River at site O1, downstream of Cooliney Bridge

Plate 3.3 The heavily modified and silted Oakfront River at site O3, located upstream of the Blackwater River SAC boundary

Plate 3.4 The heavily modified and silted Oakfront River at site O4, upstream of the Blackwater River SAC boundary

3.2.3 Awbeg River (sites A1, A2, A3, A4, A5 & A6)

No live or dead freshwater pearl mussels were recorded at *n*=6 sites along the Awbeg River via bathyscope survey or snorkelling (**Figure 3.1**). Both the main (western) and eastern branch of the Awbeg flowed through an intensive agricultural landscape (improved grassland) and the channel was heavily modified throughout its course (i.e. historically straightened and deepened). Arterial drainage had resulted in a channel with poor hydromorphology, poor floodplain connectivity, often high macrophyte coverage and particularly high levels of siltation (silt deposits often >0.2m in depth). The better-quality habitat was located at sites with faster-flowing glide and or riffle areas. For example, sites A3, A4 and A5 featured frequent gravel and cobble areas as opposed to the deep (>0.3m) silt deposits present at site A1 and A2. However, these harder substrata were partially bedded and moderately silted, thus reducing any potential for freshwater pearl mussel. The lowermost site A6, located at the L1320 road bridge, featured the best instream recovery (from arterial drainage) with superior hydromorphology, unbedded gravel and cobble substrata and lower rates of silt deposition. However, as per upstream sites, the river was evidently impacted by enrichment and siltation. In summary, despite some localised habitat suitability at survey sites A4 and A6, no freshwater pearl mussel were recorded along the Awbeg River.

Plate 3.5 Representative image of the Awbeg River (left) and Oakfront River (right) near site A2, demonstrating extensive historical modification

Plate 3.6 Representative image of the Awbeg River at Scart Bridge (site A3), demonstrating historically straightened and deepened channel

Plate 3.7 Representative image of the Awbeg River eastern branch at site A4, a site with improved hydromorphology but still not supporting freshwater pearl mussel

Plate 3.8 Representative image of the Awbeg River eastern branch adjoining the main river at Scart Bridge (site A5)

Plate 3.9 The Awbeg River at the L1320 road bridge (site A6)

3.2.4 Rathnacally Stream (sites R1, R2 & R3)

No live or dead freshwater pearl mussels were recorded at a total of *n*=3 sites on the Rathnacally Stream via bathyscope survey or snorkelling. The river flowed through an intensive agricultural landscape (dominated by improved grassland) and the channel was heavily modified throughout its course (i.e. historically straightened and deepened). Arterial drainage had resulted in a channel with poor hydromorphology, often poor floodplain connectivity and high levels of siltation. Riparian shading was invariably high (tunnelling) and the stream suffered from low flows in the upper reaches. Furthermore, salmonids were not recorded present (via electro-fishing, see accompanying fisheries report), with the impacts of siltation and poor water quality evident. There was no suitability for freshwater pearl mussel throughout the Rathnacally Stream.

Plate 3.10 The Rathnacally Stream at site R1 showing modified, heavily-silted channel

Plate 3.11 The Rathnacally Stream at site R2 downstream of a local road crossing at Ballnadrideen (historically straightened, heavy siltation)

Plate 3.12 The Rathnacally Stream (right foreground) at site R3 at the Awbeg River (east branch) confluence

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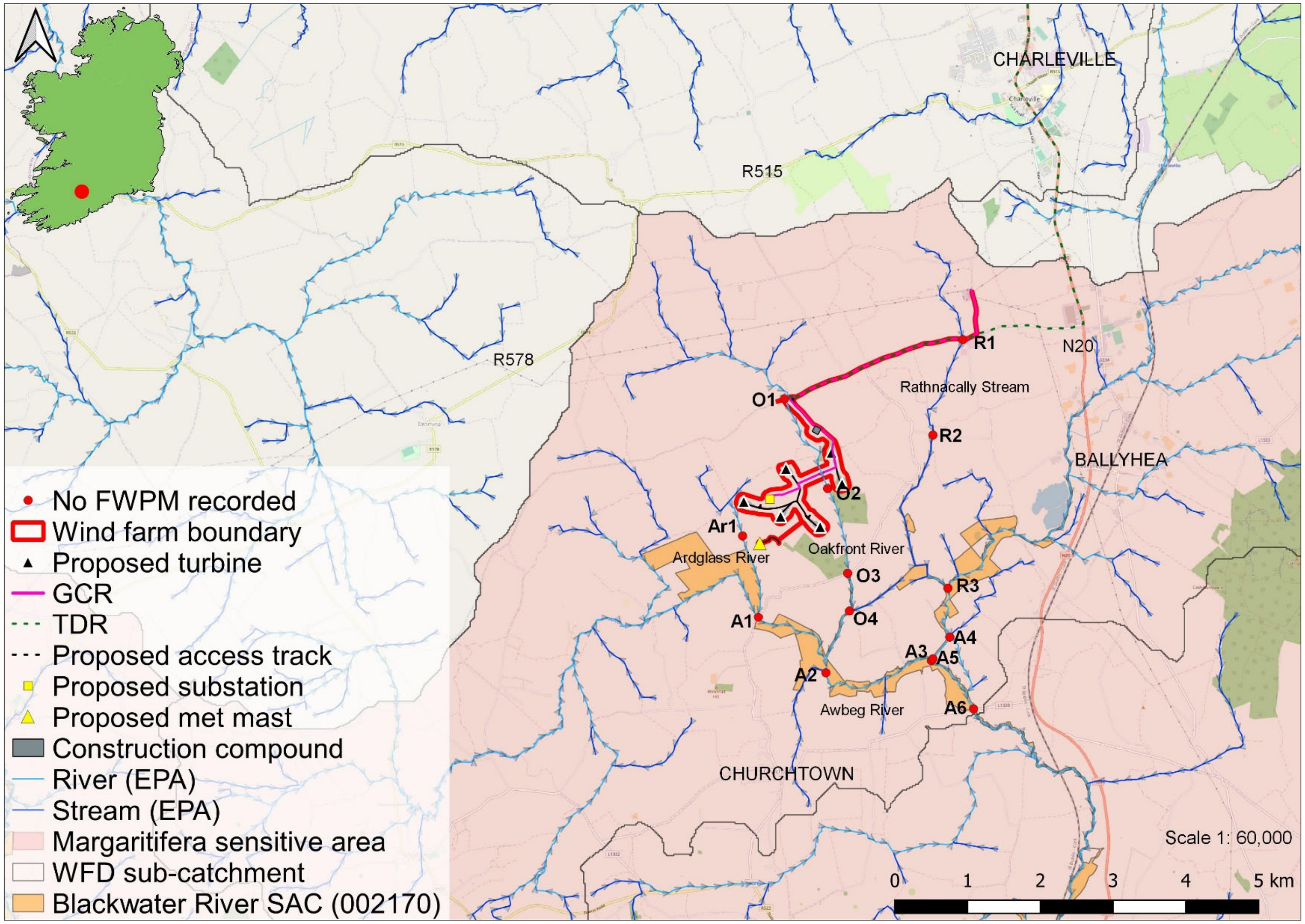

Figure 3.1 Results of freshwater pearl mussel survey in the vicinity of Annagh wind farm, September 2020

4. Discussion

Stage 1 freshwater pearl mussel surveys undertaken in September 2020 identified no freshwater pearl mussels (live or dead) on the Ardglass River, Oakfront River, Rathnacally Stream or Awbeg River in the vicinity of the proposed Annagh wind farm (**Figure 3.1**).

No historical *Margaritifera margaritifera* records were available for the survey area and the arterially-drained, historically straightened (and often deepened) survey sites were found to provide no suitability for the species. Overall, pearl mussel habitat was very poor in the agriculturally-dominated study area given high siltation levels via fine sediment deposition, bedded substrata, poor hydromorphology, seasonally low flows (affecting dissolved oxygen levels), high filamentous algal cover and or excessive macrophyte vegetation (indicating strong eutrophication). Indeed, high levels of siltation and eutrophication pressures have been identified as significant in the wider Blackwater catchment (Igoe & Murphy, 2015), leading to unfavourable conservation status within the River Blackwater SAC. Riverbed quality appears to be the most important habitat factor limiting the recruitment of the endangered freshwater pearl mussel in many European rivers (Geist & Auerswald, 2007) and the heavy siltation observed in the survey watercourses would preclude pearl mussel presence.

Furthermore, the observed poor water quality of the Ardglass River, Oakfront River, Rathnacally Stream and downstream Awbeg River channel (Q2, Q2-3 or Q3; see main EIAR report) would also preclude freshwater pearl mussel from the watercourses in the vicinity of Annagh wind farm, given that the species typically requires water quality corresponding to high ecological status (i.e. ≥Q4-5) under the Freshwater Pearl Mussel Regulations S.I. No. 296 (2009).

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6. Appendix A – survey site characteristics

Table A1 Summary characteristics of each freshwater pearl mussel survey site, September 2020

Site	Watercourse	River profile	Bordering land uses & riparian habitat	Substrata	Riverbed condition & siltation	Macrophytes & bryophytes (DAFOR)	FWPM recorded	Threats & pressures
Ar1	Ardglass River, Annagh Bogs	1.5-2m wide drainage ditch-like channel (FW4), 0.3-0.6m deep, historically straightened & deepened, steep 2m bankfull heights, imperceptible flow, high shading, high instream vegetation cover, poorly recovered riparian zone	Wet grassland (GS4), scrub (WS1), immature woodland (WS2)	100% (deep) silt	Very heavy siltation	*Phragmites australis* (A), *Lemna minuta* (F)	No	Arterial drainage (straightening and deepening), agricultural enrichment, siltation
O1	Oakfront River, Cooliney Bridge	2.5m wide, 0.2-0.3m deep, historically straightened lowland river (FW2), fast-flowing shallow glide with limited pool, steep 2m bankfull heights, low shading, low instream vegetation cover, cleared riparian zone (former treelines)	Improved agricultural grassland (GA1)	Cobble & small boulder with localised fine-medium gravels and sand/silt deposits	Bedded & compacted with low-moderate siltation	*Apium nodiflorum* (O), *Hygroamblystegium tenax* (O)	No	Arterial drainage (straightening and deepening), agricultural enrichment, siltation
O2	Oakfront River, Annagh North	2.5m wide, 0.2-0.3m deep, historically straightened lowland river (FW2), fast-flowing shallow glide with limited pool, 1- 2m bankfull heights, moderate shading, low instream vegetation cover, mature riparian zone (treelines)	Improved agricultural grassland (GA1), treelines (WL2)	Fine-medium gravels with frequent sand and occasional cobble	Partially bedded, moderate siltation	*Apium nodiflorum* (O), *Berula erecta* (R)	No	Arterial drainage (straightening and deepening), agricultural enrichment, siltation
O3	Oakfront River, bridge at Coolcaum	2-2.5m wide, 0.8-1.2m deep, historically straightened & deepened	Improved agricultural grassland (GA1),	Deep silt with very localised fine-medium	Very heavy siltation	*Callitriche stagnalis* (O), *Berula erecta* (O)	No	Arterial drainage (straightening and deepening),

Site	Watercourse	River profile	Bordering land uses & riparian habitat	Substrata	Riverbed condition & siltation	Macrophytes & bryophytes (DAFOR)	FWPM recorded	Threats & pressures
		lowland river (FW2), moderate flow, 100% deep glide, low bankfull heights (floodplain connectivity locally) but flood embankments present on west bank, low shading, moderate instream vegetation cover, little or no riparian zone (farmed to edge)	coniferous plantation (WD4)	gravels & small cobble in faster-flowing areas				agricultural enrichment, siltation
O4	Oakfront River, 0.5km d/s bridge at Coolcaum	2.5-3m wide, 0.5-1.2m deep, historically straightened & deepened lowland river (FW2), moderate flow, 100% deep glide, low bankfull heights (floodplain connectivity locally) but flood embankments present locally, low shading, moderate instream vegetation cover, little or no riparian zone (farmed to edge)	Improved agricultural grassland (GA1)	Deep silt with very localised fine-medium gravels & small cobble in faster-flowing areas	Very heavy siltation	*Sparganium erectum* (F), *Callitriche stagnalis* (O), *Berula erecta* (O), Apium nodiflorum (O), *Potamogeton perfoliatus* (R)	No	Arterial drainage (straightening and deepening), agricultural enrichment, siltation
A1	Awbeg River, Annagh Bridge	7-10m wide, 0.8-1.5m deep, historically straightened & deepened lowland river (FW2), moderate flow, 100% deep glide, low bankfull heights (floodplain connectivity locally) but flood embankments present, low shading, moderate instream	Improved agricultural grassland (GA1), scrub (WS1)	Deep silt with very localised fine-medium gravels & small cobble near bridge with occasional boulder	Very heavy siltation	*Sparganium erectum* (F), *Lemna minuta* (F), *Berula erecta* (F), *Callitriche stagnalis* (O)	No	Arterial drainage (straightening and deepening), agricultural enrichment, siltation

