1 Ellon Flood Study

How is flood risk managed by the Aberdeenshire Council?

- The Flood Risk Management (Scotland) Act 2009 aims to prioritise flood mitigation across Scotland using a proactive and risk based process for assessing flood risk.
- This approach led to the preparation of SEPA's Flood Risk Management Strategies and the Local Flood Risk Management Plan for the North East Local Plan District developed by Aberdeenshire Council.

Study objectives

1. Develop a better understanding of flood risk in the community

- Create, update or develop a new flood model for flood mapping.
- Determine existing flood risk.

2. Engage partners and stakeholders

- Present the study to SEPA, Scottish Water and the Council.
- Present the study and the preferred option to the local community – <u>the purpose of today's exhibition.</u>

3. Develop recommendations for management of flood risk

- Appraise options to manage flood risk (consider the pros, cons and economic viability of the proposed options).
- Recommend options for the future management of flood risk.

4. Select a preferred approach that the Council can take forward

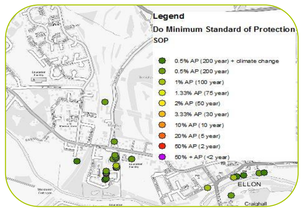
- SEPA will prioritise nationally where funding should be allocated.
- The reports and findings of our study will inform this process. Preferred option from this report must be submitted by 31st Dec 2019

What has been done so far?

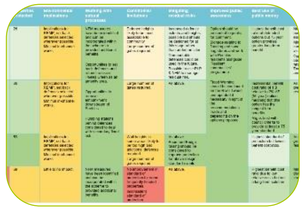
Flood review

River Surveys

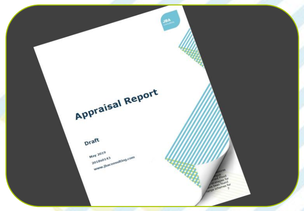
Modelling & mapping



Properties at risk and current standard of protection assessed



Options appraisal



Reporting

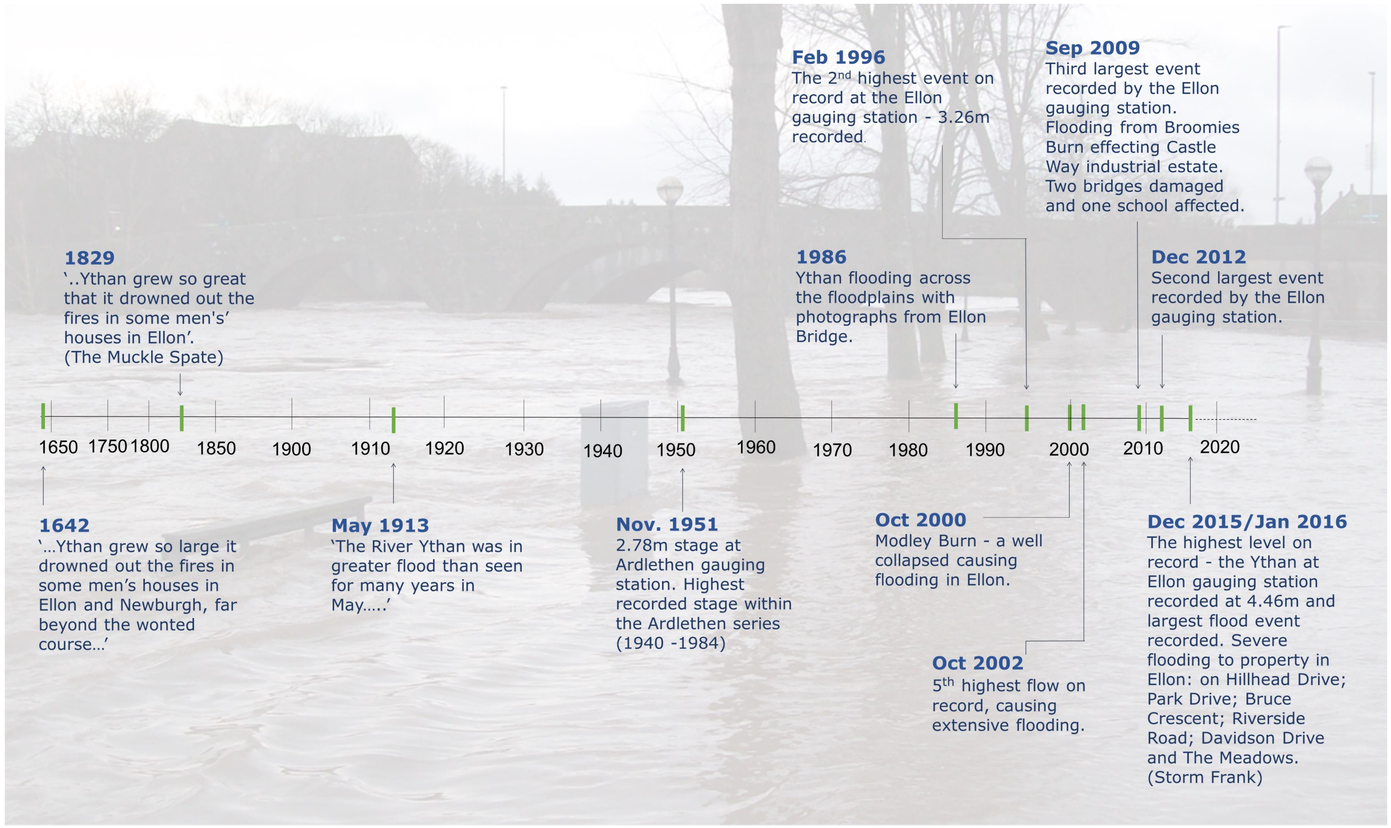
What happens next?

Moving beyond this point is dependent on having government funding approved (there is no formal commitment for Scottish Government funding)

Public consultation → Council review flood study and decides strategy, Area Committee review → Schemes submitted to SEPA for prioritisation in national strategy by 31st Dec 2019 → More detailed design and consultation (e.g. site investigations) → Scheme construction

Today

2 Ellon Flood History



- 2015/16 event estimated to be a 458 year event
- 200 year plus climate change estimated to be a 464 year event

Return periods and annual probabilities

- When a river floods the severity of the flood is referred to as a '1 in *x* year' flood or as having a certain percentage chance of occurring in any one year.
- For example, a 1 in 200 year flood event is simply a flood of a size large enough that it has a probability of occurring once every 200 years, i.e. it has a 0.5% chance of occurring in any one year.
- Any given flood, such as the 1 in 200 year event, will not necessarily occur at all in a 200 year period, but a flood of this size could equally occur tomorrow and again next year - this is just statistically unlikely.

