Section 4 Managing Vulnerability of Options and Decisions

The vulnerability of mitigation options or development decisions to climate change varies with a range of factors including the:

- Specifics of the location including the degree of exposure to flooding, what controls the flooding (flow, volume, particular structures) and whether flooding is influenced by sea level.
- Type of management option or development decision being considered and whether it relates to a specific ARI or an extreme event. Options for managing extreme events generally relate to emergency response management which, by their nature,need to be robust.
- Source of climate change vulnerability. This can come from either (or both) sea level rise and increase in rainfall intensity depending upon the location and the particular "controls" influencing flooding.
- Change in the frequency of inundation. **Figure 3** shows that with the high climate change sea level rise scenario high ocean levels regularly occur, ie. the current 100 year ARI static design ocean level occurs almost monthly by 2090-2100. This raises issues for land habitability and local drainage systems.

The impacts on flood behaviour, regularity of flooding, and damage/danger from flooding are very location specific and need to be assessed on this basis. This requires location specific strategies to manage climate change considering the vulnerability of the location, the type of management options or development decisions being made and the benefits of these strategies for the specific location.

The climate change management strategies put forward below are not exhaustive. They concentrate on the more vulnerable ARI related management options and development decisions. They are based upon managing the ramification of particular climate change scenarios and therefore aim to ensure a security to decisions for the adopted planning horizons. No matter which climate change scenario is adopted, management strategies for specific ARI events may be overwhelmed at some point as change continues.

In areas where sea level rise doesn't influence flood behaviour, climate change vulnerability comes from increased rainfall intensities and storm frequency. Where the variation of flood levels with ARI is low, the impacts and associated ramifications are unlikely to be significant. However, where the variation in flood level with ARI is high and climate change ramifications to people or property are significant careful consideration needs to be given to strategies for managing the impact.

In areas with potential climate change impacts from sea level rise, climate change impacts may also be influenced by increased rainfall intensities and storm frequency depending upon the controls influencing flood behaviour.

Section 4.1 Management Strategies Where Climate Change Ramifications are Considered MINOR

For Future Development

The following climate change management strategies are among those that could be considered:

- Adopt a current 100yr ARI flood level as the basis for flood planning levels (FPLs) and fill levels and accept that flood risk will increase over time. The potential long term protection level and associated increase in potential damages should be recognised and documented and the community informed.
- Use higher FPLs by adopting a climate change factor specific fof the location in addition to general freeboard. This will provide 100yr ARI protection at a given point in the future with a slightly higher level of protection at present.

For Existing Development

The following options are among those that should be considered:

- Do nothing, where no works are proposed to protect existing development. This decision is unlikely to change if climate change ramifications are minor.
- If works are proposed to protect existing development, consider the feasibility of allowing for climate change impacts in these projects. This may involve considering the practicality and cost versus benefit of allowing for changes now or as a modification in the future. The decision could be to do nothing, or to do nothing now but allow to upgrade in a practical way in future, or to allow for impacts in the project now.

FRM Guidelines are prepared to assist Councils in the preparation and implementation of their FRM plans
Queries can be directed to your local DECC floodplain risk management contact or duncan.mcluckie@dnr.nsw.gov.au
Version No: 1.0 Status: Final Issue date 25/10/2007 Authorisation: Director Coast & Floodplain Management

Section 4.2 Management Strategies For Future Development Where Climate Change Ramifications Are Considered SIGNIFICANT

Figures Future 1 to 7 provide examples of strategies that could be considered to manage climate change to future development where impacts are significant. These examples consider the variation in ramifications dependant upon location and the potential to effectively and practically manage these impacts. A general discussion of possible strategies with reference to relevant figures follows.

- Where the land being assessed for development may be considered marginal from a flood risk and coastal inundation perspective. With high climate change impacts the flood risk and coastal inundation impacts will become more critical. The land may not be viable for standard residential or other development.

  Therefore it may be appropriate to consider an alternate location for the development. The site could be used for purposes more compatible with the long term risk. Examples of relevant uses may include parklands, playing fields, golf courses, other recreational pursuits or agriculture or environmental purposes. **Future 1.**

  Alternatively consideration could be given to use of the site for development types that allow for planned retreat from the affected land within a specific timeframe or once climate change impacts on sea level rise or flood risk meet specific stipulated criteria. In these cases the criteria for retreat or withdrawal from the land and methods for their measurement need to be set and agreed upon prior to any approval for development.