Site	Watercourse	River profile	Bordering land uses & riparian habitat	Substrata	Riverbed condition & siltation	Macrophytes & bryophytes (DAFOR)	FWPM recorded	Threats & pressures
		vegetation cover, little or no riparian zone (farmed to egde)						
A2	Awbeg River, d/s Oakfront River confluence	7-8m wide, 0.5-1m deep, historically straightened & deepened lowland river (FW2), moderate flow, 100% deep glide, low bankfull heights (floodplain connectivity locally) but flood embankments present, low shading, moderate instream vegetation cover, little or no riparian zone (farmed to edge)	Improved agricultural grassland (GA1), scrub (WS1)	100% deep silt	Very heavy siltation	*Sparganium erectum* (F), *Lemna minuta* (F), *Berula erecta* (F), *Callitriche stagnalis* (O)	No	Arterial drainage (straightening and deepening), agricultural enrichment, siltation
A3	Awbeg River, Scart Bridge	7-8m wide, 0.8-1.2m deep, historically straightened & deepened lowland river (FW2), moderate flow, deep glide with localised pool, 2-2.5m bankfull heights (floodplain connectivity locally) but flood embankments present, low shading, moderate instream vegetation cover, little or no riparian zone (farmed to edge)	Improved agricultural grassland (GA1), scrub (WS1)	Soft silt & sand deposits with localised compacted cobble, mixed gravels & scattered boulder	Partially bedded, heavy siltation	*Ranunculus* subsp. *Batrachion* agg. (F) *Sparganium emersum* (F), *Callitriche stagnalis* (O)	No	Arterial drainage (straightening and deepening), agricultural enrichment, siltation
A4	Awbeg River (east branch), bridge at Caherconnor	4-5m wide, 0.3-0.6m deep, fast-flowing lowland river (FW2), fast-glide & riffle dominated, historically straightened & deepened d/s of bridge	Improved agricultural grassland (GA1), scrub (WS1), treelines (WL2), buildings and	Mixed gravels & cobble with occasional boulder, localised silt & sand deposits	Partially bedded due to high flows, moderate siltation (more than expected for flow type)	*Ranunculus* subsp. *Batrachion* agg. (O), *Potamogeton perfoliatus* (R), *Oenanthe crocata* (R), *Apium nodiflorum* (R)	No	Arterial drainage (straightening and deepening), agricultural enrichment, siltation

Site	Watercourse	River profile	Bordering land uses & riparian habitat	Substrata	Riverbed condition & siltation	Macrophytes & bryophytes (DAFOR)	FWPM recorded	Threats & pressures
		but some good recovery, 1.5-2m bankfull heights, low shading, moderate instream vegetation cover, little or no riparian zone (farmed to edge)	artificial surfaces (BL3) (road)					
A5	Awbeg River (east branch), u/s Scart Bridge	4-6m wide, 0.3-0.6m deep, fast-flowing lowland river (FW2), 100% fast-glide, historically straightened & deepened, 1.5-2m bankfull heights, low shading, moderate instream vegetation cover, little or no riparian zone (farmed to edge)	Improved agricultural grassland (GA1), scrub (WS1), buildings and artificial surfaces (BL3) (road)	Mixed gravels & sand with cobble, localised silt deposits	Partially bedded due to high flows, moderate siltation (more than expected for flow type)	*Ranunculus* subsp. *Batrachion* agg. (F), *Potamogeton perfoliatus* (R), *Myriophyllum spicatum* (R)	No	Arterial drainage (straightening and deepening), agricultural enrichment, siltation
A6	Awbeg River, L1320 road bridge	10-15m wide, 0.3-0.5m deep, fast-flowing lowland river (FW2), fast-glide & riffle dominated, historically straightened & deepened, 4-5m bankfull heights, low shading, moderate instream vegetation cover, poorly recovered riparian zone	Improved agricultural grassland (GA1), scrub (WS1)	Coarse gravels and cobble with occasional boulder	Unbedded substrata (mobile), low siltation but moderate-high filamentous algal cover (30%)	*Ranunculus* subsp. *Batrachion* agg. (F), *Potamogeton perfoliatus* (O), *Myriophyllum spicatum* (O)	No	Arterial drainage (straightening and deepening), agricultural enrichment, siltation
R1	Rathnacally Stream, bridge at Rathnacally	1-1.5m wide, 0.1-0.3m deep lowland river (FW2), historically straightened & deepened, shallow glide dominated, <1m bankfull heights, high shading, low instream	Improved agricultural grassland (GA1), scrub (WS1), hedgerows (WL1), treelines (WL2)	Deep silt with high clay fraction (historically excavated to clay layer) with localised cobble and medium-coarse gravels	Bedded substrata, very heavy siltation	*Apium nodiflorum* (O), *Lemna minuta* (O)	No	Arterial drainage (straightening and deepening), agricultural enrichment, siltation, surface water run-off (cattle mart)

Site	Watercourse	River profile	Bordering land uses & riparian habitat	Substrata	Riverbed condition & siltation	Macrophytes & bryophytes (DAFOR)	FWPM recorded	Threats & pressures
		vegetation cover, mature riparian zone						
R2	Rathnacally Stream, Ballnadrideen	1.5-2m wide, 0.3-0.4m deep lowland river (FW2), historically straightened & deepened, deep glide dominated, <1m bankfull heights, high shading, low instream vegetation cover, mature riparian zone	Improved agricultural grassland (GA1), scrub (WS1), hedgerows (WL1), treelines (WL2)	Deep silt with high clay fraction (historically excavated to clay layer) with very localised cobble and mixed gravels	Bedded substrata, very heavy siltation	*Apium nodiflorum* (O), *Lemna minuta* (O)	No	Arterial drainage (straightening and deepening), agricultural enrichment, siltation
R3	Rathnacally Stream, Awbeg River (east branch) confluence	1-1.5m wide shallow, heavily-silted, slow-flowing drainage ditch-like channel adjoining Awbeg River (FW2), historically straightened & deepened, 2m bankfull heights, high shading, narrow riparian zone (often farmed to edge)	Improved agricultural grassland (GA1), scrub (WS1), hedgerows (WL1)	100% silt with mixed gravels and cobble in main river channel	Very heavy siltation in Rathnacally Stream with heavily compacted substrata in main river	*Apium nodiflorum* (O), *Lemna minuta* (O) & (main river only) *Ranunculus* subsp. *Batrachion* agg. (O), *Potamogeton perfoliatus* (O)	No	Arterial drainage (straightening and deepening), agricultural enrichment, siltation

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11. Appendix C – Q-sample results (biological water quality)

Table B1 Macro-invertebrate Q-sampling results for survey sites A2, B1, B2, B3, B5, C2 and C3, September 2020

Group	Family	Species	Site A2	Site B1	Site B2	Site B3	Site B5	Site C2	Site C3	EPA class
Trichoptera	Limnephilidae	*Limnephilus* sp.			1		2			B
Ephemeroptera	Baetidae	*Baetis rhodani*			14	9			15	C
Trichoptera	Sericostomatidae	*Sericostoma personatum*		2	4		3		4	C
Trichoptera	Philopotamidae	*Wormaldia occipitalius*		1						C
Trichoptera	Racophilidae	*Ryacophila dorsalis*			2					C
Crustacea	Gammaridae	*Gammarus duebenii*	13	21	129					C
Mollusca	Planorbidae	*Planorbis* sp.	2			1	1	3		C
Coleoptera	Hydraenidae	*Hydraena* sp.				1				C
Coleoptera	Dytiscidae	*Agabus bipustulatus*	1				1			C
Coleoptera	Elmidae	*Limnius volckmari*			14	19			7	C
Coleoptera	Elmidae	*Elmis aenea*				3			1	C
Platyhelminthes	Planorbidae	*Polycelis felina*		5	3					C
Diptera	Simulidae	*Simulium* sp.		3	10					C
Diptera	Tipulidae	*Dicranota* sp.		1		3				C
Diptera	Tipulidae	*Tipula* sp.							2	C
Crustacea	Asellidae	*Asellus aquaticus*	26				22	23		D
Mollusca	Lymnaeidae	*Radix balthica*	4				6	5		D
Diptera	Chironomidae	*Chironomus* sp.					2	17	8	E
Oligochaeta	Naididae (Tubificidae)	*Tubificid* sp.		6	12			32	13	E
Oligochaeta	Oligochaeta	Unidentified species			1			13	4	n/a
Abundance			46	39	190	36	37	93	54	
Taxon richness			5	7	10	5	7	8	9	
Q-rating			Q2-3	Q3	Q3	Q2-3	Q3	Q2	Q3	
WFD status			Poor	Poor	Poor	Poor	Poor	Bad	Poor	

12. Appendix D – eDNA analysis lab report

Please see accompanying laboratory report

SureScreen Scientifics

Folio No: E9170
Report No: 1
Purchase Order: Anagh Wind Farm
Client: Triturus Environmental Limited
Contact: Ross Macklin

TECHNICAL REPORT

ANALYSIS OF ENVIRONMENTAL DNA SAMPLES FOR THE DETECTION OF CRAYFISH SPECIES AND CRAYFISH PLAGUE

SUMMARY

All organisms continuously release small amounts of environmental DNA (eDNA) into their habitat. By collecting and analysing this eDNA from water samples from lakes, ponds or rivers we can detect the presence or absence of crayfish species including: the white-clawed crayfish (Austropotamobius pallipes), signal crayfish (*Pacifastacus leniusculus*), the marbled crayfish (*Procambarus virginalis*) and the crayfish plague (*Aphanomyces astaci*).

RESULTS

Date sample received at Laboratory: 06/04/2021
Date Reported: 15/04/2021
Matters Affecting Results: None

Lab Sample ID.	Site Name	O/S Reference	Species	Result	SIC	DC	IC	Positive Replicates
C0269	ANNAGH WIND FARM 2	-	*White-Clawed Crayfish*	Positive	Pass	Pass	Pass	10
			Crayfish Plague	Negative	Pass	Pass	Pass	0
C0277	ANNAGH WIND FARM 1	-	*White-Clawed Crayfish*	Positive	Pass	Pass	Pass	2
			Crayfish Plague	Negative	Pass	Pass	Pass	0

If you have any questions regarding results, please contact us: ForensicEcology@surescreen.com

Reported by: Chris Troth **Approved by:** Chris Troth

METHODOLOGY

The analysis is conducted in two phases. The sample first goes through an extraction process where the filter is incubated in order to obtain any DNA within the sample. The extracted sample is then tested via real time PCR (also called q-PCR) for each of the selected target species. This process uses species-specific molecular markers (known as primers) to amplify a select part of the DNA, allowing it to be detected and measured in 'real time' as the analytical process develops. qPCR combines amplification and detection of target DNA into a single step. With qPCR, fluorescent dyes specific to the target sequence are used to label targeted PCR products during thermal cycling. The accumulation of fluorescent signals during this reaction is measured for fast and objective data analysis. The primers used in this process are specific to a part of mitochondrial DNA only found in each individual species. Separate primers are used for each of the species: white-clawed crayfish, signal crayfish and crayfish plague, ensuring no DNA from any other species present in the water is amplified.

Analysis of eDNA requires scrupulous attention to detail to prevent risk of contamination. True positive controls, negative controls and spiked synthetic DNA are included in every analysis and these have to be correct before any result is declared and reported. Stages of the DNA analysis are also conducted in different buildings at our premises for added security. These methods have been extensively tested since 2015 in a number of different environments, habitats, conditions and ecological situations in order to successfully enable the full application of eDNA for the detection of crayfish species and the crayfish plague.

RESULTS INTERPRETATION

SIC: **Sample Integrity Check** [Pass/Fail]
When samples are received in the laboratory, they are inspected for any tube leakage, suitability of sample (not too much mud or weed etc.) and absence of any factors that could potentially lead to inconclusive results.

DC: **Degradation Check** [Pass/Fail]
Analysis of the spiked DNA marker to see if there has been degradation of the kit or sample, between the date it was made to the date of analysis. Degradation of the spiked DNA marker may indicate a risk of false negative results.

IC: **Inhibition Check** [Pass/Fail]
The presence of inhibitors within a sample are assessed using a DNA marker. If inhibition is detected, samples are purified and re-analysed. Inhibitors cannot always be removed, if the inhibition check fails, the sample should be re-collected.

Result: **Presence of eDNA** [Positive/Negative/Inconclusive]
Positive: DNA was identified within the sample, indicative of species presence within the sampling location at the time the sample was taken or within the recent past at the sampling location.
Positive Replicates: Number of positive qPCR replicates out of a series of 12. If one or more of these are found to be positive the pond is declared positive for species presence. It may be assumed that small fractions of positive analyses suggest low level presence, but this cannot currently be used for population studies. In accordance with Natural England protocol, even a score of 1/12 is declared positive. 0/12 indicates negative species presence.
Negative: eDNA was not detected or is below the threshold detection level and the test result should be considered as evidence of species absence, however, does not exclude the potential for species presence below the limit of detection.
Inconclusive: Controls indicate inhibition or degradation of the sample, resulting in the inability to provide conclusive evidence for species presence or absence.

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FEHILY TIMONEY

CONSULTANTS IN ENGINEERING, ENVIRONMENTAL SCIENCE & PLANNING

APPENDIX 8.6

Invasive Species Management Plan

FEHILY TIMONEY

CONSULTANTS IN ENGINEERING, ENVIRONMENTAL SCIENCE & PLANNING

ANNAGH WIND FARM, CO, CORK

INVASIVE SPECIES MANAGEMENT PLAN

Prepared for: EMPower Ltd.