The goal

Protect against a 200 year plus climate change flood event. *Climate change is predicted to increase the scale of floods in Aberdeenshire by 24%.*

The long-list of options considered for appraisal to go to short list if deemed viable

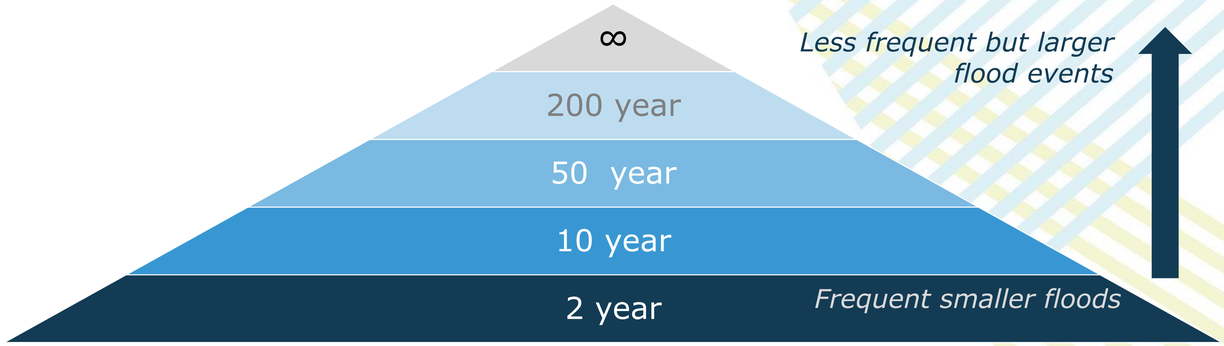
Engineering solutions:

- Storage (engineering)
- Conveyance (channel modification, diversion, realignment)
- Structure modification (enlarge culvert/bridge, trash screens)
- Control structures (weir, pumping station)
- Direct defences (wall, embankment, adaptable wall)
- Property Level Protection PLP (resistance and resilience measures)
- Sediment management (online/offline pond)

Non-structural options:

- Natural Flood Management NFM (runoff, sediment, floodplain)
- Watercourse maintenance
- Flood forecasting and warning
- Emergency planning & Local planning policies
- Self help

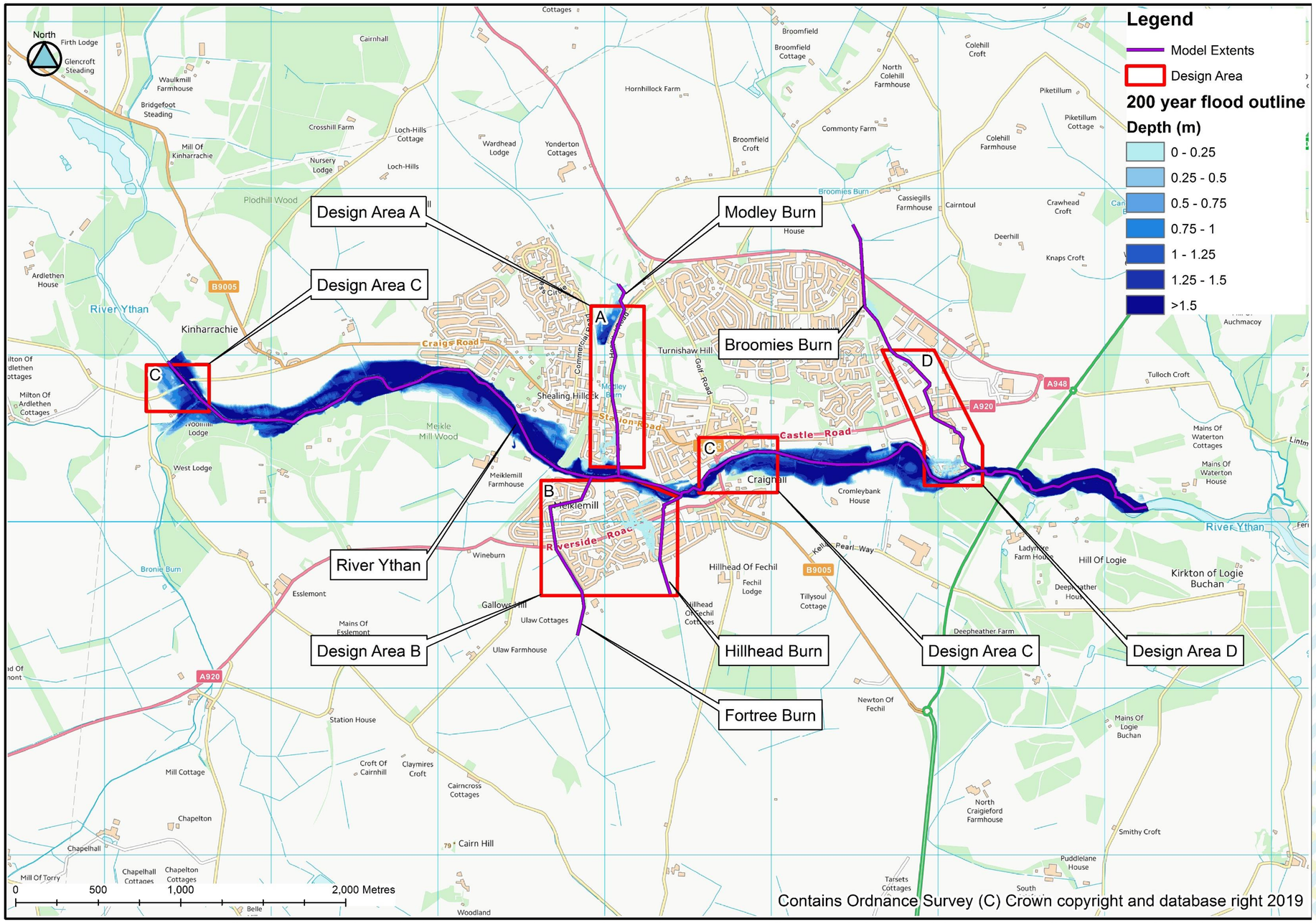
Non-structural options are expected to be carried forward alongside the engineering options.



Flood return periods

3 Ellon Watercourses

Ellon is at flood risk from the River Ythan, Broomies Burn, Modley Burn, Hillhead Burn and Fortree Burn. Each watercourse has its own mechanism of flood risk and therefore to assess flood risk, four areas have been identified.