  Depending upon the current risk and potential climate change impacts for the specific site and development alternatives, compatible uses to consider could include such developments as:

  — tourist or short term caravan parks (with no permanents occupants or mobile homes) and low cost permanent facilities where investment decisions can be made based upon known conditions of abandonment and removal; or

  — supporting land/facilities for cluster housing for residential or tourist development. Significant buildings located on adjacent higher land where risks can be effectively managed; or

  — tourist or commercial development where investment decisions are based upon known conditions of abandonment and removal.

- Include a climate change factor determined for the location in FPLs and fill levels on top of general freeboard to provide the desired protection at a given point in the future but higher protection at present. **Future 2.**
- Adopt the current 100yr flood as the basis for FPLs and fill levels and accept that flood risk will increase over time. The long term protection level (ARI) and increase in potential damages should be assessed. As potential climate change ramifications for future development may be significant this may be unacceptable to the community. **Future 3.**
- Investigate alternative options considering both present and future risk exposure. These may allow for practical development of properties but enable climate change impacts and ramifications to be managed over the long term. This could involve:

  — having a compromise position on FPLs and fill levels between the options outlined previously. Examples include: allowing for low change scenarios in fill levels but high change scenarios in floor levels, **Future 4;** making no allowance for change in fill levels but allowing for high change scenarios for floor levels, **Future 5.**

  — FPLs at current minimum levels but with a requirement for two-storey housing with flood compatible structural materials on the bottom storey. This reduces damage potential and exposure of contents to flooding even in the long term. However, this may not address issues with frequent inundation, particularly in areas where sea level controls flooding.

  — In special developments, eg schools, adopt FPLs and fill levels based upon existing situations but include elements to reduce exposure. For instance placing more vulnerable development in less exposed position on site or perhaps on a second storey, and consider improving the structural compatibility of buildings to flooding.

  — Considering the potential to retrofit solutions when significant climate change impacts occur that were not allowed for. Is it possible to set land aside now to enable the future construction of a levee to manage climate change impacts? This involves examining cost effective options that could be effectively and practically implemented in the future. Examples include: not allowing for climate change scenarios in

FRM Guidelines are prepared to assist Councils in the preparation and implementation of their FRM plans
Queries can be directed to your local DECC floodplain risk management contact or duncan.mcluckie@dnr.nsw.gov.au
Version No: 1.0 Status: Final Issue date 25/10/2007 Authorisation: Director Coast & Floodplain Management

fill levels but allowing for high climate change scenarios in floor levels with control on frequency of inundation by a levee built now or in the future, **Future 6;** making no allowance for climate change in fill or floor level conditions but allowing for the construction of a levee to reduce flood risks for the high climate change scenario, **Future 7.**

Any potential climate change impacts on emergency response management also needs consideration in developing a management strategy.

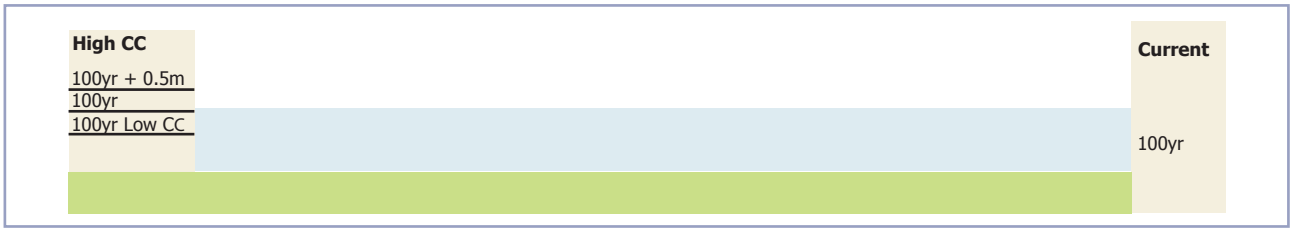
Development options should be considered on the basis that:

