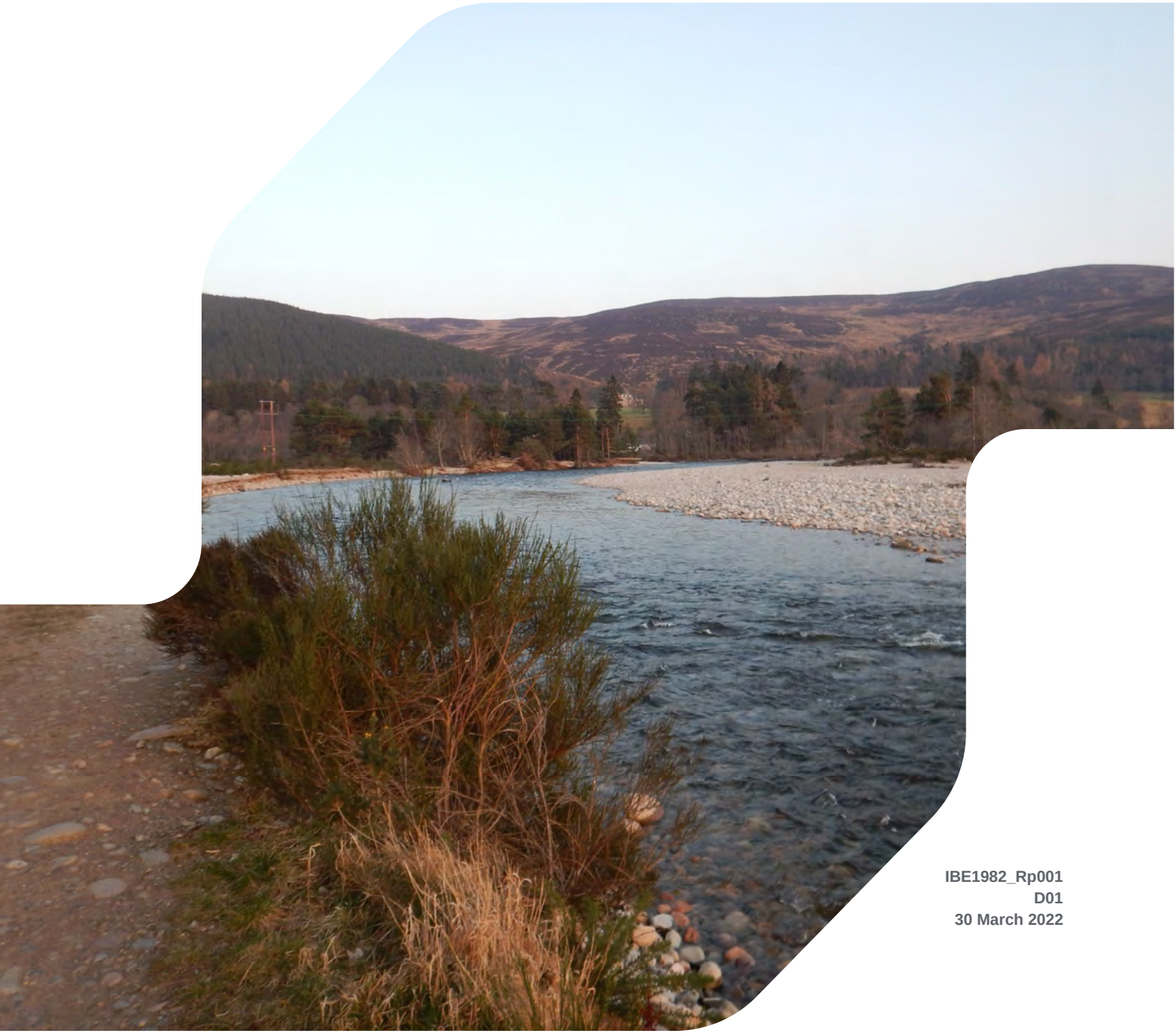
Appendix A

Defence condition inspection

BALLATER ADDITONAL FLOOD STUDY

Defence Condition Inspection



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1 INTRODUCTION

1.1 Background

Ballater is located within the Cairngorms National Park in West Aberdeenshire, Scotland. The River Dee, which is a Special Area of Conservation for salmon, trout, otters, and freshwater pearl mussels, flows through Ballater. The confluences of the River Gairn and the River Muick with the Dee are also located close to the town (see Figure 1.1).