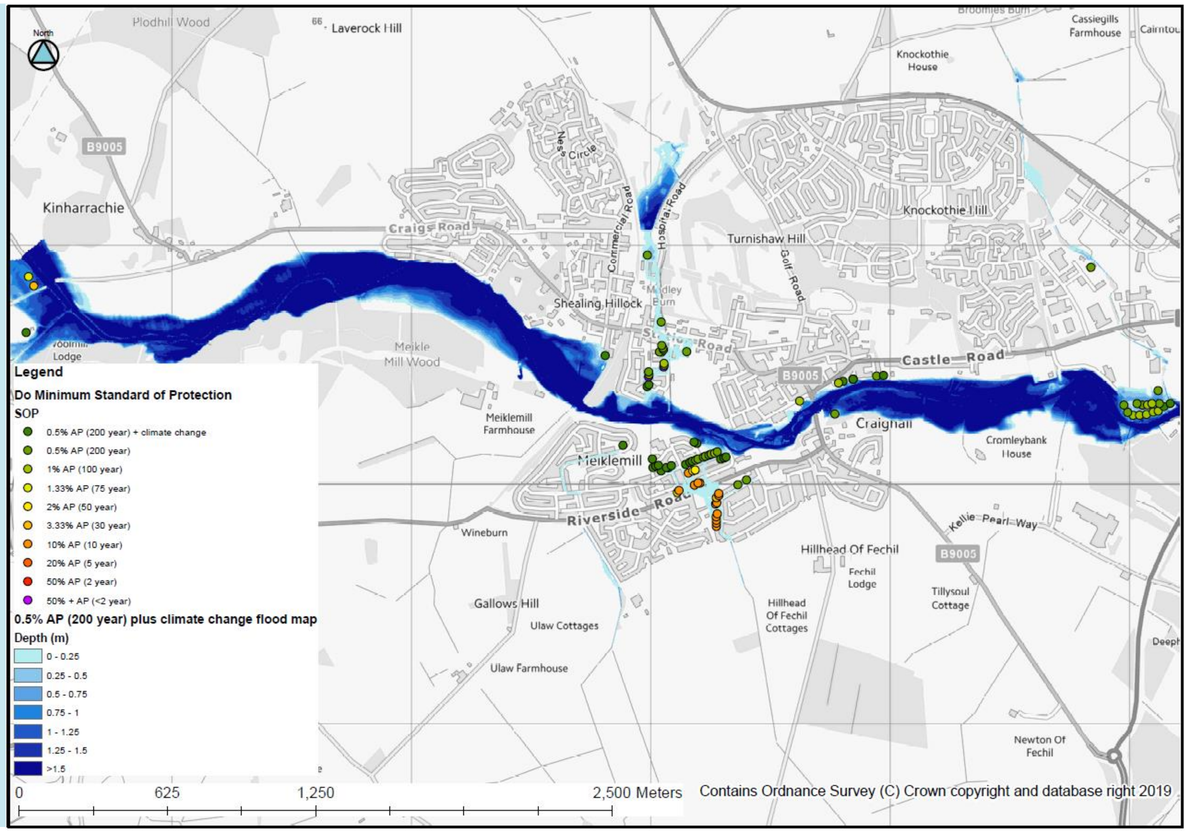


The models produced flood maps which help us to work out where the greatest flood risk lies and how water flows out of the burns and into properties.

These maps allowed us to plan where best to place flood defences or other solutions to reduce the flooding.

4 Coming up with the proposals

Standard of Protection - 200 year plus climate change flood map



The "standard of protection" map shows the maximum flood return period that each property is currently protected against. The properties shown would be expected to flood during larger floods. E.g. if a property is shown to have a Standard of Protection of 100 years, it would be expected to flood during a 200 year flood event.

Prioritising the proposals

Option	Minimum Standard of protection	Properties protected from 0.5% AP (200 year) plus CC	Environmental implications	Working with natural processes	Constraints/ limitations	Mitigating residual risks	Improved public awareness	Best use of public money	Wider benefits
Option 1 – Areas A, B, C and D hard defence, storage reservoir, two stage channel	0.5% AP – 200 year plus CC	All properties protected.	Some ecological benefits. Increase in biodiversity through storage areas and two stage channel. Minor disturbance during construction.	RBMP benefit of reconnection to a more naturalised floodplain through a two stage channel. Construction of direct defences on the channel banks will cut off some of the floodplain, although the watercourse is already highly canalised alongside Modley Place. Storage area on Hillhead Burn will also act to regulate sediment from agricultural areas.	Large direct defences required. High walls and embankments around the reservoir and storage area. High walls around The Meadows.	Protection up to the 0.5% AP (200 year event) plus climate change.	Recommendations of continued work with action groups and the community. Importance of flood warning being developed in the area.	Not cost effective due to expense of defences, benefit cost ratio of 0.3.	Minimal impacts on community other than minor aesthetics from direct defences. Standard of protection against future increase in flows.
Option 2 – Areas A, B, C and D hard defence, storage area, two stage channel	0.5% AP – 200 year	A, C and D protected. Majority of B protected.				Room for direct defences to be increased in the future. i.e. walls increased in height. Opportunities for NFM.		Not cost effective due to expense of defences, benefit cost ratio of 0.3.	Minimal impacts on community other than minor aesthetics from direct defences. Results in long term standard of protection.
Option 3 – Areas A, B and D hard defence, storage area and two stage channel. Area C PLP excluding Ythan Court direct defences	0.5% AP – 200 year	A and D protected. Majority of B and C protected.		RBMP benefit of reconnection to a more naturalised floodplain through a two stage channel. Minor implication from some construction of direct defences on the channel banks will cut off some of the floodplain, although the watercourse is already highly canalised alongside Modley Place. Storage area on Hillhead Burn will also act to regulate sediment from agricultural areas.		Room for direct defences to be increased in the future. Opportunities for NFM. Difficulty with mitigating residual risks on areas with PLP. No adaptation for mitigation of future risk.		Not cost effective due to expense of defences, benefit cost ratio of 0.4.	
Option 4 – Areas A and B hard defence, storage area, two stage channel. Areas C and D PLP excluding Ythan Court direct defence	0.5% AP – 200 year	A protected. Majority B, C and D protected.						Not cost effective due to expense of defences, benefit cost ratio of 0.7.	
Option 5 – Areas A and B hard defence, storage area and two stage channel. Areas C and D PLP	0.5% AP – 200 year	A protected. Majority B, C and D protected.		RBMP benefit of reconnection to a naturalised floodplain through a two stage channel. Storage area on Hillhead Burn will also act to regulate sediment from agricultural areas.				Not cost effective due to expense of defences, benefit cost ratio of 0.8.	
Option 6 - Full PLP	0.5% AP – 200 year	Majority A, B, C and D protected.	Little to no impact.	Little to no impact	Social constraint where PLP is not as accepted as a sole option. Lack of flood warning requires more expensive automatic systems.	No adaptation for mitigating future risk.		Benefit cost ratio of 2.0	Aside from individual property works wider community not impacted.
Option 7 – All areas defended to 0.5% AP SoP. Hard defence, areas C and D PLP	0.5% AP – 200 year	No areas protected with inclusion of climate change	Some ecological benefits. Increase in biodiversity through storage areas and two stage channel. Minor disturbance during construction.	RBMP benefit of reconnection to a naturalised floodplain through a two stage channel. Storage area on Hillhead Burn will also act to regulate sediment from agricultural areas.	High walls and embankments around the reservoir and storage area. Social constraint where PLP is not as accepted as a sole option. Lack of flood warning requires more expensive automatic systems.	Opportunities for NFM. Some opportunity for two stage channel to be increased. Difficulty with mitigating residual risks on areas with PLP.		Benefit cost ratio of 1.0	Minimal impacts on community other than minor aesthetics from the reservoir.

Negative — Neutral — Positive

The "prioritising the proposals" table summarises the pros and cons of each shortlisted option. The next few posters show these options in more detail.

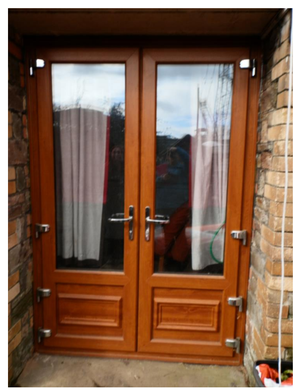
Flood walls

Flood embankments (earth)