Date: November 2021

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF PLATES

1. INTRODUCTION

1.1 Introduction

Annagh Wind Farm Limited, a subsidiary of EMP Energy Limited (EMPower) intends to apply to Cork County Council for planning permission to construct the proposed Annagh Wind Farm, near Charleville, County Cork. The proposed development for which consent is being sought is as follows:

- Construction of 6 no. wind turbines with a blade tip height of 175m, rotor diameter of 150m and a hub height of 100m;
- Construction of turbine foundations and crane pad hardstanding areas;
- Construction of new site tracks and associated drainage infrastructure;
- Upgrading of existing tracks and associated drainage infrastructure where necessary;
- Upgrade of entrance onto Local Road L1322;
- All associated drainage and sediment control including the installation of new watercourse or drain crossings and the re-use or upgrading of existing internal watercourse and drain crossings;
- Construction of 1 no. permanent onsite 38kV electrical substation to ESBN specifications including:
    - Control building with welfare facilities;
    - Electrical infrastructure;
    - Parking;
    - Wastewater holding tank;
    - Rainwater harvesting;
    - Security fencing;
    - All associated infrastructure, services and site works.
- 1 no. temporary construction site compound and associated ancillary infrastructure including parking;
- Tree felling to facilitate construction and operation of the proposed development;
- Installation of medium voltage (20/33kV) and communication underground cabling between the proposed turbines and the proposed on-site substation and associated ancillary works;
- Erection of 1 no. permanent meteorological mast with a height of 100m above ground level and associated access track;
- Installation of medium voltage (up to 38kV) underground cabling between the proposed on-site substation and the existing Charleville substation and associated ancillary works. The proposed grid connection cable works will include 2 no. watercourse crossings and the installation of 8 no. pre-cast joint bays;
- All associated site development works;
- A 10 year planning permission and 35 year operational life from the date of commissioning of the entire wind farm.

Large components associated with the wind farm construction will be transported to site via the identified turbine delivery route (TDR). It is proposed that turbine deliveries shall approach the site from the North via Foynes Port, the N69, the N18, the M20, the N20 and L1322. Temporary accommodating works will be required at selected locations along the TDR to facilitate the delivery of large components to the site.

These temporary accommodating works (referred to as TDR Nodes) will be the subject of subsequent consent process outside of the current application. No other works along the TDR outside of the TDR Node locations are required.

The above can be summarised into three elements as follows:

- The Wind Farm Site: The proposed wind farm site includes lands in the townlands of Annagh North, Coolcaum, Cooliney and Fiddane County Cork. The site is accessed from the L1322 local road, which meets the N20 at Ballyhea, approximately 4km to the east of the proposed site entrance.
- The Grid Connection Route (GCR): It is proposed to supply the power from Annagh Wind Farm to the Irish electricity network via an underground 38kV cable to the existing Charleville 110kV Substation. The GCR passes through the townlands of Cooliney, Rathnacally, Farranshonikeen, Ardnageehy and Clashganniv. The proposed grid connection will travel along the L1322 upon leaving the wind farm site and terminate at Charleville 110 kV substation in the townland of Rathnacally, County Cork.
- The Turbine Delivery Route (TDR): The proposed Turbine Delivery Route passes through the townlands of Ballyhay, Clashganniv, Ardnageehy, Farranshonikeen, Rathnacally and Cooliney , Rathnacally, Farranshonikeen, Ardnageehy, Clashganniv, and Ballyhay after leaving the N20 at Ballyhay. Prior to this the TDR traverses the N69, M20, and N20 after exiting the Port of Foynes, County Limerick.

The information in this Invasive Species Management Plan has been compiled by Fehily Timoney & Company (FT), on behalf of the applicant. It provides information on the control of invasive species during construction works and maintenance associated with the proposed development as described above.

1.2 Legislation

In Ireland, it is an offence to spread and propagate species listed in the third schedule of S.I. No. 477/2011 European Communities (Birds and Natural Habitats) Regulations 2011 to 2021. Under Regulation 49 paragraph (2) "*Save in accordance with a licence granted under paragraph (7), any person who plants, disperses, allows or causes to disperse, spreads or otherwise causes to grow in any place specified in relation to such plant in the third column of Part 1 of the Third Schedule, any plant which is included in Part 1 of the Third Schedule, shall be guilty of an offence*".

Additionally, Article 52(7) of the Wildlife Act, 1976 (as amended) states that '*Any person who— [...] plants or otherwise causes to grow in a wild state in any place in the State any species of flora, or the flowers, roots, seeds or spores of flora, ['refers only to exotic ISMP species thereof'][...] otherwise than under and in accordance with a licence granted in that behalf by the Minister shall be guilty of an offence.'*

In keeping with these pieces of legislation, the overall aim of this management plan is to put in place systems to control the spread of invasive species during construction and operation of the proposed development.

This document provides background information on the non-native invasive species present, mapping of their location, and their extent within the proposed development. It provides a legal context, sources of information including policy and guidelines to which cognisance has been paid, and the means of controlling the species safely using prevention, containment, treatment, monitoring, follow up treatment, record keeping and appropriate disposal as might be necessary.

1.3 Non-Native Invasive Species

The National Biodiversity Data Centre (Invasive Alien Species in Ireland) has published a Catalogue of Ireland's Non-native Species (CINS)[1] which provides species profiles, species distribution, identification keys, ecology, pathways of introduction, and risk assessment score. This Catalogue includes the 66 regulated Invasive Alien Species of Union concern identified in '*Regulation on the prevention and management of the introduction and spread of invasive alien species [1143/2014]*', as well as the 48 non-native High Impact[2] species and 78 Medium Impact[3] species in Ireland as identified in the national Prioritisation Risk Assessment carried out in 2013. Also included are the Watch List[4] species which are species with potential to become invasive (at a high risk level) if introduced to Ireland.

In 2014 a second detailed assessment of the risks and uncertainties surrounding a particular species, group of species or pathway of concern was carried out, called the '*Non-native species APplication based Risk Analysis (NAPRA)*'. Not all non-native species present in Ireland were included in the risk assessment. The list of species for which the risk assessments were conducted are available online at http://nonnativespecies.ie/species-list/.

For clarity, the non-native invasive species considered for inclusion in this management plan are those listed in Ireland's Catalogue of Non-native Species and those subject to risk assessment in 2014.

[1] https://species.biodiversityireland.ie/?keyword=Catalogue%2520of%2520Irelands%2520Non-native%2520Species

[2] https://www.biodiversityireland.ie/wordpress/wp-content/uploads/Invasives_taggedlist_HighImpact_2013RA-1.pdf

[3] https://www.biodiversityireland.ie/wordpress/wp-content/uploads/Invasives_taggedMediumImpact_2013RA-2.pdf

[4] https://www.biodiversityireland.ie/wordpress/wp-content/uploads/Invasives_tagged_PotentialHighmpact_2013RA-1.pdf

2. METHODOLOGY

2.1 Relevant Guidance

This management plan has been devised in consideration of the following relevant guidance:

- Ireland's Invasive Species Website: https://invasives.ie/
- NRA, (2010). Guidelines on the Management of Noxious Weeds and Non-Native Invasive Plant Species on National Roads. Revision 1, December 2010. National Roads Authority
- IW-AMP-SOP-009 Information and Guidance Document on Japanese knotweed
- O'Flynn, C., Kelly, J. and Lysaght, L. (2014). Ireland's invasive and non-native species – trends in introductions. National Biodiversity Data Centre Series No. 2. Ireland
- Tu, M., (2009). Assessing and Managing Species within Protected Areas. Protected Area Quick Guide Series. Editor J., Ervin, Arlington, VA. The Nature Conservancy, 40 pp.
- Stokes et al., (2004). Invasive Species in Ireland. Unpublished report to Environment and Heritage Service and National Parks and Wildlife Service. Quercus, Queens University Belfast, Belfast.
- Circular Letter NPWS 2/08 Use of Herbicide Spray on Vegetated Road Verges (National Parks and Wildlife Service 2008)

2.2 Desktop Study

A desktop study was carried out to identify existing records of invasive flora species both within and adjacent to the proposed development. The suitability of the habitats within the proposed development footprint were also considered in determining the potential for invasive species, having regard to the species profiles and ecology set out in the Catalogue of Ireland's Non-native Species. The following sources of information were used:

- OSI Aerial photography and 1:50000 mapping;
- National Parks and Wildlife Service (NPWS) mapping;
- National Biodiversity Data Centre (NBDC) mapping and datasets;
- Note there are no botanical records available from the Botanical Society of Britain and Ireland 2km Grid square R51D, which encompasses the proposed wind farm development.

2.3 Mapping and Evaluation of Invasive Species

An invasive species survey of the main wind farm site was undertaken on 29th June, 2nd, 14th and 15th July 2020 by FT ecologists. A site survey along the grid connection and turbine delivery route nodes were undertaken between the 10th – 11th June 2021 (FT ecologists). The location and extent of the invasive species were recorded using a handheld GPS.

The extent of invasive species recorded within the proposed Annagh wind farm and GCR is presented in Figure 3-1The invasive species recorded at TDR Nodes are detailed in Table 3-3.

3. EXISTING ENVIRONMENT

3.1 Desktop Records

Historical records of invasive species from the relevant national datasets were assessed through the National Biodiversity Data Centre on the 26th August 2021. A total of four invasive species were identified within both 2 km and 10 km grid squares encompassing the wind farm site and the 1km grid square overlapping the grid connection (listed in Table 3-1 below):

Table 3-1: Historical invasive species records within 10km and 2km grid squares overlapping Wind Farm and 1km squares overlapping the Grid Connection Route and TDR Nodes

Species	1km (Grid Cable Route/TDR Nodes)	2km (wind farm)	10km (wind farm)	Invasive Impact	Legal Status	Recorded in study area
Cherry Laurel *Prunus laurocerasus*	R5219 (GCR) (Nodes 10.5 – 10.7)	-	R51	High Risk	None	Planted along northern boundary of study area.
Japanese Knotweed *Fallopia japonica*	None (GCR)	-	R41	High Risk	Third Schedule	No
Sycamore *Acer pseudoplatanus*	R5219 (GCR) (Nodes 10.5 – 10.7)	-	R41, R51	Medium Risk	None	Present in some treelines in northern part of study area.
Russian-vine *Fallopia baldschuanica*	None (GCR)	-	R51	Medium Risk	None	No
Winter Heliotrope *Petasites fragrans*	R5053 (Node 4)	-	-	Low Risk	None	No
Canadian Waterweed *Elodea canadensis*	R5455 (Nodes 5 & 6)	-	-	High Risk	Third Schedule	No
Giant Hogweed *Heracleum mantegazzianum*	R5238 (Node 8)	-	-	High Risk	Third Schedule	No

3.2 Results of Field Survey and Mapping

The field survey detected 13 non-native invasive species during surveys of the proposed Annagh wind farm, GCR, and TDR. Within these, a total of nine have had their invasiveness risk evaluated, while a further four have not been formally assessed in terms of invasiveness (NBDC, 2021). One of the species recorded is Third Schedule listed (Spanish Bluebell).

The non-native species recorded at the wind farm site, GCR and TDR Nodes are listed below in Table 3-2, while specific results for TDR Nodes are detailed in Table 3-3.

The location of invasive/non-native species recorded at the wind farm site and along the GCR are shown in Figure 3-1.

Table 3-2: Non-native species and relevant project elements (Third Schedule listed species shown in bold)

Species	Risk of Invasiveness (NBDC Classification)	Wind farm	Grid Connection	TDR
Cherry Laurel *Prunus laurocerasus*	High	✓	✓	✓
Sycamore *Acer pseudoplatanus*	Medium	✓	✓	✓
Wilson's Honeysuckle *Lonicera nitida*	Not assessed	✓	✓	✓
Montbretia *Crocosmia* X *crocosmiflora*	Not assessed	✓	X	X
Snowberry *Symphoricarpos albus*	Low	X	✓	✓
Flowering Currant *Ribes sanguineum*	Not assessed	X	✓	X
Red Osier Dogwood *Cornus sericea*	Low	X	X	✓
Old Man's Beard *Clematis vitalba*	Medium	X	X	✓
Butterfly Bush *Buddleja davidii*	Medium	X	X	✓
Norway Maple *Acer platanoides*	Low	X	X	✓
Spanish Bluebell *Hyacinthoides hispanica*	**Low**	X	X	✓
Small-leaved Lime *Tilia cordata*	Not assessed	X	X	✓
Turkey Oak *Quercus cerris*	Medium	X	X	✓

Table 3-3 below details the invasive species recorded at TDR Nodes, including the relative location of plant growths to TDR Node footprints:

Table 3-3: Invasive/Non-native Species at TDR Nodes (Third Schedule listed species shown in bold)

Species	Invasive Impact	Location
Node 2 – Port Access Road/N69		
Red Osier Dogwood *Cornus sericea*	Low Risk	Node 2.0 - Ornamental planting in oversail area footprint
Old Man's Beard *Clematis vitalba*	Medium Risk	Node 2.0 - Growing in pine tree in oversail area footprint
Butterfly Bush *Buddleja davidii*	Medium Risk	Node 2.3 - Ornamental planting immediately adjacent to outer extent of trailer path
Node 4 – Clarina Roundabout		
Norway Maple *Acer platanoides*	Low Risk	Ornamental planting in load bearing footprint
Spanish Bluebell *Hyacinthoides hispanica*	Low Risk/ **Third Schedule**	Ornamental outside load bearing footprint (c. 10m away)
Node 5 -Mungret Interchange – Western Roundabout		
Norway Maple *Acer platanoides*	Low Risk	Ornamental planting in load bearing footprint
Small-Leaved Lime *Tilia cordata*	Not assessed	Ornamental planting outside load bearing & oversail footprint
Node 6 -Mungret Interchange – Eastern Roundabout		
Norway Maple *Acer platanoides*	Low Risk	Ornamental planting outside load bearing & oversail footprint
Small-Leaved Lime *Tilia cordata*	Not assessed	Ornamental planting outside load bearing & oversail footprint
Node 7 – M20/N20 Off-ramp Southbound		
Red Osier Dogwood *Cornus sericea*	Low Risk	Ornamental planting in oversail area footprint
Turkey Oak *Quercus cerris*	Medium Risk	Ornamental planting in oversail area footprint
Node 8 – N20 Right Curve Ballymacrory		
No invasive species.	-	-
Node 9 – N20/L1322 Junction Ballyhea		
No invasive species.	-	-
Node 10 – L1322		
Sycamore *Acer pseudoplatanus*	Medium Risk	Node 10.3 – in hedgerow in oversail area footprint;

Species	Invasive Impact	Location
		Node 10.5 – grassy bank/hedgerow in oversail area footprint; Node 10.10 – grassy bank/hedgerow in oversail area footprint Node 10.11 – in woodland in bell-mouth entrance footprint
Wilson's Honeysuckle *Lonicera nitida*	Not assessed	Node 10.3 – in hedgerow in oversail area footprint Node 10.11 – in woodland in bell-mouth entrance footprint
Cherry Laurel *Prunus laurocerasus*	High Risk	Node 10.6 – in garden immediately adjacent to oversail area footprint
Snowberry *Symphoricarpus albus*	Low Risk	Node 10.9 – in hedgerow in oversail area footprint; Node 10.10 – in hedgerow in oversail area footprint

3.3 Location and links to Sensitive Habitats

Montbretia is present along the Oakfront River, which is a tributary of the River Awbeg, part of which is within the Blackwater (Cork/Waterford) SAC. This species could spread via the river network by transportation of seeds and/or disturbed corms. Spread could occur unaided, or through disturbance of plants and movement of vector material. However, it is noted that no proposed works overlap the area where Montbretia is located.