The Ballater Flood Protection Study (FPS) focused on management of the main source of flood risk from the River Dee and its two significant tributaries, the Rivers Gairn and Muick, and was undertaken as part of the current cycle of the Flood Risk Management Plan. The Ballater Additional Flood Study is focussed on assessing any change in flood risk associated with recent changes in the river flow path and assessing potential minor works that might be implemented to manage flood risk until such time that a decision is made on implementing the main scheme.

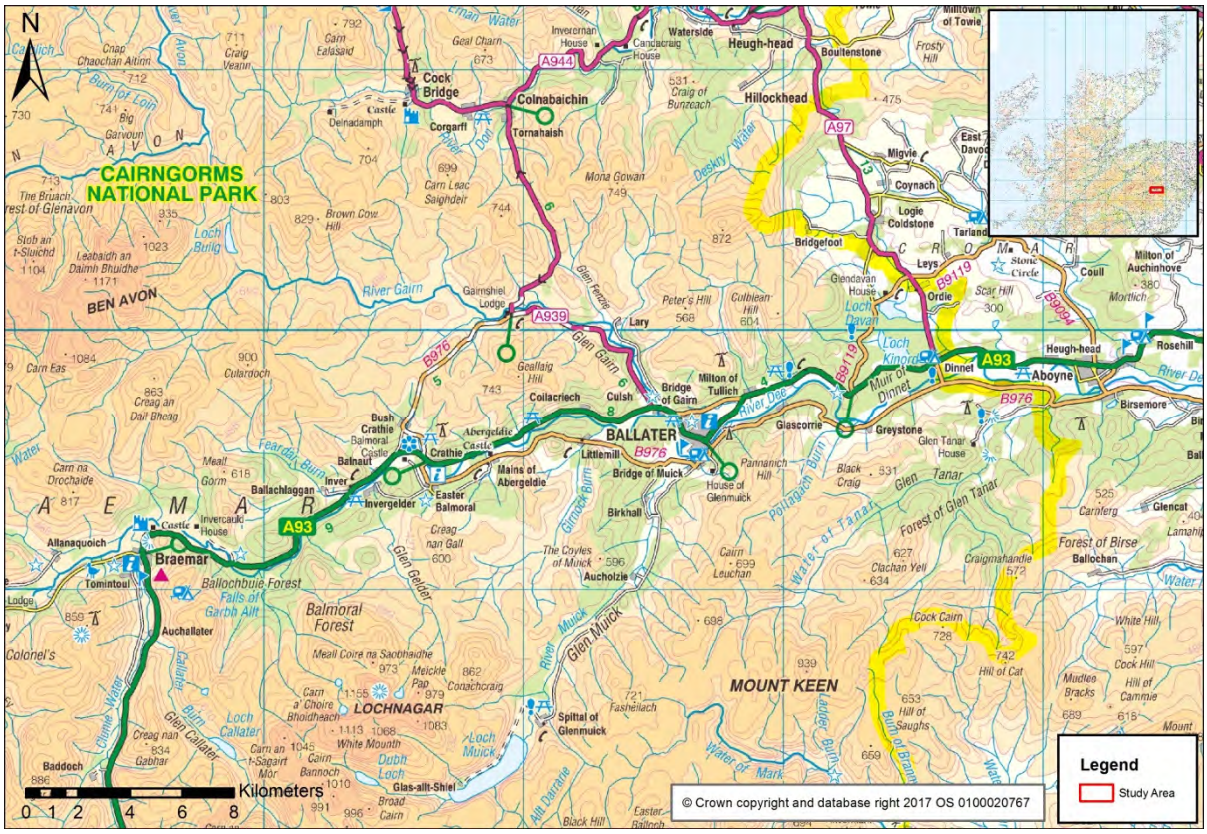

Figure 1.1 Location of Ballater, West Aberdeenshire

1.2 Objectives of the Study

The objective of this element of the additional study was to revisit site and determine any change in the structural condition of the existing flood risk management assets since they were last inspected in 2018. This

report documents the findings of a visual condition survey undertaken for the existing informal flood defence lines along the River Dee in Ballater, to the same extent as was surveyed in 2018, as indicated in Figure 1.2.