Typical examples of direct defences

Riparian buffer

Typical example of Natural Flood Management



Typical example of automated flood resilience

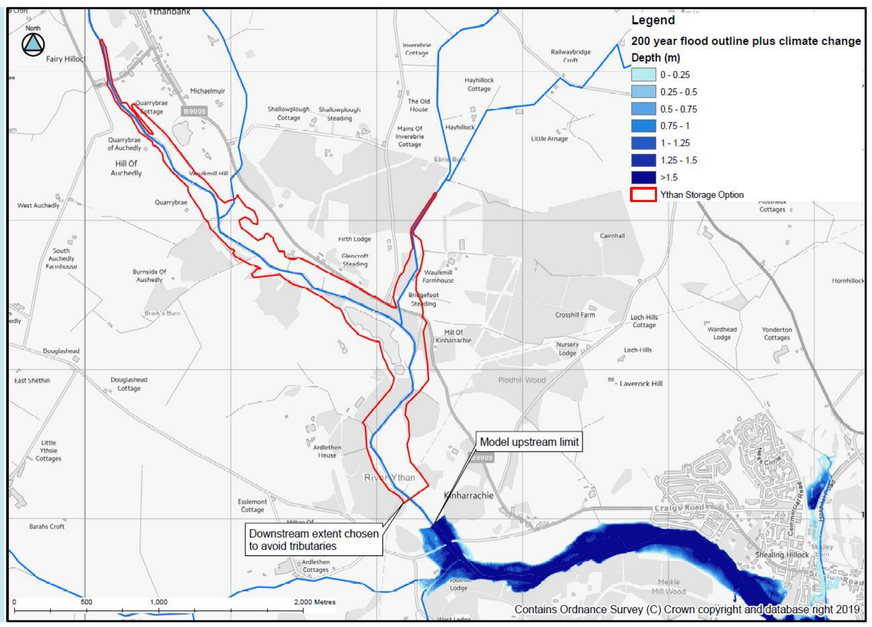
PLP would involve the installation of products such as waterproof doors, self-sealing airbricks and improved render on the outside of a property. This can only protect a property against water 0.6m (2ft) deep – above this depth the pressure of the water against walls can cause damage.

Some residents may already have manually-installed door guards and air brick covers but we would recommend measures that are constantly in place, such as waterproof doors, so that a property is always protected even if nobody is at home.

5 Feasibility Testing

These maps show the options that were tested further for feasibility but were **ultimately discounted** due to reasons detailed below.

1. River Ythan storage



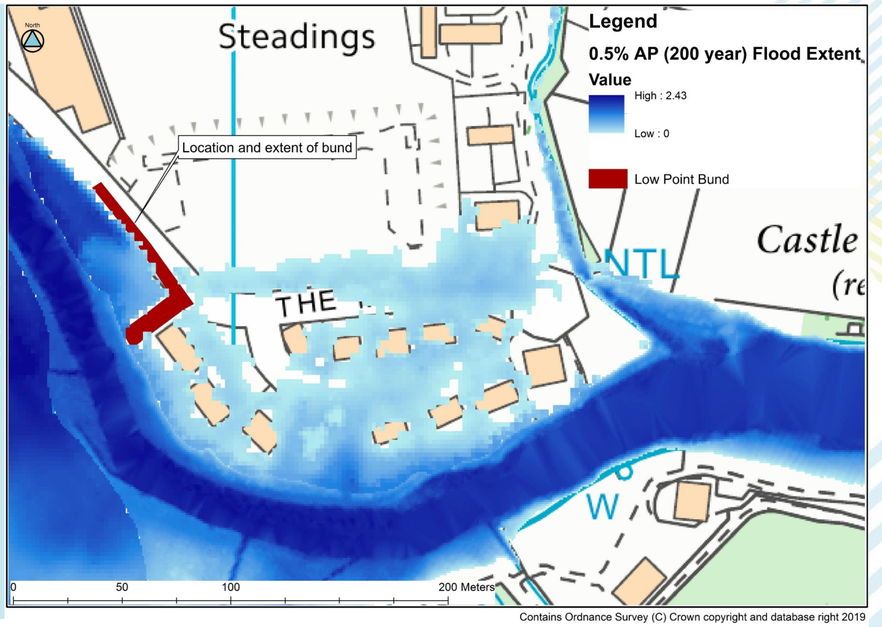
1. Storage (discounted)

- Other locations discounted due to being too far away from the study area or not having an adequate storage volume.
- Unachievable dam / wall heights required due to extremely large volumes to be stored. (4.3 m wall height required when reducing flow to pass the 100 year event)
- Large environmental impacts.
- Current conditions show the Ythan already has good connection with its floodplain therefore already utilising a lot of the storage area.

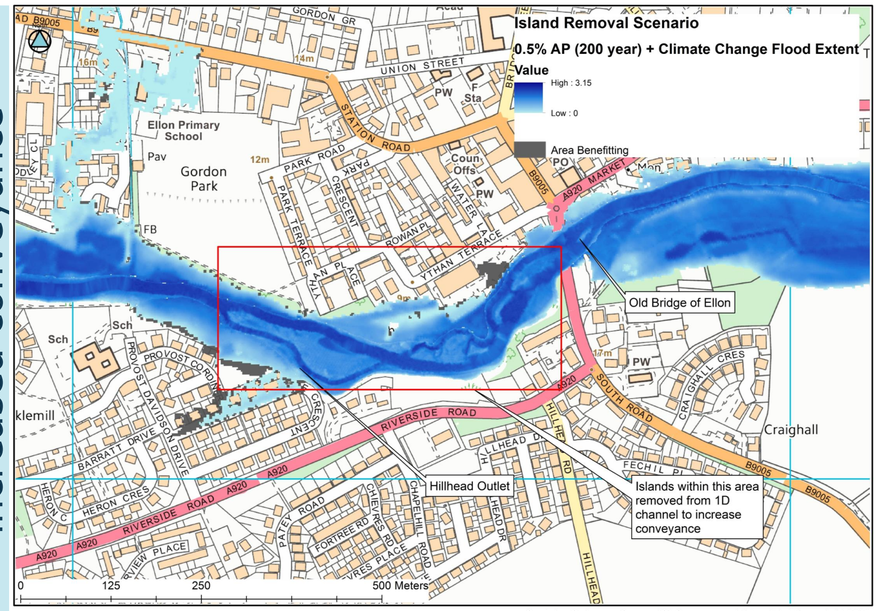
2. Meadows Bund (discounted)

- Blocking this flow pathway does not remove flood risk to The Meadows due to other flow pathways bypassing this area.

2. The Meadows low point bund



3a. Old Bridge of Ellon increased conveyance



3. Increased conveyance

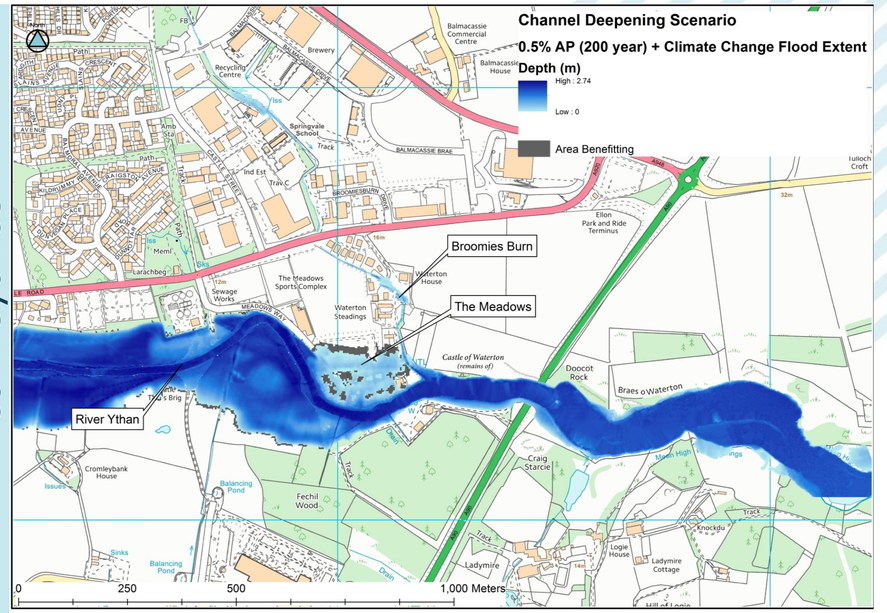
3a. Old Bridge of Ellon ***(discounted)***

- Full removal of the islands does not alleviate the flood risk to Bruce Crescent.
- This option is not sustainable due to the nature of the river being at the tidal limit, which slows channel velocities causing the river to deposit on a frequent basis.
- Large environmental impacts.
- Potential for bridge invert and pier scour downstream.