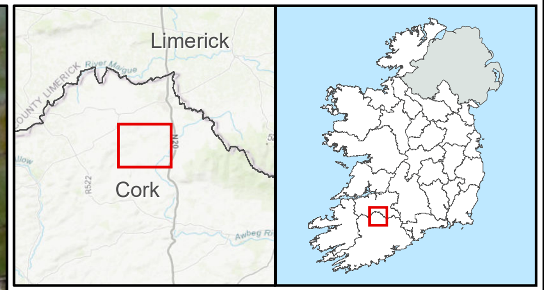
Invasive species near watercourses could be spread via drainage channels and streams if vector material enters the hydrological network. An indirect effect could arise from siltation and nutrient input caused by disturbance of drains, riverbanks or adjacent ground if mechanical clearance is undertaken (including excavation and mechanical destruction of vegetation).

The inappropriate use of herbicides near watercourses could have negative effects on aquatic ecology.

Where invasive species are present in hedgerows, their removal may affect the hedgerow through collateral damage of adjacent native species, and by the physical alteration resulting from removal of invasive shrubs which contribute to the structure of the hedgerow.

Path: R:\Map Production\2020\P2359\Workspace\EIAR\P2359_GIS_Fig8-9_InvasiveSpecies_A3.mxd

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community



Legend

- Site Boundary
- Underground Cable Route

Invasive Species:

- Cherry Laurel
- Flowering Currant
- Montbretia
- Snowberry
- Sycamore
- Wilson's Honeysuckle

TITLE: Invasive Species at Site Entrance and along Grid Connection	
PROJECT: Annagh Wind Farm	
FIGURE NO: 3.1	
CLIENT: EMP Group	
SCALE: 1:18000	**REVISION:** 0
DATE: 13/10/2021	**PAGE SIZE:** A3

FEHILY TIMONEY
Cork | Dublin | Carlow
www.fehilytimoney.ie

0 0.25 0.5 1 Kilometers

4. INVASIVE/NON-NATIVE SPECIES ACCOUNTS

The International Union for Conservation of Nature (IUCN) in their 'IUCN Guidelines for the Prevention of Biodiversity Loss Caused by Alien Invasive Species' 2000 paper describes non-native invasive species (referred to as an invasive species) as:

> "*an alien species which becomes established in natural or semi-natural ecosystems or habitat, is an agent of change, and threatens native biological diversity*".

The 13 non-native species listed below were recorded at the proposed main windfarm site, grid connection route and/or TDR Nodes. Accounts of these species, summaries of their ecology, growth and management periods, and distribution are included below. The species in bold are included in the Third Schedule.

It is noted that within the group of species not included in the 2014 NAPRA risk assessment, only Montbretia is known to be aggressively invasive. Small-Leaved Lime is unlikely to pose problems outside of semi-natural native woodland settings.

Species formally identified as invasive:

- **Spanish Bluebell (*Hyacinthoides hispanica*)**
- Sycamore (*Acer pseudoplatanus*)
- Cherry Laurel (*Prunus laurocerasus*)
- Snowberry (*Symphoricarpos albus*)
- Red Osier Dogwood (*Cornus sericea*)
- Old Man's Beard (*Clematis vitalba*)
- Butterfly Bush (*Buddleja davidii*)
- Norway Maple (*Acer platanoides*)
- Turkey Oak (*Quercus cerris*)

Non-native species not yet risk assessed for invasiveness:

- Flowering Currant (*Ribes sanguineum*)
- Small-Leaved Lime (*Tilia cordata*)
- Wilson's Honeysuckle (*Lonicera nitida*)
- Montbretia (*Crocosmia* X *crocosmiflora*)

The following species: Spanish Bluebell, Butterfly Bush, and Flowering Currant are outside but adjacent to the proposed footprint of works. As such measures have been included on a precautionary basis in the event they need to be implemented (i.e. if they spread or there is a risk of interaction with seeds/underground plant material due to proximity). Small-leaved Lime is outside the proposed footprint; no measures are required for this species. Montbretia is outside the proposed footprint and no interaction with works is likely. Measures to remove Montbretia are proposed in order to enhance the ecology of the Site.

4.1 Sycamore (*Acer pseudoplatanus*)

4.1.1 Species Ecology

The Sycamore tree can grow up to 35m tall and has a distinctive fruit with wings. Originally it was thought to be damaging to native woodlands and to support a much narrower range of diversity than native species. However, it has been shown to support a wide range of lichens and other species. The principal concern would be Sycamore dominated woodlands, though Sycamore seedlings are out competed by ash under Sycamore canopy and vice versa, suggesting that there is a pattern of succession in mixed woodlands. Undisturbed woodlands have relatively few Sycamore trees compared to disturbed sites, even when Sycamore trees are present at nearby sites. Poor growth of Sycamore in dry conditions suggests that careful management of forests can mitigate any effects of sycamore invasion. Sycamore is of medium invasive impact when growing in native woodland areas.

Plate 4-1: Sycamore Leaf. Source : Biodiversityireland.ie (August 2021)

4.1.2 Timeframe

Control and disposal of plant material is best carried out before seeds are produced. As is common with invasive species, careful monitoring and follow-up applications of herbicides may be necessary.

4.2 Cherry Laurel (*Prunus laurocerus*)

4.2.1 Species Ecology

Cherry Laurel is an evergreen shrub that forms dense thickets comprised of either a single stem or multiple stems (especially if it has been trimmed). The thick evergreen 5-15cm long oblong-ovate leaves are glossy green on the surface and pale underneath. Leaves are arranged alternately on short leaf stalks and leaf edges are toothed with pointed tips. Small white fragrant flowers are held in clusters (racemes) and flowers are comprised of five petals and many yellow stamens. The fruits are purple/black and cherry-like and held in clusters.

Plate 4-2: Cherry Laurel. Source: Kingcounty.gov (August 2021)

4.2.2 Timeframe

Cherry Laurel can be cut down at any time of year; the herbicide glyphosate can also be applied throughout the year, however May to October inclusive is a sub-optimal period. Of principle concern when cutting and/or moving vegetation or surrounding soil would be the movement of viable seeds. As such the optimal time for cutting would be outside the flowering and fruiting period.

4.3 Wilson's Honeysuckle (*Lonicera nitida*)

4.3.1 Species Ecology

Wilson's Honeysuckle is a woody shrub with many thin, round glandular/hairy stems, arching branches and a bushy growth habit. The leaves are miniscule, opposite, oval, green and waxy. Flowers are also small, usually in pairs at leaf-axils, five-lobed, white-pale yellow, and covered in glands with a robust stigma extending above the petals (Plate 4-3).

Plate 4-3: Wilson's Honeysuckle. Source: naturespot.org.uk; credit: Graham Calow (August 2021)

It is widely planted and established, and primarily associated with roadsides and hedgerows. This plant produces berries, which could potentially be dispersed by animals or human intervention. Its risk of impact on native Irish species has not been assessed.

4.3.2 Timeframe

Physical control should preferably be undertaken before seeds are produced, to reduce the likelihood of reproductive spread.

4.4 Montbretia (*Crocosmia* X *crocosmiflora*)

4.4.1 Species Ecology

Montbretia (*Crocosmia* X *crocosmiflora*) is an invasive perennial that grows from underground corms. The X within its scientific name indicates it is a hybridised species. The species was developed in France for horticultural use and has since escaped and is naturalised throughout Ireland. Montbretia can survive in most open habitat types such as wet grassland, gardens and roadsides.

Due to fast growth rates, Montbretia outcompetes other species, dominating the habitats to which it is introduced. This dominance can impact native species and processes within these habitats. Dense tussocks of Montbretia can prevent the regeneration of seedlings and saplings, thus preventing natural re-generation of woodland (DAFM, 2016).

Montbretia flowers are reddish to orange in colour. They can be between 25 to 55mm long and are arranged loosely along two opposite sides of the flower stem, in a zig-zag formation (Plate 4-4). They have a hollow tubular corolla with six petals. The green leaves are 'grass-like', long, narrow, soft, and hairless. Leaves also have pointed tips and can reach 30-80cm long.

Montbretia spreads vegetatively using underground corms and rhizome fragments. The corm is bulb-like and stores energy for survival during the winter months. It is estimated that each Montbretia plant can produce 14 new corms annually. These corms are thought to break off from the parent plant, thus spreading further into the habitat. The corms, corm fragments and rhizomes can be spread unintentionally because of ground disturbance, dumping of garden waste and by attaching to machinery.

Plate 4-4: Montbretia flowers. Source: Wildflowersofireland.net (August 2021)

4.4.2 Timeframe

Montbretia growth begins in early spring with leaves sprouting from the ground in March. The plant flowers between July and September. The most effective time to remove Montbretia is just before full flowering occurs in summer (DAFM, 2016).

4.5 Snowberry (*Symphoricarpos albus*)

Snowberry is an invasive, often overlooked, species that is often present in hedgerows. Other than its pale white fruit, the species seems to blend into the other species within the habitat. Snowberry is a twiggy and straggly plant, which can reach over 2.5m high, often suspended using suckers. Snowberry impacts habitats and species as it forms dense thickets that outcompete native vegetation.

4.5.1 Species Ecology

Snowberry produces small pale-pink 'funnel-shaped' flowers with five pale-petalled flowers (4-6mm across), which flower from June to September. Its oval leaves are small and untoothed. In autumn the berries are round (1.5-2cm diameter) and whiten when ripe. Each berry contains two seeds. This plant was introduced from North America. It is thought that bird species within Ireland have not yet adapted to feed upon berries of such a colour, as no native plant in Ireland holds ripe white berries.

Plate 4-5: Snowberry berry and leaves. Source: www.nonnativespecies.org (August 2021)

4.5.2 Timeframe

Snowberry comes into flower from June to September; their berries are ripe in Autumn. As such, the optimal time for treatment would be outside the flowering and fruiting period.

4.6 Red Osier Dogwood (*Cornus sericea*)

4.6.1 Species Ecology

Red Osier Dogwood is a deciduous shrub that stands up to 6m tall. Between June and July (and sporadically in autumn) it produces small dense creamy white-yellow flowers. These flowers are four-petalled (8-10mm) in a flat topped head, with a faintly foetid smell. This species produces white berries. The leaves are pointed ovals in shape with tapering points, opposite, stalked with prominent veins and redden in autumn. These red leaves make it easy to identify in winter. Plate 4-6 displays characteristic features of red osier dogwood.

Red Osier Dogwood has the potential to outcompete native hedgerow or woodland. It has only been recorded in a few wetland habitats across Ireland. It is classified by the National Biodiversity Data Centre as having a risk of low impact on native Irish species.

Pointed oval leaves showing characteristic reddening, red veins and white berries.

Creamy white flowers in a flat top head

Red twigs

Plate 4-6: Characteristic features of Red Osier Dogwood. Source: www.wikipedia.org (August 2021)

4.6.2 *Timeframe*

Red Osier Dogwood spreads via its seeds contained within its white berry-like fruits or frequently via vegetative runners, resulting in colonies of shrubs. Therefore, it is recommended to avoid treatment during fruiting, and conduct treatment in winter and spring.

4.7 Old Man's Beard (*Clematis vitalba*)

4.7.1 *Species Ecology*

This deciduous perennial is a climber that can reach heights of 10-15m meters and will use structures and other plants to climb. The flower produces 2cm (across) fragrant cream flowers comprised of four sepals and many spread out stamens. Flowers are borne in clusters from July to September. Seed clusters are produced and have a feathered (achenes) appearance and are white to grey in colour. Leaves are opposite pinnately compound with three to five levels and are elliptical shaped with rough toothed margins.

Plate 4-7: Old Man's Beard leaves. Source: woodlandtrust.org (Dec 2020)

This garden escapee reproduces predominantly via seed, but re-growth from vegetative material has also been known to occur. It is mainly found in alkaline soils and is common along Irish roadsides and hedgerows. This plant impacts surrounding plants by using them as a climbing frame and competing for light. It can form a dense carpet covering the crowns of trees. It has been assessed by the National Biodiversity Data Centre as having a medium risk of impact on native Irish species.

4.7.2 Timeframe

Removal is most successful when carried out in winter when the vines can be more easily removed.