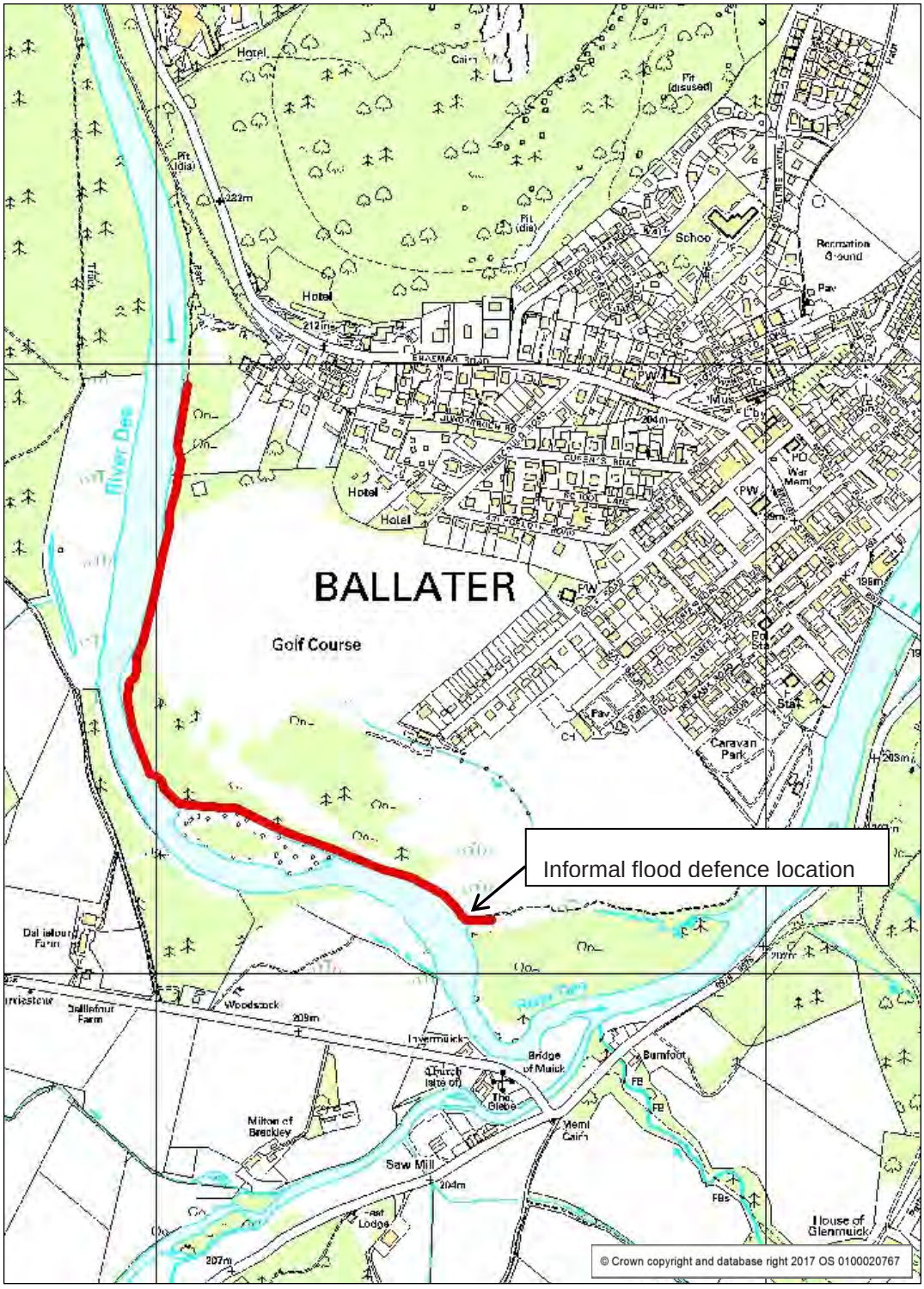

Figure 1.2 Location of informal flood defence in Ballater (2018)