- Development of the area is considered appropriate (flow conveyance maintained, cumulative impacts of development managed, and residual hazard is manageable through development controls and/or emergency response management in accordance with the strategic requirements of the Manual.
- Flood related development conditions are put in place regardless of climate change.
- Emergency response management can be managed for the existing conditions.
- The following issues are considered in deciding upon an appropriate climate change management strategy:
  1. Does climate change impact upon the areas practical for development? What is the opportunity cost of reducing development potential due to climate change? Is other more practical or less exposed land available?
  2. Does the option provide the community with the degree of protection it believes it should receive?
  3. Does flood hazard in the planning flood alter with climate change? Is the additional hazard to people resulting from increased flood depths or velocities in the same ARI events significant? Can it be successfully and practically managed?
  4. Does flood hazard for events greater than the planning flood up to the PMF alter with climate change? Is the additional hazard to people resulting from increased flood depths or velocities in the same ARI events significant? Can it be successfully and practically managed?
  5. Does frequency of exposure of people to hazardous flood situations external to buildings alter with climate change? How does this compare to strategy Future 2 and what are the associated extra emergency response management issues? Can the additional hazard and issues be effectively managed?
  6. Does regularity of inundation of land alter with climate change? What are the ramifications for habitability of the land particularly where sea level rise influences climate change? Can this be effectively managed?
  7. What extra flood damage is the community exposed to due to climate change? Is this acceptable or manageable?
  8. What is the extra cost involved in allowing for the future impacts? For example, are there extra development costs for fill and setting aside land for levees, extra building costs, or extra costs for levee construction and maintenance in the future? Are there more practical sites with less exposure available?
  9. What additional emergency response management issues relate to evacuation due to increased frequency of inundation? How can these be managed?
  10. Can the area behind a climate change management levee be effectively drained, given the potential water levels outside the levee? Is pumping infrastructure required? What are the additional costs of drainage?
  11. What are the practical, aesthetic and environmental issues? How can the potential resistance of residents to loss of amenity of property (water views or access) in the future due to the construction of a levee or due to house raising be dealt with?
  12. Can climate change impacts be effectively managed by a future strategy?
  13. What is the potential to adapt with changed climate change information? Is this feasible?
  14. If these issues cannot be addressed is this still the right option? Is there an alternative location for development? Are other options feasible?
  15. Are planned retreat options viable? Would these be compatible with current levels of risk? Is it possible to effectively condition and therefore control retreat? What forms of land use would be appropriate prior to retreat? Can infrastructure investment be controlled given the relatively short term of possible occupation?

FRM Guidelines are prepared to assist Councils in the preparation and implementation of their FRM plans
Queries can be directed to your local DECC floodplain risk management contact or duncan.mcluckie@dnr.nsw.gov.au
Version No: 1.0 Status: Final Issue date 25/10/2007 Authorisation: Director Coast & Floodplain Management

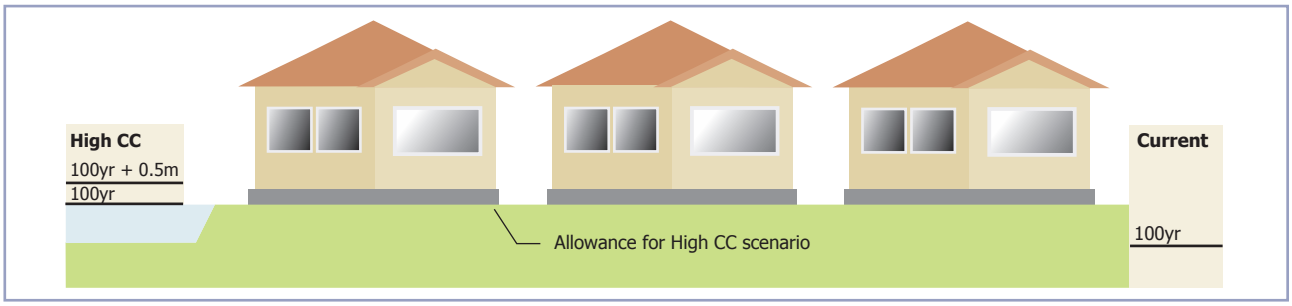
Strategy Future 1 — Site not Occupied Long Term

Develop in an alternate location where flood risk with climate change is more acceptable to the community or develop in an alternative way compatible with long term risk (parklands, play grounds or as a supporting area for cluster development on higher land) or consider development options that allow for planned retreat.