3b. The Meadows ***(discounted)***

- Deepening of the bed to the invert of the A90 bridge up to the start of The Meadows does not alleviate the flood risk.
- Unsustainable solution due to the nature of the river being at the tidal limit, which slows channel velocities causing the river to deposit on a frequent basis.
- Risk of erosion and damage to the A90 road bridge.
- Large environmental impacts.

3b. The Meadows increased conveyance

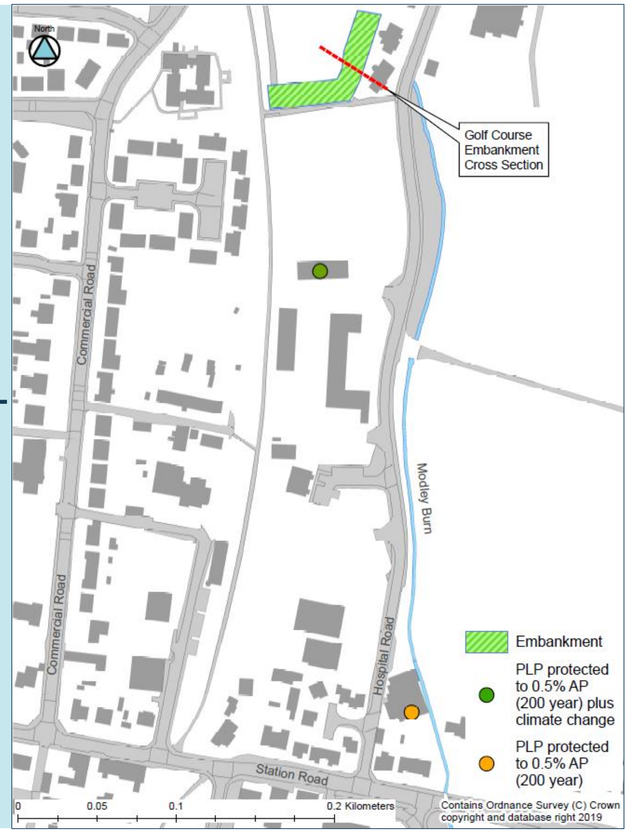


6 Area A - Options

Area A (Modley Burn):

- Current standard of protection - **< 2 year**
- Properties at risk from the 200 year event - **2**
- Properties at risk from the 200 year plus climate change event - **13**

Area A – Modley Burn at Hospital Road options



Option A1(standard of protection 200 year plus climate change):

- Golf course embankment at Hospital Road – maximum height from golf course 2.25 m, 18.5 m wide with gradual slopes.
- Two stage channel at Modley Place – Left bank extended by 5 m for 47 m to convey more flow.
- Plastic sheet piles (covered with soil to form a bund) – right bank height increased by maximum 0.26 m.
- Ellon Primary School footbridge removal.

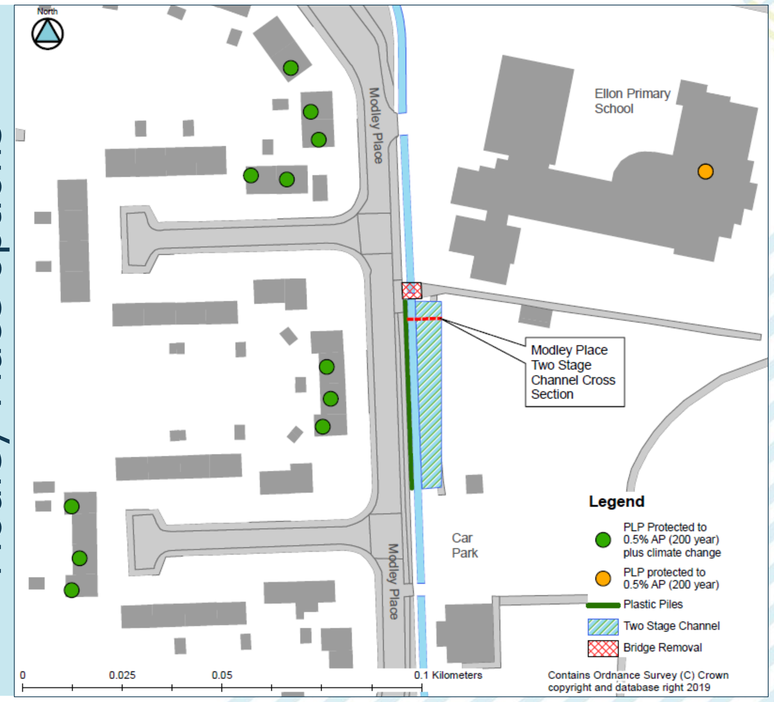
Option A2 (standard of protection 200 year):

- Two stage channel at Modley Place – Left bank extended by 5 m for 47 m to convey more flow.
- Plastic sheet piles at Modley Place (covered with soil to form a bund) – right bank height increased by maximum 0.26 m.
- Ellon Primary School footbridge removal.

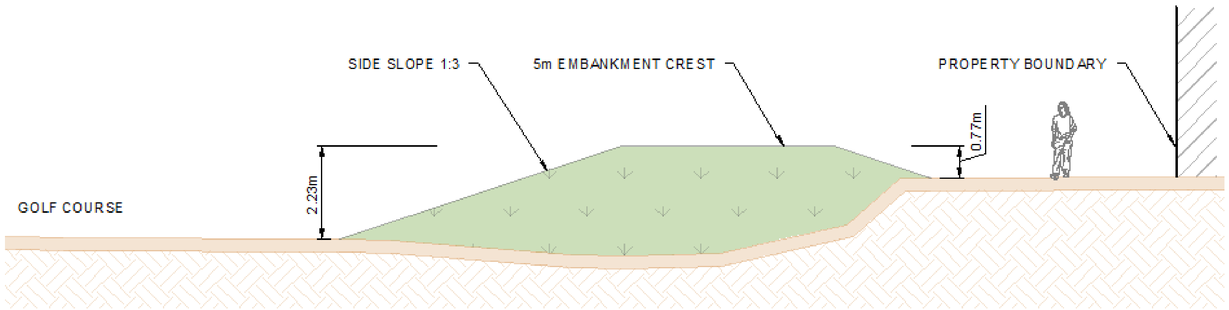
Option A3 (standard of protection 200 year):

- Property level protection (PLP), properties in orange are over 0.6 m depth during the 200 year event plus climate change.