2 DEFENCE CONDITON SURVEY

2.1 Overview

Previously an experienced Coastal/ River Engineer from RPS visited Ballater on 18th and 20th April 2018 to undertake a visual inspection of the existing defences, based on the procedures set out in the Environment Agency Condition Assessment Manual. Weather conditions during the survey were fair, although river levels were elevated, as a result of snow melt. The surveyor initially walked the length of the defences in the company of a representative of Aberdeenshire Council starting at Salisbury Road and working upstream. A subsequent follow up visit was undertaken to check anomalies in initial GPS positions and re-examine key areas.

The same Engineer again visited the area on 23rd and 24th March 2022 to repeat the visual condition assessment of the defences identified in 2018 and any additional defences. In this document images of the majority of the defences as observed in 2018 and 2022 are presented for comparison. During the site visit in 2022, in addition to walking the line of the informal flood defences noted in 2018, the entire length of the river from immediately upstream of the Royal Bridge to the vicinity of Craigendarroch upstream was walked.

2.2 Inspection Notes

It was noted that a wall alongside the river immediately upstream of the Royal Bridge, not noted in the 2018 inspection appears to provide flood protection to residential properties at Cornellan Square as shown in Plate 1 and Plate 2. This wall appeared to be of relatively recent construction and to be in **Good** condition. Access to the riverside path is facilitated via steps over the wall as shown in Plate 1.

Plate 1 View of rear face of wall at Cornellian Square (2022)

Plate 2 View of riverside face of wall at Cornellian Square (2022)

Further upstream, to the south of Cornellian Square, the wall type changes to an older wall of slightly lower height as shown in Plate 3. This wall also appeared to be in **Good** condition, with no obvious defects visible.

Plate 3 Overview of walls upstream of Royal Bridge (2022)

Upstream of Dee Street, no evidence of any raised embankment or other flood defence structures were observed at the Caravan Park, as shown in Plate 4 and Plate 5.

Plate 4 Riverbank upstream of Dee Street (2022)

Plate 5 Riverbank at Caravan Park (2022)

Beyond the Caravan Park the riverside path extends westwards along the River Dee through an area of rough land at the southern boundary of the Golf Course, on slightly raised ground as shown in Plate 6.

Plate 6 View of riverside path along southern boundary of the Golf Course (2022)

During the 2018 inspection a flood defence embankment was encountered at Grid Reference 36549,95086, see Plate 7, extending upstream along the bank of the River Dee until circa grid reference 36049,95965. In 2018 the embankment between 36617,95012 and 36465,95159 was observed to be constructed of riverbed material and the observed lack of significant vegetative cover indicated this to be of relatively recent construction. The embankment in this area stood between 1.5 and 2m above the ground behind with a crest width of 2-3m. This section of the Ballater flood defences was assessed to be in **Fair** to **Poor** condition in 2018 on account of the steep faces of the embankment and the lack of significant stabilising vegetation.

During the 2022 inspection there was no evidence of this embankment, and the riverbank was encountered at 36595,95092, see Plate 8, i.e. approximately 45m east of where it was in 2018. Plate 9 and Plate 10 show the view south from the point at which the path met the river in 2019 and 2022 respectively, and again it is noticeable that there is now no raised embankment. The change in the river course in this area is further illustrated in Plate 11 and Plate 12 which show the route of the main river channel to have switched from right (west, Glen Muick) side to the left (east, Ballater) side.

Plate 7 Embankment at south end of Golf Course looking NW (2018)

Plate 8 Same area at south end of Golf Course looking NW- no embankment present (2022)

Plate 9 Embankment at south end of Golf Course looking SE (2018)

Plate 10 View south from point at which path meets river (2022)

Plate 11 General View of River Upstream of Confluence with the Muick (2018)

Plate 12 General View of River Upstream of Confluence with the Muick (2022)

Continuing north-westward along the embankment the 2018 inspection noted the formation of the embankment to incorporate a boulder toe on the river side as shown in Plate 13. This form of construction extended from 36465,95139 to around 36323,95186 beyond which the boulder toe ceased although erosion protection was provided by a vegetated bank of river deposits. This section of the embankment was the subject of the repairs Aberdeenshire Council undertook in 2016.