4.8 Butterfly Bush (*Buddleia davidii*)

4.8.1 Species Ecology

The Butterfly Bush is a multi-stemmed shrub that can reach 4m in height. From June to September, the arching branches bear conical panicles of lilac flowers, which may occasionally be white, pink, red or purple. Leaves are long and serrated along the edges. In the winter, flower heads and seed capsules remain despite the plant being deciduous. Up to 3 million seeds are produced per plant and can remain dormant in the soil for many years. Butterfly Bush is common throughout Ireland. It spreads through abundant seed dispersal by wind and draught behind vehicles. While being a valuable source of nectar, especially for butterflies, *Buddleia* can cause structural damage to buildings by rooting in cracks in masonry.

Plate 4-8: Butterfly Bush (*Buddleia daviddii*) Source: wildflowers of Ireland (Dec 2020)

4.8.2 *Timeframe*

Optimal time for treatment and/or movement of material is outside of flowering and seed-bearing periods and treatment should be undertaken in winter and spring.

4.9 Norway Maple (*Acer platanoides*)

4.9.1 Species Ecology

The Norway Maple is deciduous broadleaf tree that reaches heights of 25m. The bark of this tree is grey with fine ridges. Twigs are slender and brown with small white spots. In winter, this species is identified by individual green and red buds. Leaves are palmate, five-lobes and with few pointed teeth (Plate 4-9). Flowers are bright green growing in clusters up to 30. Winged seeds fall in autumn and are dispersed by wind. It is classified as having a low risk of impact by the National Biodiversity Data Centre.

Plate 4-9: Norway Maple Fruit and Leaves. Credit: Tim Gatney/Alamy Stock Photo, Source: woodlandtrust.org.uk (August 2021)

4.9.2 Timeframe

Removal of Norway Maple should occur before flowering to ensure seeds are not produced, leading to further dispersal.

4.10 Spanish Bluebell (*Hyacinthoides hispanica*)

4.10.1 Species Ecology

Spanish Bluebell (*Hyacinthoides hispanica*) is native to the Iberian Peninsula. It was introduced into Britain and Ireland as an ornamental plant but since has become invasive. The main threats associated with the species include hybridisation with the native Bluebell (*Hyacinthoides non-scripta*) and their ability to spread out competes other flora thus limiting the species diversity of an area.

The species is abundant in terrestrial dry woodlands and gardens. The species, unlike Japanese Knotweed, can spread both by seed and vegetatively, through the growth of roots leading to new bulbs being formed. The Native and Spanish Bluebell are closely related species, thus making hybridisation easier, which has negative implications for the native population.

Spanish Bluebell is a perennial herb with white spherical bulbs. It has narrow green leaves of 20 to 50cm in length. Each bulb has 4-6 leaves that become erect before flowering, then collapse later in the season . Their bell-shaped flowers are visible from April to June and are a lilac to blue colour. Anthers, within the flower are blue, in comparison to those of the native species, which are creamy white. The Spanish Bluebell dies back once seeds have been produced in late summer.

Plate 4-10: Spanish Bluebell (Paul, 2016)

4.10.2 Timeframe

The optimal time for treatment is in spring before flowers emerge; this will prevent the plant reproducing sexually and setting seed.

4.11 Small-Leaved Lime (*Tilia cordata*)

4.11.1 Species Ecology

The small leaved lime is a deciduous tree reaching over 20m in height. The grey-brown bark is smooth and develops flaky plates as it ages. The brown-red twigs appear shiny in sunlight. Leaves are heart shaped, between 3-8 cm in length and feature a pointed tip.

These leaves are hairless on top but have reddish-brown tufts on vein-joints on the leaf underside. This hermaphroditic species has green-yellow flowers with five petals, which grow in clusters of four to ten. Fruits are smooth with pointed tips (Plate 4-11).

Plate 4-11: Leaves of Small Leaved Lime. Source: woodlandtrust.org.uk, Credit: Paul Sterry/WTML (August 2021).

This introduced species has not been assessed by the National Biodiversity Data Centre for Invasiveness and is long-established in Ireland.

4.11.2 Timeframe

Removal of Small Leaved Lime should occur before flowering to ensure fruits and seeds are not produced, leading to further dispersal.

4.12 Turkey Oak (*Quercus cerris*)

4.12.1 Species Ecology

Turkey Oak is a deciduous broadleaved tree growing up to 40m tall. The deeply fissured dark grey bark can sometimes be scaly. The dark green leaves (9-12cm long) have 4-9 lobes, which are pointed and glossy with a felted underside. This tree produces small yellow catkins and small flowers. Following pollination, acorns are produced. These acorns have a green-brown tip with an orange base, with a cup covered in long scales. This species is host to three species of gall wasp, which damage native oak species upon moving from Turkey Oak, which acts as a vector for these gall wasps. The Turkey Oak was assessed to have a risk of medium impact as an invasive species by the National Biodiversity Data Centre.

Plate 4-12: Characteristic features (Acorns, Catkins, Leaves) of the Turkey Oak. Source: WoodlandTrust.org.uk, Credit: Clare Topping/WTML; Zoonar Gmbh/Alamy Stock Photo; FLPA/Alamy Stock Photo (August 2021).

4.12.2 *Timeframe*

Removal of Turkey Oak should occur before flowering to ensure fruits and seeds are not produced, leading to further dispersal.

4.13 Flowering Currant (*Ribes sanguineum*)

4.13.1 Species Ecology

This is a deciduous flowering shrub with bright green palmate leaves and an upright growth form made up of many thin stems. The bright pink flowers are borne in drooping bunches at the tips of branches. Plate 4-13 displays characteristic features of Flowering Currant.

Plate 4-13: Characteristic features of Flowering Currant. Source: wikipedia.org, Credit: Mark Robinson (August 2021).

It was introduced from North America in the 1800s and has since become naturalised, aided by birds that feed on its berries and disperse it's seed. Its risk of impact on native Irish species has not been assessed.

4.13.2 Timeframe

Physical control should preferably be undertaken before seeds are produced, to reduce the likelihood of reproductive spread.

5. PROPOSED MEASURES FOR THE MANAGEMENT OF INVASIVE SPECIES WITHIN AND ADJACENT TO THE PROPOSED DEVELOPMENT

It is recommended that a qualified and competent specialist in the treatment of invasive plant species, with appropriate experience and expertise, is employed for the duration of the project to ensure that all the measures proposed in relation to the Invasive Species Management Plan are implemented.

Specific consideration will be given to particular locations, due to their potential for disturbance during works. It is proposed to fell Sycamore trees at the site entrance, which contains Sycamore and Wilson's Honeysuckle; Cherry Laurel is also present in an adjacent hedgerow within the site entrance footprint. The footprint of proposed works at a number of TDR Nodes also overlaps invasive species growth (see Table 3-3), with potential for spread arising from ground works and/or vegetation trimming. It is noted that control measures along the TDR are only required at Nodes where works may interact with invasive species.

Control and removal of Montbretia (located outside the proposed development footprint) is advocated to enhance the site's environment and prevent the site acting as a reservoir for the spread of invasive species to other areas. This species is present near the entrance along the Oakfront stream, but not in the footprint of works.

As a general rule, where invasive species are within the footprint of proposed works, they must be contained and disposed of correctly. Where they are outside the proposed footprint, avoidance can be relied on where feasible to prevent their spread.

As such, options for avoidance, control and removal are detailed below.

5.1 General Measures

While it is extremely important and more efficient to contain invasive species at the point of infestation, care shall be taken ensure that invasive species are not spread outside the site.

Invasive Species Ireland (ISI) notes that invasive non-native species are the second greatest threat (after habitat destruction) to worldwide biodiversity. Invasive species negatively impact Ireland's native species by changing habitats and ultimately threatening ecosystems, which impacts on biodiversity as well as economics, as they are costly to eradicate.

Halting the spread of non-native invasive species can be achieved via prevention, containment, treatment and eradication (ISI, 2021).

5.1.1 Prevention

Prevention of the spread of invasive species will be achieved by:

- The full implementation of the invasive species management plan in conjunction with a competent and experienced Invasive Species Specialist Contractor.
- Supervision of control measures and treatment works by an appropriately qualified ecologist or invasive species specialist.

- Raising awareness of site workers via toolbox talks given by a suitably qualified person as part of site introduction, informing workers what to look out for and what procedure to follow if they observe an invasive species.
- Only planting or sowing native species within the proposed Annagh Wind Farm site, GCR and TDR will be allowed.
- Where invasive species are physically removed, disturbed soil will be seeded or replanted (including 5cm deep mulch) with native plant species. This will prevent the colonisation of bare soil by invasive species in the area.
- Unwanted material originating from the site will be transported off site by an appropriately licensed waste contractor and disposed of properly at a suitably licenced facility.
- Signs will warn people working there that there is invasive species contamination.
- Stockpiles of soil contaminated Spanish Bluebell and or other invasive species are to be indicated clearly with appropriate signs and isolated.
- Ensure good hygiene practices.
- Remove the build-up of soil on equipment.
- Keep equipment clean.
- Do not move fouled equipment from one site to another.
- All vehicles exiting the site will be washed down with a pressure washer to prevent the transport of seeds, since this cannot be prevented comprehensively by any other measure.
- Wastewater from washing facilities will be stored securely and treated to prevent spread outside the site.
- Footwear and clothing of operatives working near invasive species will be checked for seeds, fruits, or other viable material before exiting the site.

5.1.2 Containment

The three most common ways a site can become infected are:

1. Importation of infected soil.
2. Contamination on vehicles and equipment.
3. Illegal dumping.

Containment of invasive species will be achieved by:

- A pre-construction survey to reconfirm the findings of the EIAR during the growing season immediately prior to the construction phase. This will mark out the extent of invasive plant species. This survey shall inform the finalised draft of the invasive species management plan prior to the commencement of works. Prior to the construction phase, invasive species are to be treated (Section 5.2 for treatment methods).
- Cordoning of invasive species outside the works footprint shall include a buffer of 1m surrounding the area of infestation.

This will prevent plants with underground rhizomes being transported to other sections of the site and it will also prevent contact with plants which could result in the transport of seed, fruit or vegetation to other parts of the site. No construction works will occur within exclusion zones prior to the eradication of invasive species.

- No machinery or personnel shall be allowed within exclusion zones. Similarly, there shall be no storage of materials within or adjacent exclusion zones.
- No soil or vegetation shall be removed from this area unless it is contained and is transported via an appropriately licensed waste contractor to a suitably licenced facility for treatment.
- Informing all site staff through toolbox talks as part of site inductions.
- Any new sightings of invasive plant species shall be relayed to construction staff and the developer. These areas shall follow the same protocol as current infested areas.
- It is possible, particularly in the first year of control, that new plants will sprout following the initial removal/treatment, either because shade suppression will be reduced or due to soil disturbance. As such, several additional visits will likely be required. Three visits, May/June, July/August and September/October should be sufficient to catch all regrowth, although, a cautionary approach is advisable. Plants that germinate after September/October are very unlikely to have sufficient time to complete their life cycle and produce seeds.

5.1.3 Prevent Spread:

- Import only clean soil from known sources.
- Ensure all vehicles and equipment are cleaned to avoid cross contamination.
- Follow instructions provided for containment of invasive species (Section 5.1.2).
- Promote native species and biodiversity, only native species are to be introduced to the site.
- Report all sightings.

5.2 Species-Specific Measures

5.2.1 Sycamore

Generally, site-wide control measures for this species are not required; however, Sycamore will not be planted as part of landscaping. Control will focus on the correct disposal of cut material in areas where Sycamore felling and trimming is required. Sycamore reproductive plant material is required to be carefully disposed of.

The contractor must appropriately dispose of Sycamore plant material in accordance with the NRA (2010) guidelines, where cut, pulled or mown non-native invasive plant material arises, its disposal will not lead to a risk of further spread of the plants. Care will be taken near watercourses as water is a fast medium for the dispersal of plant fragments and seeds. Material that contains flower heads or seeds will be disposed of by burial at a depth of no less than 2m, or disposal to licensed landfill in the case of non-native invasive species. All disposals will be carried out in accordance with the Waste Management Acts.

5.2.2 Cherry Laurel

Four options for the treatment of Cherry Laurel have been proposed. Any one or a combination of these four options shall be used to eradicate Cherry Laurel from the site and avoid the spread of the species. However, the following general recommendations will be adhered to as part of the plan:

- No treatment measures to take place in these areas without supervision and agreement by appointed Cherry Laurel eradication specialist.
- The Cherry Laurel plant contains cyanide and as per good practice will only be handled with gloves. This plant will be disposed of via an appropriately licensed waste facility.
- Equipment, clothing and footwear is to be checked following treatment operations and cleared of fruits/seeds as necessary.

Option 1 – Cut to stump and dig out stump; bury onsite

This method involves cutting the main stem of the plant down near ground level and digging out the stump and any visible roots. This option is not usually practical in areas where there are other invasive plants present as the disturbed soil can allow for the setting of seeds or the spread of rhizomes of adjacent species (ISI, 2008).

Option 2 – Cut to stump and treat stump with herbicide

This method involves cutting the main stem of the plant down near ground level, and applying herbicide to the freshly cut wound.

The herbicide concentrations used, and timings of applications vary according to which chemical is used. When treating many stems, vegetable dye added to herbicide is useful for highlighting the stems that have and haven't been treated. The use of a brush or other such applicator will provide an accurate application and prevent damaging adjacent non-target plants via spray drift. Please see table below for best treatment time (ISI, 2008).