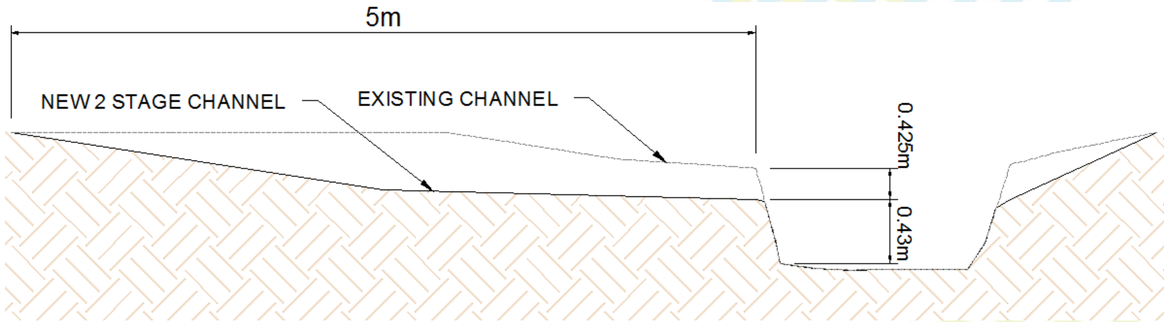
Area A – Modley Burn at Modley Place options



Golf Course Embankment Cross Section



Modley Place Two Stage Channel Cross Section



7 Area B - Options

Area B (Hillhead and Fortree Burns):

- Current standard of protection - **10 year**
- Properties at risk from the 200 year event - **18**
- Properties at risk from the 200 year plus climate change event - **26**

Option B1 (standard of protection 200 year plus climate change):

- Reservoir creation over an area of 4,646 m^2.
- Reservoir embankment from property face from the north, maximum height 2.88 m.
- Reservoir wall along the eastern face towards the new property development, maximum height 2.33 m.
- Existing Hillhead outfall, trash screen, headwall and wingwalls replaced.
- Bruce Crescent flood embankment 95 m long with a maximum height of 1.71 m.
- Pumping station to operate on Hillhead culvert outlet when submerged during high flood events.

Option B2 (standard of protection 200 year):

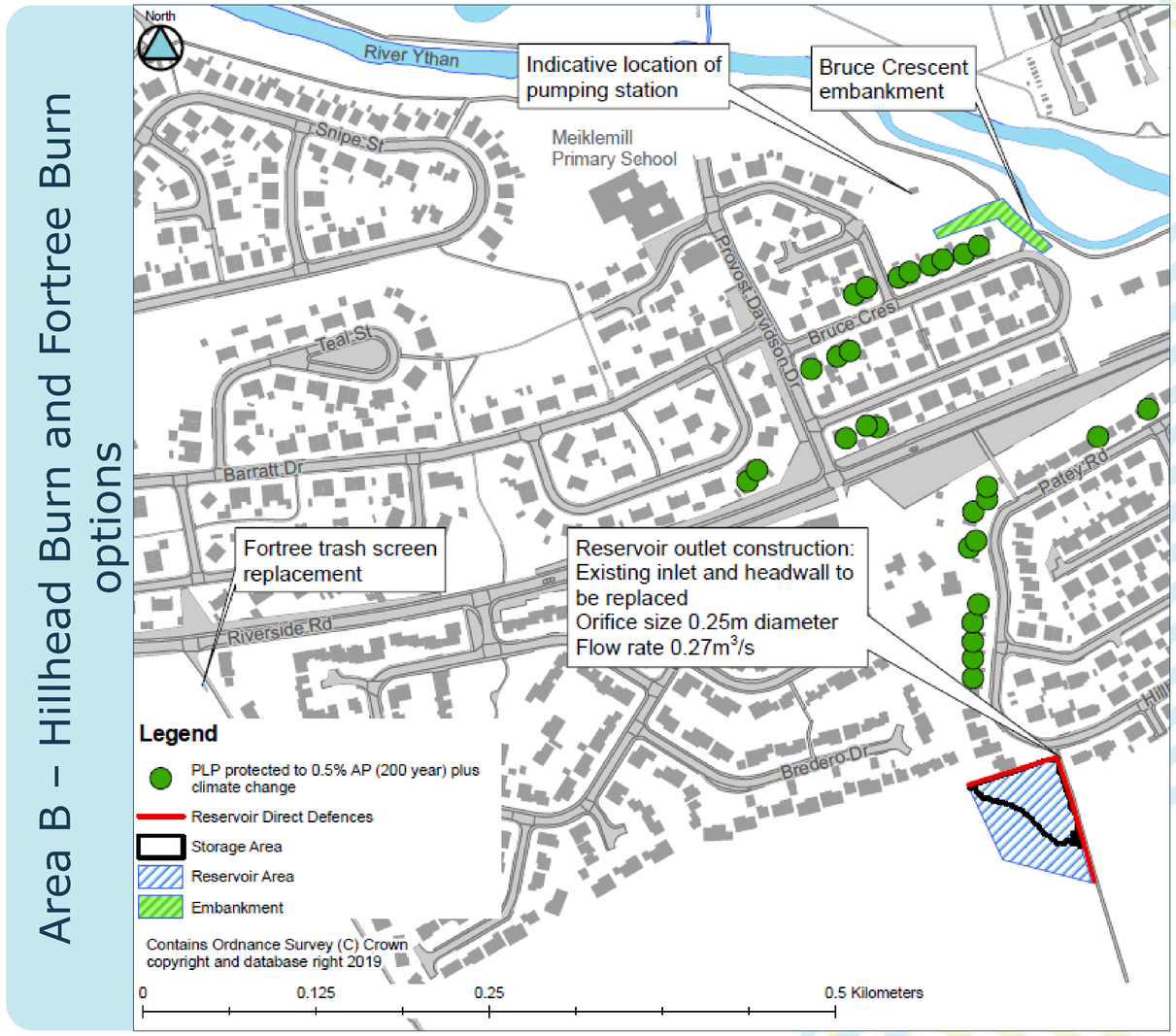
- Storage creation over an area of 2,323 m^2.
- Storage embankment from property face to the north, maximum height 2.8 m.
- Storage wall along the eastern face towards the new property development, maximum height 2.25 m.
- Existing Hillhead outfall, trash screen, headwall and wingwalls replaced.
- Bruce Crescent flood embankment 95 m long with a maximum height of 1.71 m.
- Pumping station to operate on Hillhead culvert outlet when submerged during high flood events.

Option B3 (standard of protection 200 year plus climate change):

- Property level protection (PLP).

Option B4 (standard of protection 200 year):

- Storage creation over an area of 2,323 m^2.
- Storage embankment from property face to the north, maximum height 2.8 m.
- Storage wall along the eastern face towards the new property development, maximum height 2.25 m.
- Replace existing Hillhead outfall, trash screen, headwall and wingwalls.
- Pumping station to operate on Hillhead culvert outlet when submerged during high flood events.



For all options which include new Bruce Crescent embankment, footpath to be either retained or rebuilt. Drainage to be considered for the embankment with use of the pumping station to prevent ponding on the "dry" side.

8 Area C - Options

Area C (Bridge of Ardlethen and Old Bridge of Ellon):

- Current standard of protection - **30 year**
- Properties at risk from the 200 year event - **4**
- Properties at risk from the 200 year plus climate change event - **6**

Option C1(standard of protection 200 year plus climate change):

- Embankment at Bridge of Ardlethen north west of the properties – maximum height 1.93 m, 16.6 m wide with gradual slopes.
- Embankment at Bridge of Ardlethen south east of the properties – maximum height 2.28 m, 18.7 m wide with gradual slopes.
- Flood wall at Bridge of Ardlethen – height ranging from 1.76 m to 2.43 m.
- Western flood wall at Old Bridge of Ellon – height ranging from 1.12 m to 1.41 m.
- Eastern flood wall at Old Bridge of Ellon (Ythan Court) – height ranging from 0.49 m to 1.47 m.
- Embankment at Old Bridge of Ellon – maximum height 1.92 m, 16.5 m wide with gradual slopes.