The core of the embankment appears to be composed of a mix of cobble, gravel, and sandy soil, potentially riverbed material, however it was significantly more heavily vegetated than the embankment to the south, as

shown in Plate 14. The ground to the rear of this section of the embankment was noted to be significantly higher than to the south with the embankment height being observed to be circa 1m with a similar crest width to the previous section of the embankment. There was no significant evidence of the deposition of material on the ground behind or of recent breach/over-topping of this section of the embankment. In general, this section of the embankment was classified as being in **Good** condition.

Corresponding images of this embankment from 2022 are presented in Plate 15 and Plate 16 and indicate little change in the formation or condition of this structure. Thus, this part of the flood defence embankment would still be classed as being in **Good** condition although some evidence of the large boulder at the toe starting to move was noted at the southern end.

Plate 13 Embankment with boulder toe (2018)

Plate 14 Vegetation on northern section of embankment with boulder toe (2018)

Plate 15 Embankment with boulder toe (2022)

Plate 16 Vegetation on northern section of embankment with boulder toe (2022)

Continuing westwards the 2018 inspection noted the embankment to remain in **Good** condition, Plate 17 and Plate 18, until approximately 36133,95261 where the river side face was observed to be partially eroded, Plate 19. This was considered to most likely be due to pedestrian activity given the very localised nature of the erosion although it is possible that it was the result of the removal of a large tree and root system during recent floods. Similar images from 2022 are presented in Plate 20 to Plate 22 which show very little observable change from the images recorded in 2018 with the same area of damage still being visible.

This section of the embankment has a relatively low height (1-1.5m) and good crest width (circa 3m). Again, the embankment appears to have been formed from typical river/ glacial deposits with evidence of cobble visible amongst the vegetative cover. Generally, this section of the embankment is in **Good** condition, however, the damaged section was assessed as being in **Poor** structural condition due to the exposure of the core material.

Plate 17 Typical view of embankment beyond Golf Road (2018)

Plate 18 Typical view of embankment (2018)

Plate 19 Partial breach of embankment at 36133,95261 (2018)

Plate 20 Typical view of embankment beyond Golf Road (2022)

Plate 21 Typical view of embankment (2022)

Plate 22 Partial breach of embankment at 36133,95261 (2022)

The embankment continues in a similar form with extensive vegetation, including mature trees evident until circa 36000,95275 as shown in Plate 23 and Plate 25. Similar images from 2022 are presented in Plate 24 and Plate 26 which show little change in the nature or condition of the embankment.

Plate 23 Pathway on embankment crest (2018)

Plate 24 Pathway on embankment crest (2022)

Plate 25 Mature trees both sides of embankment (2018)

Plate 26 Mature trees on both sides of embankment (2022)

Beyond 35005,05316 the embankment appeared to have been recently re-constructed using sand and gravel at the time of the 2018 inspection as shown in Plate 27 and Plate 29. These works appeared to be in response to the previous embankment having been over-topped as evidenced by the present of riverine detritus and debris scattered amongst the forest area behind, see Plate 31. Equivalent images from 2022 are presented

in Plate 28 and Plate 30 which show evidence of scouring of the finer material from the path, potentially indicative of this section of path having been over-topped. However, the riverside face has become extensively vegetated indicating that the underlying structure is reasonably stable.

Plate 27 Re-profiled embankment (2018)

Plate 28 Re-profiled Embankment (2022)

Plate 29 Unvegetated face of re-profiled embankment (2018)

Plate 30 Former unvegetated face of embankment (2022)

Plate 31 Riverine deposits behind embankment, including former fisherman's hut (2018)

In 2018 the condition of the repaired section of the embankment was classified as being **Poor to Very Poor**, principally on account of the nature of the material used and the lack of vegetative cover to resist erosion and hold the material in place. However, it was noted that over time vegetation would establish on this section of the embankment, potentially increasing the condition grading to Fair. This assumption appears to have been correct based on what was observed during the 2022 inspection and thus this section of embankment can now be classed as **Fair**.