Since the 26th November 2015, only a DAFM-registered professional user can apply Plant Protection Products that are authorised for professional use. As such any application of herbicide must be carried out by a professional user. Since the 26th November 2016, it has been a requirement for sprayers to have passed a Pesticide Application Equipment Test before being used to apply professional use Plant Protection Products.

Option 3 – Cut to main stem and inject stem with herbicide

This method involves the 'drill and drop' method where the main stem is cut, and a hole drilled into the cut. The main drawback to this technique is that the plant is left in place to rot, which can take a decade or more. Please see Table 5-1 below for best treatment time (ISI, 2008).

Option 4 - Cut back to stump and spray regrowth with herbicide

This application involves cutting a main stem down near ground level and then treating the new stems with herbicide. This method is the least effective as some stems may be missed and not treated. Also, the application of herbicide is generally via spraying, which can result in adjacent non-target plants being killed off. Please see Table 5-1 below for the best treatment times(ISI, 2008).

Cutting	J	F	M	A	M	J	J	A	S	O	N	D
Glyphosate	J	F	M	A	M	J	J	A	S	O	N	D
Tryclopyr*	J*	F*	M*	A*	M*	J*	J*	A*	S*	O*	N*	D*
Ammonium sulphate	J	F	M	A	M	J	J	A	S	O	N	D

Optimum treatment time. Remember to consider breeding birds before embarking on a programme.
Suboptimum treatment time but can be effective. In the case of glyphosate based herbicides consider higher concentrations 25--100% during this time period.
* Suitable for treatment any time after cutting and appearance of new growth.

Figure 5-1: Optimum time for the treatment of Cherry Laurel (ISI, 2008).

Any reproductive plant material will be carefully disposed of following NRA (2010) Guidelines (See Section 5.2.1). Any equipment used will be inspected and thoroughly cleaned, as will the footwear and clothing of operatives removing invasive species material. Any material arising from cleaning of equipment and footwear will be disposed of in a manner which will not cause the spread of invasive species.

5.2.3 Montbretia

Two options for the treatment of Montbretia at the site have been proposed to avoid the spread of this species. It is noted that Montbretia was not recorded within the project footprint, and removal will therefore be an enhancement measure. The following general recommendations will be adhered to as part of the plan:

- No treatment measures of Montbretia are to be conducted without supervision and agreement by the appointed invasive species specialist.
- No material shall be taken from areas of infestation, unless for disposal. All material will be either deep buried (2m) or transported by an appropriately licensed waste contractor and received by an appropriately licensed facility.
- As Montbretia was recorded along a stream, treatment options are restricted.

Option 1 – Digging

In the case of small stands, digging by hand can be used to extract corms and additional root system from the site. This must be completed before seeds are produced, pre-July. If corms are damaged lost during excavation it is likely that new growth would form from these. Tools and PPE must be cleaned before exit from the area of infestation. Subsequent excavated materials will be buried onsite, or removed from the site, using appropriately licenced transport, to an appropriately licenced facility equipped to deal with such volumes (IWS, 2018). Any areas of disturbed soil will be seeded with native grass species and compacted to prevent sediment runoff. As such, digging must be carried out during spring/early summer to allow time for grass to establish.

Option 2 – Chemical Treatment

A herbicide such may be applied by wiper application to avoid spray drift to other habitats and the adjacent river. This must only be undertaken by a trained operative and approved pesticide user at a time when dry weather is forecast to persist for several days. Follow up treatment may be required for a number of years if regrowth occurs.

Any reproductive plant material will be carefully disposed of following NRA (2010) Guidelines (See Section 5.2.1). Any equipment used will be inspected and thoroughly cleaned, as will the footwear and clothing of operatives removing invasive species material. Any material arising from cleaning of equipment and footwear will be disposed of in a manner which will not cause the spread of invasive species.

5.2.4 Snowberry

The primary means of preventing spread of this species due to the works is predicted to be avoidance, as it is located in hedgerows bordering the L1322.

In the event of interaction of works with Snowberry, one option for the treatment of Snowberry at the site has been proposed to avoid the spread of the species. The following general recommendations will be adhered to as part of the plan:

- Snowberry is spread both by seed, a buffer area of 1m will be left to prevent further contact with plants, possibly causing seeds to fall or become attached to machinery or people. Disturbed seeds may result in the propagation of a new snowberry population elsewhere.
- Staff shall be made aware of this buffer zone when working within areas of infestation.
- Areas of infestation will be fenced off from other works areas including a buffering distance of up to 1m to create exclusion zones.
- Construction works will not be allowed within exclusion zones until the species has been fully removed but may continue outside of these areas.
- No treatment measures to take place in these areas without supervision and agreement by appointed eradication specialist.
- All machinery and vehicles operating within areas of infestation to be thoroughly checked and if necessary cleaned prior to leaving the area to protect against further spreading of snowberry.
- No material shall be taken from areas of infestation, unless for disposal. All material will be either deep buried (2m) or transported by an appropriately licensed waste contractor and received by an appropriately licensed facility.
- All staff shall be made aware of nature of threat via toolbox talks as part of site inductions. Toolbox talks shall be undertaken with all personnel accessing the site to ensure that the details of the invasive species management plan are adhered to and to raise awareness of the potential treat of invasive species.
- Wheel washes shall be put in place at entry and exit points, if considered appropriate. Wastewater from these facilities will need to be stored and treated to avoid further outbreaks.
- If operating within an area of known infestation all machinery, vehicles, equipment, foot ware and clothing will need to be cleaned thoroughly (if necessary, using steam cleaners) in a contained area to avoid further contamination.

Option 1- Excavation

Excavation of the entire root system is thought to be a very effective method of Snowberry control. This must be done before the plants' seeds ripen in autumn. Plant matter from this process can be disposed of using a licenced landfill site or may be buried to a depth of over 2m.

Any reproductive plant material will be carefully disposed of following NRA (2010) Guidelines (See Section 5.2.1). Any equipment used will be inspected and thoroughly cleaned, as will the footwear and clothing of operatives removing invasive species material. Any material arising from cleaning of equipment and footwear will be disposed of in a manner which will not cause the spread of invasive species.

5.2.5 Old Man's Beard

Old Man's Beard, present within the oversail area of Node 2 at the TDR will be treated using the following option.

Option 1- Physical Removal

Seedlings can be pulled out of the ground and larger plants can be cut to the stem (and foliage will die) and roots and stem removed. Roots can then be grubbed out with material stored above the ground, so plants cannot take root again.

For more mature plants, the stem can be cut near ground level and herbicide applied to the outer rim of the stem. The stem is likely to produce regrowth in the next growing season and herbicide will need to be applied to this growth. Glyphosate can be used in late spring and summer and Triclopyr can be applied in summer. This is the preferred option where plants infest the crowns of trees.

The contractor must appropriately dispose of Old Man's Beard plant material and soil containing plant material in accordance with the NRA (2010) guidelines, where cut, pulled or mown non-native invasive plant material arises, its disposal will not lead to a risk of further spread of the plants. Care will be taken near watercourses as water is a fast medium for the dispersal of plant fragments and seeds. Material that contains flower heads or seeds will be disposed of either by composting or burial at a depth of 2m, or disposal to licensed landfill in the case of non-native invasive species. All disposals will be carried out in accordance with the Waste Management Acts.

5.2.6 Butterfly Bush

Butterfly Bush which is present adjacent to TDR Node 2 is likely to spread within the area regardless of potential transport by humans, due to its mode of spread by wind. Nonetheless, efforts will be taken to prevent the spread of this species as follows:

- Disturbing ripe seed heads will be avoided during the turbine delivery by implementing an exclusion zone;
- Bags will be placed over the flower spikes to avoid dislodging and spreading seeds during the turbine delivery;
- Machinery will be checked for the presence of seed to avoid accidental transportation.

If this species has spread into the proposed works zone prior to TDR works and trimming/felling are required any reproductive plant material will be carefully disposed of following NRA (2010) Guidelines (See Section 5.2.1). Any equipment used will be inspected and thoroughly cleaned, as will the footwear and clothing of operatives removing invasive species material. Any material arising from cleaning of equipment and footwear will be disposed of in a manner which will not cause the spread of invasive species.

5.2.7 Norway Maple

Control of Norway Maple along the TDR will focus on the correct disposal of cut material in areas where felling and trimming is required. It is vital that reproductive Norway Maple plant material is carefully disposed of. The contractor must appropriately dispose of Norway Maple plant material in accordance with the NRA (2010) guidelines, where cut or mown non-native invasive plant material arises, its disposal will not lead to a risk of further spread of the plants. Care will be taken near watercourses as water is a fast medium for the dispersal of plant fragments and seeds. Material that contains flower heads or seeds will be disposed of by burial at a depth of no less than 2m, or disposal to licensed landfill in the case of non-native invasive species. All disposals will be carried out in accordance with the Waste Management Acts.

Any material arising from cleaning of equipment and footwear will be disposed of in a manner which will not cause the spread of invasive species.

Norway Maple will not be intentionally planted as part of landscaping.

5.2.8 Spanish Bluebell

Care will be taken to avoid disturbing Spanish Bluebell, which is present outside the load bearing footprint at Node 4. This will be achieved by cordoning off the area during TDR Node works. Staff will be made aware of this buffer zone.

In the event this species has spread to the proposed works area prior to TDR Node works, any plants in the footprint will be dug out and stored securely but at TDR Node 4. Any equipment used to excavate the plants will be inspected and thoroughly cleaned, as will the footwear and clothing of operatives removing Spanish Bluebells material. Any such material will be retained and stored with the excavated Spanish Bluebell material.

It should be noted that Third Schedule species plant material cannot be moved offsite without a licence from the NPWS and as such a licence for transport and availability of a suitably licenced facility will be required to be in place before any works affecting Spanish Bluebell commence.

5.2.9 Small-Leaved Lime

Small-Leaved Lime is unlikely to pose an invasion threat. Furthermore, it is outside the footprint of proposed works. Therefore, no treatment measures are necessary.

No intentional planting of Small-Leaved Lime will occur.

5.2.10 *Turkey Oak*

Turkey Oak present in the oversail footprint of Node 7 of the TDR will be assessed prior to TDR Node works. If trimming and felling are required any reproductive plant material will be carefully disposed of following NRA (2010) Guidelines (See Section 5.2.1). Any equipment used will be inspected and thoroughly cleaned, as will the footwear and clothing of operatives removing invasive species material. Any material arising from cleaning of equipment and footwear will be disposed of in a manner which will not cause the spread of invasive species.

Furthermore, no intentional planting of this species will be undertaken.

5.2.11 *Red Osier Dogwood*

Red Osier Dogwood, present in the oversail footprint of Node 2 and Node 7 of the TDR will be assessed prior to TDR Node works. If trimming and felling are required any reproductive plant material will be carefully disposed of following NRA (2010) Guidelines (See Section 5.2.1). Any equipment used will be inspected and thoroughly cleaned, as will the footwear and clothing of operatives removing invasive species material. Any material arising from cleaning of equipment and footwear will be disposed of in a manner which will not cause the spread of invasive species.

Furthermore, no intentional planting of this species will be undertaken.

5.2.12 *Flowering Currant*

This species is unlikely to be affected by GCR works and as such the primary means of prevention of spread is avoidance.

If interaction with this species is unavoidable, any reproductive plant material will be carefully disposed of following NRA (2010) Guidelines (See Section 5.2.1). Any equipment used will be inspected and thoroughly cleaned, as will the footwear and clothing of operatives removing invasive species material. Any material arising from cleaning of equipment and footwear will be disposed of in a manner which will not cause the spread of invasive species.

5.2.13 *Wilson's Honeysuckle*

In the removal of Wilson's Honeysuckle from the site entrance, one option is proposed for control and prevention of spread.

Excavation

- Excavate stems and rootstock. Ensure all root material are excavated.
- Physical control must preferably be undertaken before seeds are produced, to reduce the likelihood of reproductive spread.
- If being stockpiled on-site, plant material must be stored securely, monitored and re-growth treated with herbicide where necessary.
- Alternatively, plant material may be buried to a depth of 1m.
- Disposal at a licensed facility is also an option.
- Any machinery used for excavating and transporting plant material must be washed thoroughly in a designated area following operations.

Any reproductive plant material will be carefully disposed of following NRA (2010) Guidelines (See Section 5.2.1). Any equipment used will be inspected and thoroughly cleaned, as will the footwear and clothing of operatives removing invasive species material. Any material arising from cleaning of equipment and footwear will be disposed of in a manner which will not cause the spread of invasive species.

6. MANAGEMENT PLAN

The management of any invasive species is achieved by the assessment and mapping of the invasive species, containment once found, continual monitoring and record keeping as well as the safe disposal of invasive species material.

6.1 Containment

For the efficient use of resources, namely financial and physical effort, it is important to prevent the further spread of invasive species by containment. Containment will be achieved via:

- Cordoning off the area of infestation using demarcation fencing to prevent further spread of seed by people or machinery.
- Mark the cordoned off area with an information/warning sign.
- Toolbox talks to be carried out for all maintenance workers working within the site.
- Landholder to be informed of location of the invasive species and the management plan.
- To help with monitoring of the infestation, the area is to be outlined with spray paint.
- Ensure anyone treating the infestation is a suitably qualified trained and certified professional who follows the management plan.
- The site will be re-surveyed prior to treatment / construction works to confirm the findings of the original survey.
- Follow up surveys will be carried out post-construction to determine effectiveness of treatment and trigger further treatment if required.

6.2 Schedule

The schedule for treatment is detailed in Table 6.1.

Re-surveys for all invasive species will be required, to ensure that treatment measures were effective, and to trigger further treatment if necessary.

Please note that the schedule and treatment method may require amendment following any given site visit.