Option C2 (standard of protection 200 year):

- Eastern flood wall at Old Bridge of Ellon (Ythan Court) – height ranging from 0.49 m to 1.47 m.
- Property level protection (PLP) at Bridge of Ardlethen, property in orange is over 0.6 m depth during the 200 year event plus climate change.

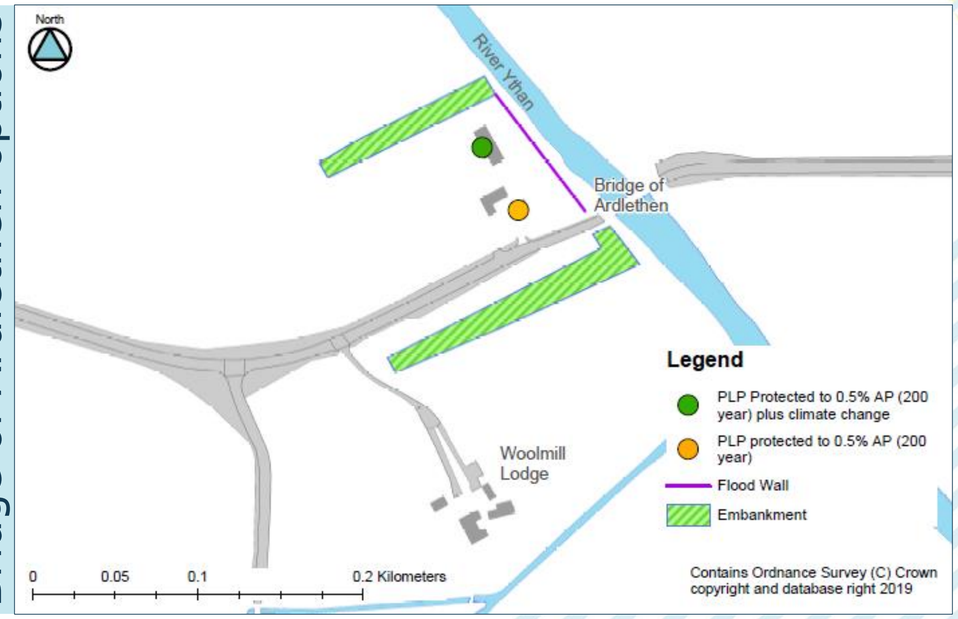
Option C3 (standard of protection 200 year):

- Property level protection (PLP), property in orange is over 0.6 m depth during the 200 year event plus climate change.

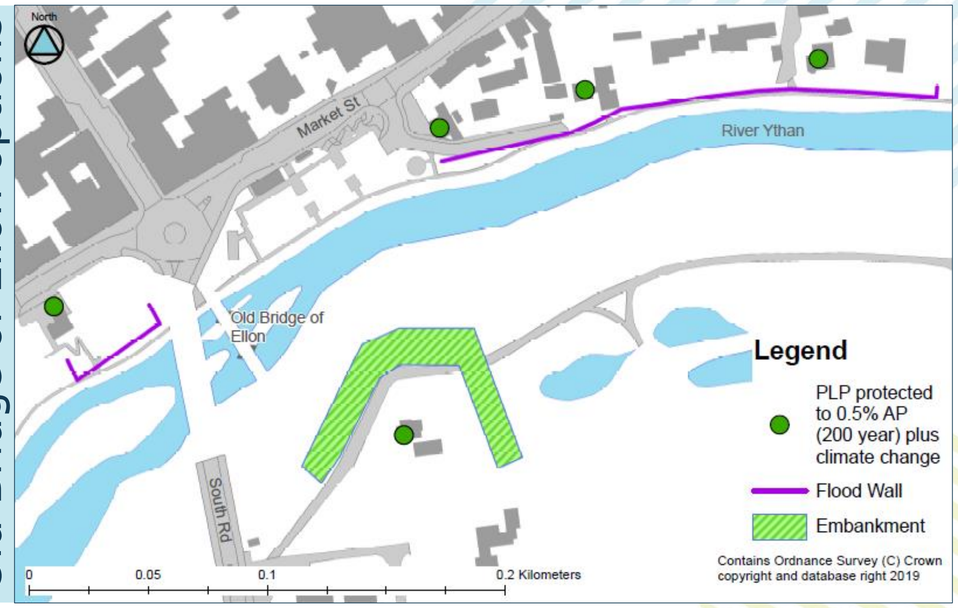
Option C4 (standard of protection 200 year):

- Property level protection (PLP) for properties at risk during the 200 year event. 4 properties, 2 at Bridge of Ardlethen and 2 western properties on the left bank at Old Bridge of Ellon.

Area C – River Ythan at Bridge of Ardlethen options



Area C – River Ythan at Old Bridge of Ellon options



9 Area D - Options

Area D (The Meadows):

- Current standard of protection – **100 year**
- Properties at risk from the 200 year event - **6**
- Properties at risk from the 200 year plus climate change event - **14**

Option D1 (standard of protection 200 year plus climate change):

- Flood embankment on Broomies Burn at Castle Way, maximum height 0.83 m filling a low point in the existing bank.
- Flood wall at The Meadows, 485 m in length, extending 40 m along Meadows Way and 80 m up Broomies Burn to block all flow paths behind the defence. Maximum height 2.81 m constructed along the informal footpath, offset from the watercourse as far as possible.
- Swale construction to intercept overland flow from the playing fields. Indicative location and sizing to accommodate 1369 m^3 of water and outfall under the Meadows Way road and back into the Ythan. Volume to be updated after full drainage study.

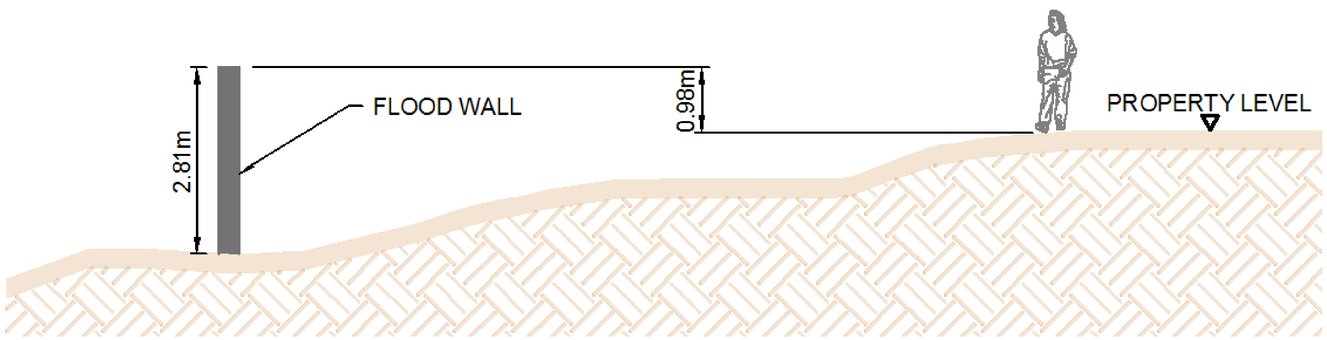
Option D2 (standard of protection 200 year):

- Property level protection (PLP), properties in orange are over 0.6 m depth during the 200 year event plus climate change.