The repairs/ re-profiling of the embankment continued with some brief interruption to circa 35958,95482 beyond which it reverted to a similar vegetated form to previous sections although in this area there was more exposed cobble noted on the river side, Plate 32 and Plate 34. It was not obvious from the visual inspection if this was the remnants of a deliberate attempt to armour the exposed face of the embankment or simply the results of selective erosion having removed much of the finer material, however the embankment appeared relatively stable as evidenced by the presence of mature trees growing out of the river facing slope. Similar images from 2022 are presented in Plate 33 and Plate 35 and show little change from those taken in 2018 apart from an increase in vegetation cover.

The embankment continues in this form, Plate 36 and Plate 37, until the 14th Tee, where again little discernible difference was noted between the 2018 and 2022 inspections.

This section of the embankment was assessed to be in **Good** condition at the time of both site inspections.

Plate 32 Typical view of embankment south of the 14th Tee (2018)

Plate 33 Typical view of embankment south of the 14th Tee (2022)

Plate 34 Embankment south of the 14th Tee showing exposed cobble (2018)

Plate 35 Embankment south of the 14th Tee showing more vegetation over exposed cobble (2022)

Plate 36 View of embankment approaching 14th Tee (2018)

Plate 37 View of embankment approaching 14th Tee (2022)

During the 2018 inspection it was noted that there was a noticeable gap in the presence of mature vegetation on the embankment alongside the 14th Tee, Plate 38. It was not known if this was a result of deliberate vegetation management or the consequence of a reported breach during Storm Frank. Plate 39 shows the

same area at the time of the 2022 inspection and shows even less scrub vegetation that in 2018 indicating that the limited scrub coverage is probably a consequence of vegetation management.

Plate 38 Scrub vegetation on embankment at 14th Tee (2018)

Plate 39 Scrub vegetation on embankment at 14th Tee (2022)

Irrespective of the reason for the lack of mature vegetation, the riverside face of the embankment was observed to be “armoured” with exposed boulders and cobble as shown in Plate 40, which was assessed to be in **Good** condition. There was no evidence of armouring on the landward face and the vegetation cover was limited to grass, but again this warrants a **Good** classification. Plate 41, shows the same area in 2022 and confirms the 2018 classification of **Good** condition.

Plate 40 Exposed cobbles/boulders on river side of embankment at 14th Tee (2018)

Plate 41 Exposed cobbles/boulders on river side of embankment at 14th Tee (2022)

Immediately north of the 14th Tee the landward face of the embankment is composed of built masonry as shown in Plate 42 and Plate 43. This form of construction may also have extended to the riverside face, however it is now interrupted by the establishment of mature trees and other vegetation as shown in Plate 44 and Plate 45. Generally, this section of the embankment appears to be in **Fair** to **Good** condition.

Plate 42 Masonry revetment to rear face of embankment north of 14th Tee (2018)

Plate 43 Masonry revetment to rear face of embankment north of 14th Tee (2022)

Plate 44 River face of embankment north of 14th Tee (2018)

Plate 45 River face of embankment north of 14th Tee (2022)

North of approximately 36020,95756 the riverside path drops off the crest of the embankment to run along the ground behind the embankment as shown in Plate 46 and Plate 47 and continues like this until circa

36034,95854. The embankment along this section comprised a narrow bank approximately 1.2-1.3m high with no significant crest, Plate 48 and Plate 49.

Plate 46 Transition of riverside path from top of embankment to land behind (2018)

Plate 47 Transition of riverside path from top of embankment to land behind (2022)

Plate 48 Typical view of embankment north of 36020,95756 (2018)

Plate 49 Typical view of embankment north of 36020,95756 (2022)

This embankment appears to be formed of a pile of predominantly cobble and while vegetated, the 2018 inspection identified numerous small holes as shown in Plate 50. These holes did not show any clear evidence of being animal burrows and were thought to be related to the makeup of this structure being predominantly

large cobbles and boulders with little fine material. The structure was assessed as being or **Poor** condition. At the time of the 2022 inspection there was less vegetation cover and none of the holes noted in 2018 were visible, Plate 51, however a precautionary grading of **Poor** was still considered relevant.