Table 6-1: Schedule of measures to eradicate and prevent spread of invasive species at the proposed Annagh Wind Farm

Year	Details of measures
1	• A pre-construction survey (to reconfirm the findings of the EIAR) will be undertaken during the growing season to mark out the extent of invasive species within the footprint of the project prior to any works commencing on-site. • Invasive species material that is to be retained onsite will be buried in advance of other works, and no further excavation or disturbance of these areas will take place. • Invasive species material that is to be retained onsite will be buried in advance of other works, and no further excavation or disturbance of these areas will take place. • All invasive species observed shall include a buffer of up to 1m surrounding the area of infestation. This will prevent plants with underground rhizomes being transported to other sections of the site and it will also prevent contact with plants, which could result in the transport of seed, fruit or vegetation. • Treatment of invasive species using one or more of the treatment options proposed in Section 5. • Only once treatment has been completed and invasive species have been removed from within the area of works/buried securely will works commence. • Toolbox talk shall be given to all personnel accessing the site. • Site to be monitored continually for signs of regrowth of all invasive species during operation. Disposal of ALL cut and excavated plant matter, if chosen to be processed off-site, must be done so through a licenced waste processor. Adequate licences may also need to be obtained for the transportation of such matter.
2 - 5	• For 5 years following construction, site to be monitored annually for signs of regrowth of invasive species. • Monitoring of material collected during equipment washing for signs of growth during following growing season.

6.3 Mapping, Evaluating and Record Keeping

During each treatment the following will take place before control treatments:

- Check that the area of infestation is still cordoned off and a warning/information sign is still in place;
- Photographs of the area(s) of invasive species infestation;
- Map the extent via recording GPS coordinates and measure the length and width of infestation and plot on map;
- Evaluate the status/condition of the infestation;
- If the infestation has spread spray paint the extent of the new area (for comparison on next visit);
- Make sure step 1-5 are recorded.

At the end of each site visit the recorded data will be compared with the findings of this report and where required the management plan shall be updated. A short report on the progress of treatment works, and any subsequent monitoring will be produced annually during the construction and monitoring periods.

6.4 Appropriate Disposal

6.4.1 Storage

As outlined in Section 5, all cut and excavated plant matter will be stored securely in line with the relevant treatment methodology.

6.4.2 Disposal

Deep Burial (onsite)

Burial of plant matter and possible contaminated soil from within the proposed site will be completed as per the species-specific measures discussed in Section 5. Invasive species material generated within the site may be disposed of within the planning boundary, in accordance with the measures detailed in Section 5.

Licensed Disposal

Disposal of plant matter and soil generated off-site (i.e. at TDR Nodes not encompassed by planning boundary) will be completed through an appropriately licenced haulier and waste facility. It is noted that all invasive species material disposed of off-site requires acceptance at a licensed facility. In addition to this, Third Schedule-listed species such as Spanish Bluebell also require an additional licence for transportation.

7. CONCLUSION

There is a legal obligation not to spread plants listed on the Third Schedule of the European Communities (Birds and Natural Habitats) Regulations 2011-2021; the relevant species (associated with TDR Node 4) therefore that of principal concern, are Spanish Bluebell (*Hyacinthoides hispanica*).

Environmental best practice, and the need to prevent the spread of the other invasive species present on-site to European sites, dictates the need to take measures to prevent the spread of these species.

Various treatment measures are advocated for the invasive species present on-site, with several options available in most cases.

It is recommended that a competent, licenced and experienced invasive species management contractor is appointed to eradicate invasive species from the site. Any operatives applying herbicides must be appropriately trained and certified.

A dedicated invasive species survey is required to be undertaken by the appointed contractor to reconfirm the findings of the preplanning surveys.

All invasive species present on-site will be required to be cordoned off prior to any treatment works, with exclusion zones in place as specified in Section 5.

A quarantine zone where equipment washing, and inspection of clothing and footwear can be carried out will be established at the site entrance prior to treatment works and remain in operation until all vegetation has been removed or buried.

Following burial, areas should remain cordoned off, with appropriate methodologies in place to ensure no disturbance occurs during subsequent works.

Treatment works will be supervised by an appropriately licenced invasive species specialist.

Yearly monitoring for re-growth of invasive species is recommended for up to five years following construction.

With the implementation of the measures detailed in this document, the spread of invasive plant species will not result from any activities associated with the proposed project. The primary measures are avoidance, control, correct disposal, and sanitation of equipment. Where specified, localised eradication will also be carried out, to enhance habitats and remove reservoirs for further infestation.

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APPENDIX 8.7

Collision Risk Modelling Report

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Collision Risk Modelling Calculations for target species at the proposed Annagh Wind Farm (Summer 2019 to Winter 2020/2021)

Prepared for: EMPower

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TABLE OF CONTENTS

LIST OF TABLES

1. INTRODUCTION

This report presents the results of the collision risk modelling for the proposed Annagh Wind Farm, Co. Cork. This modelling used data from vantage point (VP) surveys carried out in the summers of 2019 and 2020 and winters of 2019/2020 and 2020/2021. VP surveys were SNH (Scottish Natural Heritage) compliant (SNH 2017). Nine target species were recorded in flight within the study in the potential collision zone during survey work. Three of the target species (mute swan, sparrowhawk, and snipe) recorded were present during the winter only and three (lesser black-backed gull, little egret and mallard) were present during the summer only, while the remaining three (buzzard, grey heron, and kestrel) were present throughout the year. Not all target species were recorded at the site across all two years of survey work. Target species which did not occur within the rotor swept zone and thus were automatically omitted from the collision risk model are as follows: black-headed gull, cormorant, common gull, goshawk, hen harrier, and peregrine.

The modelling was carried out using the Scottish Natural Heritage Collision Risk Model (Scottish Natural Heritage 2000; Band *et al.,* 2007). The bird occupancy method (SNH 2000) was used to calculate the number of bird transits through the rotors, and the spreadsheet accompanying the SNH report was used to calculate collision probabilities for birds transiting the rotors.

2. DATA SOURCES

The following data and information were provided for this assessment:

- Spreadsheet data listing all observations of flight activity recorded during the VP surveys.
- GIS mapping of flight lines recorded during the summers of 2019 and 2020 and winters of 2019/2020 and 2020/2021 VP surveys.
- Mapping of the VP locations.
- Mapping of the proposed turbine locations.
- Technical specifications for the proposed turbines.
- Various clarifications about the survey methodology.

All of the survey data used in this assessment was provided internally by Fehily Timoney and Co or externally by subcontractors working on behalf of Fehily Timoney and Co. Additional information, including technical details (e.g. turbine specifications) were provided by the client.

3. REVIEW AND ANALYSIS OF THE VP SURVEY COVERAGE AND RESULTS

VP locations and viewshed coverage

Two VPs were used for surveys across the study period: VP1, and VP2 (Table 3.1). The locations of these VPs were selected to maximise viewshed coverage of the 500 m buffer around the site boundary, as recommended by SNH (2017) guidance. VP1 was moved in summer 2020 when turbine locations were first identified. Prior to this, the study area was significantly smaller, thus VP1 was moved south to cover the new turbine buffer. An additional two six-hour surveys were completed at VP1 and VP2 in April 2021 to compensate for the lack of survey effort in September 2020.

For the purposes of collision risk modelling, a 500 m radius buffer was drawn around each of the proposed turbine locations. This buffer was used as the flight activity survey area, following SNH (2017) guidance.

A total of 97.46 percent of the total flight activity survey area (500m radius buffers surrounding the turbine locations) was visible from the two VP locations, which is marginally greater than the 97% recommended by SNH (2017) guidance. For the purposes of collision risk analysis, a correction factor has been applied to the flight durations recorded to account for the disparity in viewshed coverage. This provides a more conservative estimate of collision risk at the site.

Table 3.1: VPs Used for Avian Surveys

VP Number	Grid Reference (ITM)
1	550115, 616205
2	550037, 616468

VP survey effort

VP surveys were carried out at the site monthly from April 2019 to March 2021 inclusive. The winter season was defined as running from October to March inclusive (six months) for 2019/20, 2020/21 and the summer season from April to September inclusive (six months) for both 2019 and 2020. Note that missed surveys from September 2020 were included in April 2021. Therefore, over the entire survey period, two summer surveys were completed and two winter surveys. Watches were 2 * 3 hours = 6 hours per VP per month. Thus, the following survey effort was completed for the following seasons:

- Winter 2019/2020. 2 VPs * 6 hours / VP / month * 6 months = 72 hours 10 minutes or 259,800 seconds.
- Summer 2019. 2 VPs * 6 hours / VP / month * 6 months = 72 hours or 259,200 seconds.
- Winter 2020/2021. 2 VPs * 6 hours / VP / month * 6 months = 72 hours 4 minutes or 259,440 seconds.
- Summer 2020. 2 VPs * 6 hours / VP / month * 6 months = 72 hours 2 minutes or 259,320 seconds.

Total survey effort over the entire period was 288 hours 16 minutes or 1,037,760 seconds.

VP survey protocol

The VP surveys recorded flight activity of all target species within fixed visual envelopes. During the course of the study, the vertical distance bands were modified several times to reflect changes in proposed turbine models. The first set of height bands are 0-20, 20-40, 40-80, 80-150, 150+. These are superseded by the following: 0-10, 10-20, 20-30, 30-50, 50-100, 100-185, 185+. Next, they were updated to 0-20, 20-30, 30-50, 50-100, 100-185, 185+, and finally, height bands were updated to 0-25, 25-50, 50-100, 100-175, 175+. Thus, all previous flight height bands have been discarded and flight heights are assigned to the rotor swept zone (25-175m) based on this most recent set of height bands. Previous height band sets can still be used to work in unison with the most recent set. For example, for the first set “0-20, 20-40, 40-80, 80-150, 150+”, all bands bar 0-20 are in the rotor swept zone. That is, once a height band is within one of the upper or lower parameters, despite falling short or overshooting in the beginning or end, it is considered to be rotor swept. Although, the height band 20-40 begins five metres shorter than the lower rotor swept threshold, it continues up to 40m, which is within the rotor swept zone, and thus it is included.

Selection of target species for the collision risk model

The following ten raptor, wader and waterbird species were recorded inside the 500m turbine buffer boundary at rotor swept heights during the VP surveys across 2019, 2020 and 2021:

- Buzzard (*Buteo;* Green-listed);
- Grey heron (*Ardea cinerea*; Green-listed);
- Kestrel (*Falco tinninculus*; Amber-listed);
- Little egret (*Egretta garzetta*; Green-listed, Annex I);
- Lesser black-backed gull (*Larus fuscus*; Amber-listed);
- Mallard (*Anas platyrhynchos*; Amber-listed);
- Mute swan (*Cygnus olor*; Amber-listed);
- Sparrowhawk (*Accipiter nisus*; Amber-listed); and
- Snipe (*Gallinago gallinago*; Amber-listed).

Black-headed gull, common gull, cormorant, hen harrier and peregrine were also recorded during VP surveys but were not recorded within the 500 m turbine buffers or at rotor swept heights. Consequently, they were not included for collision risk analysis as the collision risk was predicted to be effectively zero.

Post-hoc correction of flight activity data

Flight lines that intersected the 500 m turbine buffer were included for collision risk modelling (CRM) in alignment with SNH (2017) guidance. This is a conservative approach in relation to flightlines that pass both within and outside the 500 m turbine buffer. For flightlines of this nature, the full observation time both inside and outside the buffer has been included for modelling, rather than splitting the observation time retrospectively.

The proposed turbines have a tip height of 175 m, a hub height of 100 m and a rotor diameter of 150 m. Therefore, the rotor swept height is 25 - 175 m. All flight duration data within the rotor swept height were therefore considered to be at potential collision risk heights (PCHs).

For the earlier vertical distance bands, this corresponded to flights recorded at 20-40, 40-80, 80-150m, 150+; 20-30, 30-50, 50-100, 100-185m. For the later vertical distance bands, this corresponded to flights recorded at 25-50, 50-100, 100-175m.

Flight times

Calculations were carried out using the flight times recorded intersecting the 'at-risk' 500 m buffer zone area for a watch time of 2 years, as there were two summer seasons and two winter seasons in our study period. The calculation process accounted for this fact, allowing a probability of collision risk per year instead of per 2 years to be provided (see example calculation for buzzard). In the CRM calculations, flight times were averaged over the 2 years watch time.

The total flight times for each species inside the 500 m buffer at rotor swept height across 2 years are shown in Table 3.2 below:

Table 3.2: Total Flight Times (Winters 2019/20, 2020/21 and summers 2019 and 2020)

Species	Total flight times in rotor swept height band (seconds)[1]
Buzzard	8931.33
Grey heron	246.24
Kestrel	3717.198
Little egret	15.39
Lesser black-backed gull	29297.43
Mallard	10465.2
Mute swan	47.196
Sparrowhawk	395.01
Snipe	41.04

The biometrics and flight speed values used in the calculations for each of the target species is shown in Table 3.3 below. The bird body lengths and wingspans were sourced from the BTO bird facts website (https://www.bto.org/understanding-birds/birdfacts/find-a-species; accessed 4th August 2021). The flight speeds used come from Alerstam *et al.*, 2007.

Birds are assumed to be active for 8 hours a day in winter and 12 hours a day in summer (except for snipe, which was assumed to be active for 15 hours a day in summer to account for crepuscular/nocturnal display flights).

[1] Flight times shown are the raw values. For collision risk calculations, they have been adjusted by multiplying by (100/97.46) to correct for viewshed coverage.