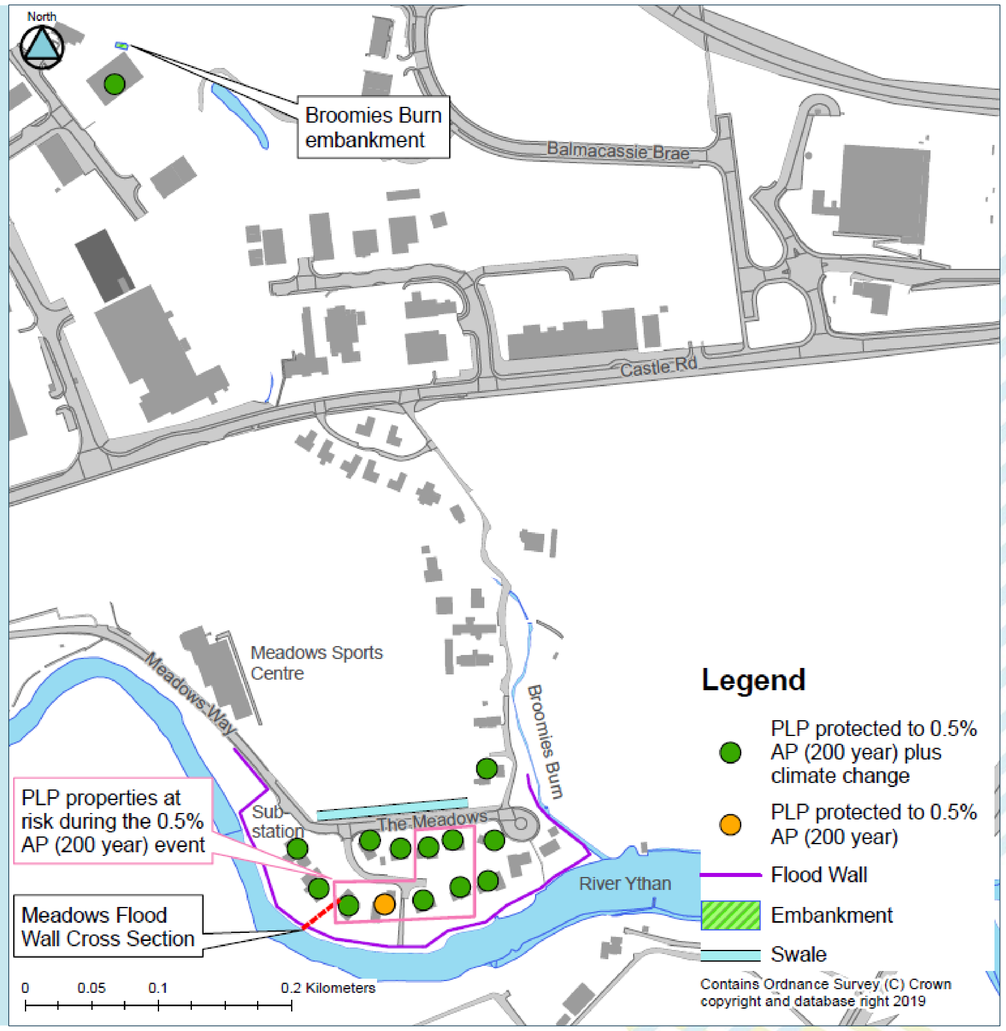
Option D3 (standard of protection 200 year):

- Property level protection (PLP), for the 6 properties highlighted at risk during the 0.5% AP (200 year) event.

Meadows Flood Wall Cross Section



Area D – River Ythan and Broomies Burn at The Meadows



10 Option Combinations

Option 1

A1 – Golf course embankment and two stage channel

B1 – Hillhead reservoir, pumping station and direct defence

C1 – Direct defences

D1 – Direct defences

BCR = 0.3

Option 2

A1 – Golf course embankment and two stage channel

B2 – Hillhead storage area*, pumping station and direct defence

C1 – Direct defences

D1 – Direct defences

BCR = 0.3

Option 3

A1 – Golf course embankment and two stage channel

B2 – Hillhead storage area, pumping station and direct defence

C2 – PLP (excluding Ythan Court)

D1 – Direct defences

BCR = 0.4

Option 4

A1 – Golf course embankment and two stage channel

B2 – Hillhead storage area, pumping station and direct defence

C2 – PLP (excluding Ythan Court)

D2 – PLP

BCR = 0.7

Option 5

A1 – Golf course embankment and two stage channel

B2 – Hillhead storage area, pumping station and direct defence

C3 – PLP

D2 – PLP

BCR = 0.8

Option 6

A3 – PLP

B3 – PLP

C3 – PLP

D2 – PLP

BCR = 2.0

Preferred option

Option 7

A2 – Two stage channel

B4 – Hillhead storage area and pumping station

C4 – PLP

D3 – PLP

BCR = 1.0

Combined Options

All options are shown in more detail on their corresponding design area poster.

*The difference between the reservoir and storage area is option 2 is protecting against the 200 year event without climate change where the volume has significantly reduced (a reservoir is a volume >10,000 m^3).

How the options have been assessed

Damages to all properties over 100 years ÷ Full cost of the scheme = Benefit Cost Ratio (BCR)

Each option has been assessed economically where if the damages over 100 years exceeds the cost of the scheme it is deemed to be economically viable (BCR > 1).

Option 1 was the starting point which protects all properties against the 200 year event with climate change. However this option is not cost-effective.

All of the other options were developed to reduce costs but they do not protect against climate change.

The slight deviation from the previous option is highlighted in orange.

Economical benefit (options with a BCR > 1) is the main driver though sustainability and environmental benefit has also been strongly considered when evaluating options.

11 Preferred Option

Option 7

A2 – Two stage channel

B4 – Hillhead storage area and pumping station

C4 – PLP

D3 – PLP

Why is this the preferred option?

- *Option is economically viable with a benefit cost ratio of 1.0.*
- *Option achieves a full standard of protection of 200 year while including some more engineered solutions to the areas with currently the lowest standard of protection.*

A2 Modley Burn (standard of protection 200 year):

- Two stage channel at Modley Place – Left bank extended by 5 m for 47 m to convey more flow.
- Plastic sheet piles at Modley Place (covered with soil to form a bund) – right bank height increased by maximum 0.26 m.
- Ellon Primary School footbridge removal.

B4 Hillhead and Fortree (standard of protection 200 year):

- Storage creation over an area of 2,323 m^2.
- Storage embankment from property face to the north, maximum height 2.8 m
- Storage wall along the eastern face towards the new property development, maximum height 2.25 m.
- Replace existing Hillhead outfall, trash screen, headwall and wingwalls.
- Pumping station to operate on Hillhead culvert outlet when submerged during high flood events.

C4 River Ythan (standard of protection 200 year):

- Property level protection (PLP) for properties at risk during the 200 year event. 4 properties, 2 at Bridge of Ardlethen and 2 western properties on the left bank at Old Bridge of Ellon.

D3 The Meadows (standard of protection 200 year):

- Property level protection (PLP), for the 6 properties highlighted at risk during the 0.5% AP (200 year) event.

Additional Options for Consideration

There is no formal commitment for Scottish Government funding. Should a scheme achieve funding and hence move forward to detailed design Option 4 and Option 6 would also be considered further due to the following:

- Option 4 – more sustainable but low BCR
- Option 6 – highest BCR but less sustainability

Option 4

A1 – Golf course embankment and two stage channel

B2 – Hillhead storage area, pumping station and direct defence

C2 – PLP (excluding Ythan Court)

D2 – PLP

BCR = 0.7

Option 6

A3 – PLP

B3 – PLP

C3 – PLP

D2 – PLP

BCR = 2.0