Plate 50 Holes in raised embankment (2018)

Plate 51 Rear face of raised embankment (2022)

North of approximately 36034,95854 the path again re-joins the riverbank with a low “embankment” running along the landward side of the path as shown in Plate 52 and Plate 53 as far as 36049,95965 beyond which no form of flood defence was observed. This structure was noted to be circa 0.5m in height with a similar crest width and was assessed as being in **Good** condition.

Plate 52 Low embankment on landward side of path (2018)

Plate 53 Low embankment on landward side of path (2022)

2.3 Summary of Defence Condition Inspection

In summary the visual assessment of the existing flood defence structures at Ballater undertaken by RPS in 2018 showed that the condition of the existing defences ranges from Good to Very Poor with the lower grading generally applying to areas that appeared to have been repaired following Storm Frank. At the time of the 2018 inspection, it was considered that with time, vegetation establishment may provide some erosion protection and hence allow those structure to be re-graded as Fair and possibly Good although that is probably dependent on the number and frequency of flood events that they are subject to during this period.

It was also noted that while the preceding assessment considered the condition of the embankment slopes the presence of the unbound path along the crest of virtually all of these defences represented a potential weakness should they be overtopped as there was nothing to bind this material together and resist erosion. Thus, in terms of the EA condition assessment guidelines virtually all of the structures could only achieve an overall grading of **Fair**.

3 ASSESSMENT OF MINOR WORKS PROPOSALS

A secondary function of the RPS site visit in March 2022 was to evaluate the practicality of and potentially inform a subsequent appraisal of the benefit of implementing the following minor works measures:

1. Removal of dead trees from river channel and reuse in bank reinforcement,
2. Clearance of deposited gravel from main river channel on Glenmuick side,
3. Clearance of outlet channel for watercourse across Golf Course,
4. Build new bund across rough ground at southern end of Golf Course.

3.1 Removal of dead trees/debris

During the site inspection it was noted that significant amounts of fallen trees and other debris, were caught between the standing tree on the floodplain, Plate 54, particularly on the left bank upstream of the caravan park. This debris will represent a significant resistance to water flow through this area during flood events and potentially increases water levels upstream.

Plate 54 View of debris caught amongst standing trees on floodplain and bend upstream of Caravan Park

Removal/ clearance of this debris should increase conveyance along this section of the flood plain, however the impact of this would need to be assessed using the hydraulic model to determine if it would make any significant difference to water levels adjacent to the Golf Course even during low return period flood events. Consideration would also need to be given the potential for the enhanced conveyance resulting from the removal of this material to increase flood risk at the Caravan Park, some that again would be best quantified by use of the hydraulic model before and extensive clearance is undertaken.

Assuming that the modelling does identify a beneficial impact of removing this material, it is entirely reasonable that the material extracted could be used to enhance the erosion resistance of existing defence structure or any new defence, such as that discussed in Section 3.4. However, if this approach is adopted it will be imperative that the material is adequately secured to prevent it from being washed away and further contributing to potential blockage of flow downstream.

3.2 Clearance of Channel on Glenmuick side

It was obvious from the 2022 site visit that the main flow channel of the River Dee had migrated from the Glenmuick side to the Ballater side in the area around the confluence with the River Muick, see Plate 11 and Plate 12. This change is flow path has been associated with infilling of the former flow channel with riverine gravel and sand, to the extent that the feature formerly known as the Manse Pool on the Glenmuick side no longer exists, Plate 55 and Plate 56.

Plate 55 View downstream toward the former area of the Manse Pool

The change in flow path of the River Dee is such that the flow approaching the former channel on the Glenmuick side of the river is now deflected to the east, towards Ballater which is probably what has contributed to the bypassing of the former Glenmuick channel. The exact reason for this change in flow path is uncertain, however from what could be observed on site, and derived from a review of online historic mapping it appears that the left-hand bend upstream has become more pronounced, which combined with potentially more resistant bank material on the Glenmuick side has resulted in the change in flow direction. Thus, while it may appear desirable to excavate the deposited material from the former channel on the Glenmuick side, it is very doubtful that alone would result in the River Dee returning to its former path. It was also observed that the quantity of material to be moved in such an operation would not be insignificant for potentially limited benefit.