Table 3.3: Avian Biometric Data and Avoidance Rates

Species	Length (m)	Wingspan (m)	Average speed (m/s)	Avoidance rates[2] (%)
Buzzard	0.52	1.2	13.3	98
Grey heron	0.94	1.85	12.5	98
Kestrel	0.34	0.76	10.1	95
Little egret	0.6	0.92	9.2	98
Lesser black-backed gull	0.58	1.42	13.1	98
Mallard	0.58	0.9	22.35	98
Mute swan	1.52	2.23	15.64	98
Sparrowhawk	0.33	0.62	11.3	98
Snipe	0.26	0.46	17.1	98

[2] Avoidance rates refer to the frequency at which birds may avoid a wind farm. SNH (2018) guidance states that this may be due to displacement from the area, avoidance of turbines or evasive action to prevent a collision. Avoidance rates may be different for different bird species and SNH (2018) guidance provides a list of recommended avoidance rates that should be applied to raw collision risk probabilities.

4. MODEL DETAILS

Collision risk calculations have been performed using a random flight model as detailed by Band *et al.,* (2007).

The planned turbine model for the 6 no. turbines of the proposed development is the Vestas V150. Details of the turbine parameters are show in Table 4.1 (below):

Table 4.1: Wind Farm and Wind Turbine Parameters

Parameter	Value	Notes
Hub height (m)	100	Information provided by client
Blade diameter (m)	150	Information provided by client
Blade radius (m)	75	Calculated
Maximum swept height (m)	175	Information provided by client
Minimum swept height (m)	25	Calculated
Number of blades	3	Information provided by client
Maximum blade chord depth (m)	4.2	Information provided by client
Fastest rotational speed (r.p.m)	12.9	Information provided by client
Fastest rotation period (s)	4.76	Calculated
Blade pitch (degrees)	6	Typical value
Number of turbines with these dimensions proposed	6	Information provided by client
Wind farm operation (%)	85	Typical value

5. EXAMPLE CALCULATION OF THE COLLISON RISK FOR BUZZARD (*BUTEO BUTEO)*

An example of a collision risk calculation used for buzzard is provided below.

Buzzard is a resident species in the area around the proposed wind farm site. A total of 8931.33 bird-seconds (i.e. each flight duration was multiplied by the number of birds flying) of buzzard flight time within the rotor swept height was observed from the VP watches in the winters 2019/20, 2020/21 and summers of 2019 and 2020. A correction factor was applied to all raw flight times (i.e. all flight times were multiplied by (100/97.46) to account for viewshed coverage. All flight times across the 2 years of surveys were averaged to calculate a mean annual flight time.

The total watch time across two summers and two winters was a total of 288 hours 16 minutes or 1,037,760 seconds. As flight times were averaged to mean annual flight times, the watch time was also assumed to be for a single summer and single winter i.e., a total of 144 hours 8 minutes or 259,200 seconds

(i) To calculate the probability of a bird flying through the rotor swept area:

Note, the time at rotor swept height, proportion of observation time at rotor swept height and flight activity per visible hectare was calculated individually for each VP viewshed. Flight activity per visible hectares was averaged across both VPs. This accounts for the overlap in the areas that were viewed from different VPs. For the sake of brevity, only calculations for VP1 are shown below.

Flight time (corrected and averaged over 2 years) at which buzzards were recorded at potential collision height (PCH; heights between 25 m and 175 m) at VP viewshed 1: 8378.316 bird-seconds.

Proportion of total observation time during which buzzards were recorded in flight at PCH:

(1) t = 4189.158 / 259,350= 0.016152527(proportion)

The proportion of flight activity per hectare of visible area, F = t/Area of VP1 viewshed.

(2) F = 0.016152527/ 298.5 = 5.41 x 10^{-5} (proportion per hectare) for VP1.

This process was then repeated for the VP2 viewshed. The mean value of F across both VP viewsheds = 2.878 x 10^{-5}

The Flight Risk Area of the proposed wind farm (calculated in QGIS as the area of a minimum convex polygon based on the locations of all proposed turbines, surrounded by an additional buffer corresponding to the 75 m rotor radius) = 1,077,215.795m^2.

Therefore, the proportion of flight time spent at PCH in the wind farm area is:

(3) t2 = F * (Flight Risk Area / 10,000) = 3.004 x 10^{-5}
(4) * (1,077,215.795/ 10,000) = 0.003100 (proportion)

In order to account for buzzard occupancy over the summer survey period, birds have been assumed to be present between April to September inclusive (183 days). An assumption is made that the birds are active for 12 hours per day during summer. For winter, birds have been assumed to be present between October to March inclusive (182 days) and have been assumed to be active for 8 hours per day.

Note: Snipe was assumed to be active for 15 hours a day in summer to account for crepuscular/nocturnal display flights

(5) Occupancy, n of risk area per year = 3,652 * 0.003100 = 11.322 hours per year.

The flight risk volume, Vw = flight risk area * diameter of rotors

(6) Vw = 1077215.795m^2 * 150 metres = 161582369.3m^3

Volume swept by the rotors, Vr = number of turbines * πr^2 * (d+l), where d is the average depth of the rotors, l is the average length of the birds and r is the radius of the rotors (75 m). Average chord length is assumed to be the same as average rotor depth.

(7) Vr = 6 * π*$(75)^2$ * (4.2 + 0.52) = 500,455.7097m^3.

The bird occupancy of swept volume, b = n * (Vr/Vw) * 3,600, where n is the bird occupancy for the year, from (4) above.

(8) b = 11.322 * (500,455.7097/ 161582369.3) * 3,600 = 126.248 seconds per year.

Time taken for a bird to fly through rotors of one turbine, t3 = (d+l)/v, where v is the average velocity of the birds.

(9) t3 = (4.2 + 0.52) / 13.3 = 0.354887218 seconds.

Therefore, number of bird transits through the rotors is:

(10) b / t3 = 126.248 / 0.354887218 = 355.740 bird transits per year.

(ii) To calculate the probability of the birds colliding with the turbine rotors:

The probability of a bird actually colliding with the turbine blades when making a transit through a rotor depends on a number of factors that are imperfectly known and at present have to be estimated. Not least of these is the avoidance factor that is used to approximate the ability of birds to take evasive action when coming close to wind turbine blades. The method of Band *et al.,* (2007) makes a number of assumptions: birds are assumed to be of a simple cruciform shape, turbine blades are assumed to have width and pitch angle, but no thickness, birds fly through turbines in straight lines and their flight is not affected by the slipstream of the turbine blade etc. In the calculations the length of a buzzard is taken to be 0.52 metres and the wingspan 1.2 metres (these figures are the means of published ranges taken from the BTO website on 09/08/2021). The flight velocity of the buzzard is assumed to be 13.3 metres per second. The maximum chord of the blades is taken to be 4.2 metres, pitch is assumed to be 6 degrees and the rotation cycle at maximum operating speed is taken to be 4.76 seconds per rotation.

A probability, ρ (r, ϕ), of collision for a bird at radius r from the hub and at a position along a radial line that is at angle ϕ from the vertical is calculated. This probability is then integrated over the entire rotor disc, assuming that the bird transit may be anywhere at random within the area of the disc.

Scottish Natural Heritage have made available a spreadsheet to aid the calculation of these probabilities (http://www.snh.gov.uk/planning-and-development/renewable-energy/onshore-wind/bird-collisionrisks-guidance/). For a full explanation of the calculation methods see Band *et al.,* (2007).

Assuming the worst-case scenario (i.e., shortest rotation time and bird flapping rather than gliding), the average of the upwind and downwind probabilities of collision is 6%.

Estimated maximum operation of the wind farm is assumed to be 85%.

So, the product of the number of bird transits per year and the probability of collision (assuming 85% operation) is:

(11) 355.74 X 0.06 X 0.85 = 18.19 collisions per year, without any avoidance of the turbine blades by the birds.

The SNH (SNH, 2018) recommended avoidance rate for buzzard is 98%.

Therefore, the predicted number of buzzard collisions per year with 98% avoidance is:

(12) 18.19 X (1-(98/100)) = **0.36 collisions per year**.

This is equivalent to one collision approximately every 2.75 years using the flight data between 25 and 175 metres.

The calculations detailed for buzzard above were also carried out for each of the other target species.

6. RESULTS

The results of the collision risk calculations for all target species are shown in Table 6.1 below. The avoidance rate factors used are as recommended by Scottish Natural Heritage (SNH, 2010; SNH 2018). Note that it should be cautioned that VP surveys are not a recommended method of recording snipe flight activity, as a significant proportion of display and other flight activity is crepuscular and unlikely to be meaningfully recorded. To account for this, snipe was assumed to be active for 15 hours a day in the collision risk calculations.

For all target species, the probabilities of collision with turbines were all < 1 per year, except for lesser black-backed gull with 1.33 predicted collisions per year. This is due to several large flocks (maximum count of 34 birds on 04/09/20) being recorded during a small window, rather than a constant movement of the species throughout the survey period.

Table 6.1: Collison Risk Modelling Results

Species	Number of predicted collisions per year[3]	Number of years between predicted collisions	Number of predicted collisions in 30-year nominal lifespan of wind farm
Buzzard	0.36	2.75	10.91
Grey heron	0.01	78.92	0.38
Kestrel	0.26	3.85	7.79
Little egret	0.00	1839.01	0.02
Lesser black-backed gull	1.25	0.80	37.53
Mallard	0.62	1.62	18.47
Mute swan	0.00	283.29	0.11
Sparrowhawk	0.01	86.52	0.35
Snipe	0.00	554.03	0.05

[3] With correction factors applied for the following: avoidance rates, operating time, and fact that 97% and not 100% of the study area was visible during surveys. Where the number of predicted collisions is shown as 0.00, it means the number of predicted collisions are <0.01 per year.

7. DISCUSSION

From the collision risk probabilities calculated, it can be concluded that the proposed Annagh Wind Farm will have a negligible effect on collision risk for the populations of all target species, except for one. No collisions (<1 predicted collision) are predicted for fourteen target species (black-headed gull, buzzard, cormorant, common gull, goshawk, grey heron, hen harrier, kestrel, little egret, mallard, mute swan, peregrine, sparrowhawk, and snipe) in the 30-year nominal lifespan of the wind farm. The one case of concern is that of amber-listed lesser-backed gull which has been predicted to have 1.25 collisions per year or 37.53 over the course of the thirty-year lifespan of the proposed wind farm. This figure, however, originates from several sightings of large flocks, the largest of which contained 34 birds. These sightings occurred over a small time frame, rather than being spread out over the span of the two-year study, and this this may have skewed results. A total of seven flocks were noted, the smallest of which contained four birds. Of these seven flocks, six occurred on 04/09/20, with the other on 08/01/20. All flocks noted in September 2020, were described as flying in the "same direction and manner" and it was further noted that a farmer spreading slurry in the fields at the time was likely attracting the birds. Thus, it is highly likely that such numbers of birds on site is an event which is limited to rare slurry-spreading events.

The Band CRM model involves making a number of assumptions. The amount of time that a species may be active within the site is also required for the model and must be estimated with respect to the bird species' known behaviour and observations of its occurrence at the study area.

The model assumes that no action is taken by a bird to avoid collision, so that the unadjusted collision risk figures derived are purely theoretical and represent worst case estimates. In reality, birds are able to perceive potential obstacles while in flight and actively take avoiding action. Given the general absence of empirically derived avoidance estimates for individual species, additional assumptions about likely levels of active avoidance on the part of birds are generally made in order to draw conclusions. Available evidence to date (SNH, 2010; SNH, 2017; Fernley *et al.*, 2006; Whitfield & Madders, 2006; Whitfield, 2009; Whitfield & Urquhart, 2015) suggests that avoidance rates are well in excess of 95%. Accordingly, outputs from collision risk analysis where precautionary avoidance rates are used must be interpreted with care.

The Band model favoured by SNH has been the subject of academic study regarding its relevance and usefulness (Chamberlain *et al.*, 2005; Chamberlain *et al.*, 2006) and the conclusions have been that the model can be considered to be mathematically robust. However, the main influence on the final result of collision risk analysis is the avoidance rate that is applied to the model; and without accurate avoidance rates, the usefulness of the model as a predictor of impact can be badly impaired. The avoidance rate factors used are those that are currently recommended by SNH (SNH, 2010; SNH, 2018). These avoidance rates are widely considered to be highly precautionary in nature. It should be remembered that the difference between an avoidance factor of 98% and 99% will have the effect of doubling the calculated annual collision rate. In many cases where collision mortality has been monitored for operating wind farms, observed mortality has been below that which was predicted by modelling pre-construction bird survey data.

In the case of the calculations for the proposed Annagh wind farm site, a conservative approach was taken in the choice of which bird flights to include in the collision risk calculations. In addition, a worst-case scenario i.e. shortest rotation time (top turbine rotating speed) and birds flapping, rather than gliding has been used. Other studies use the mean of the worst-case scenario and best-case scenario (longest rotation period and bird gliding rather than flapping) probabilities. Finally, the calculations have used the conservative downtime estimate (15%, or turbines rotating 85% of the time), but in reality, this level of downtime may be greater. A conservative correction factor was also applied to the recorded flight durations based on the assumption that 97.46% of the 500 m turbine buffer area was visible during surveys. Therefore, the likely empirical collision mortality figures should be lower than those presented here.

In conclusion, the results show that the proposed Annagh Wind Farm will likely have negligible impacts on populations of the all but one species (amber-listed lesser black-backed gull). It is noted that most records of this species over two years of surveys were concentrated around a single event, with large flocks being attracted to slurry spreading near the site. As such the predicted collision risk is the result of an anthropogenic event, rather than being representative of the habitual movements of this species.

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