Plate 56 View upstream of the former site of the Manse Pool

Plate 57 Flow across former Glenmuick Channel at Ballater

While complete removal of the deposited material from the former channel on the Glenmuick side of the River Dee channel is unlikely to be an achievable solution, there may be merit in the removal or redistribution of some material from the northern end of the cobble bank that has become established to try to encourage the Dee to take a more southerly trajectory. The suggested area for consideration for re-profiling is indicated by

the red oval in Plate 58, which clearly shows how this gravel bank was forcing flow northwards at the time the image was captured. It is unlikely that this would make any significant direct contribution to the management of flood risk at Ballater, however it may reduce the potential threat of further erosion along the left bank of the river and hence the risk of further section of the informal flood embankment/ footpath being lost.

Plate 58 Google Image showing area of cobble bank that is deflecting flow towards Ballater

3.3 Clearance of Outlet channel at Golf Course

The minor watercourse that flows through/ under the Golf Course discharges to the River Dee just upstream of the caravan park. Whilst the channel within the Golf Course is well maintained and free of debris, once it passes beyond the actual playing course it flows through the area of tress and scrub on the inside of the bend of the river at the confluence of the River Dee and River Muick and this section is heavily choked with debris from previous flood event on the Dee. Plate 59 show a typical example of the accumulation of debris and silt/sand across the channel which is an obvious impediment to flow.

Plate 59 Typical debris pile in Golf Course stream channel

Clearance of this channel would increase its conveyance potential, which should assist in draining flood waters from the area of the Golf Course and hence might to some degree reduce the flood risk to the developed area of Ballater particularly during more frequent flood events. However, as with the general clearance of flood debris from the floodplain the effect of clearing this channel would need to be examined via the hydraulic model to ascertain what benefit would accrue. Whilst it is unlikely there is also a possibility that clearance of this channel could allow any backed-up flood water from the area immediately upstream of the Royal Bridge to flow back on to the Golf Course potentially increasing the flood risk to the developed area on Ballater. Thus, before any decision can be made on the effectiveness of this measure the updated hydraulic model simulations would need to be completed.

3.4 New bund at southern end of Golf Course

At the time of the 2018 site inspections there was a river side bund present at the south end of the gold course, Plate 7, which is understood to have been washed away during the flood event of February 2021, Plate 8. Anecdotal reports from locals on the February 2021 event suggest that his structure held back flood water for some time, before succumbing to erosion and therefore may have reduced the extent of flooding experienced. Consequently, there is concern locally that the lack of this structure may represent an increased flood risk to Ballater even during relatively frequent flood events. One of the tasks associated with the Ballater Additional Flood Study is to update the previously developed hydraulic model to reflect the post February 2021 channel geometry and establish how this has affected the flood risk to Ballater. This task will confirm if there is indeed an increased flood risk to Ballater and hence the potential need for remedial works to maintain the previous standard of flood protection.

Irrespective of the outcome of the modelling, it was clear from the site inspection that the re-establishment of a flood defence along the present riverbank is unlikely to be sustainable due to the change in orientation of the River Dee, something that is also accepted by the Golf Club and local representatives. Visual examination of the topography within the area of rough ground belonging to the golf Club at the south end of the course identified a potential alternative line making use of generally raised ground levels extending in a more or less straight line between circa, 36599,95143 and 36491, 95162 that might represent a more sustainable alignment for any future flood embankment. Construction of an embankment along this alignment would involve crossing the watercourse draining the Golf Course, which flows through a low point in the topography, however culverting of this short stretch should not be a significant challenge, there are already numerous culverts and crossing throughout the Golf course and where the existing riverside pathway crosses a short distance to the south of the identified alignment.

The series of images below, Plate 60 to Plate 62, illustrate how the course of the Dee has changed in this area over the past 12 years and clearly show how it is now starting to bypass the bend that once held the Manse Pool. By constructing any flood defence along the alternative alignment indicated above, the course of the Dee would be able to continue to evolve in the area to the south, indeed it is foreseeable that the change in the path of the Dee may eventually cut right though the wooded area south of the Golf course given its present trajectory.

Plate 60 Google imagery from 2010

Plate 61 Google Imagery from 2019

Plate 62 Google Imagery from 2021