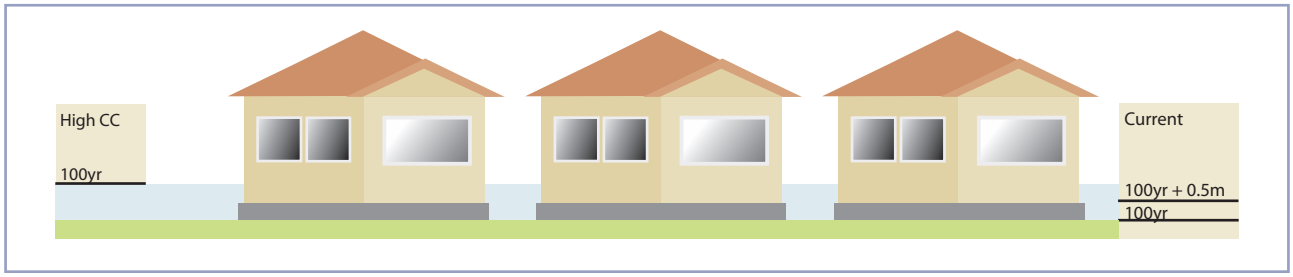
Strategy Future 2 — Allow for High Scenario Climate Change Scenario Now

Minimum fill and floor levels include an allowance for high scenario climate change now. This allows for changes in rainfall intensities and sea level rise.



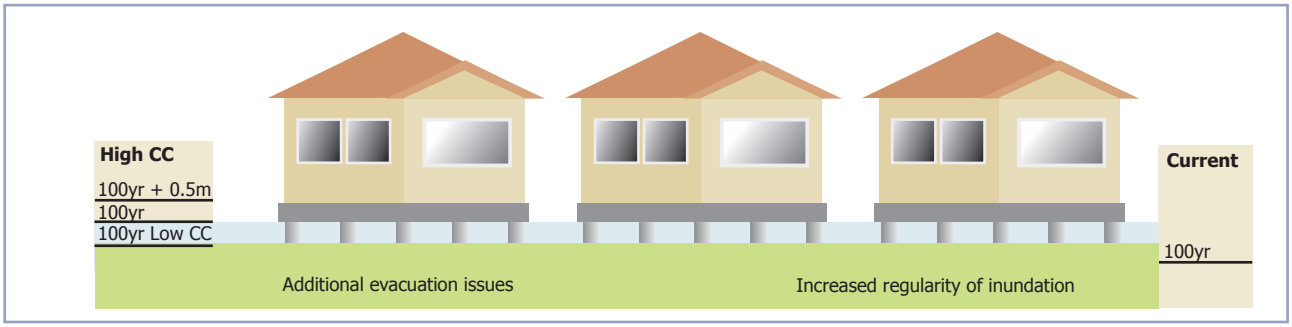
Strategy Future 3 — Development Conditions have No Climate Change Allowance

Minimum fill and floor levels based upon existing situation and additional flood risk due to climate change accepted.



Strategy Future 4 —High Level Climate Change Allowed for in Floor Levels. Low Climate Change in Fill Levels

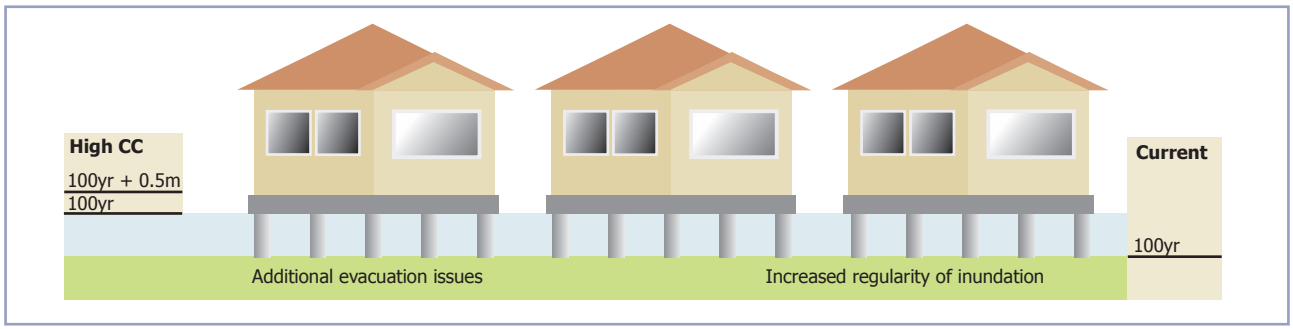
Provides additional protection for homes with surrounding land inundated more regularly in the long term.



FRM Guidelines are prepared to assist Councils in the preparation and implementation of their FRM plans
Queries can be directed to your local DECC floodplain risk management contact or duncan.mcluckie@dnr.nsw.gov.au
Version No: 1.0 Status: Final Issue date 25/10/2007 Authorisation: Director Coast & Floodplain Management

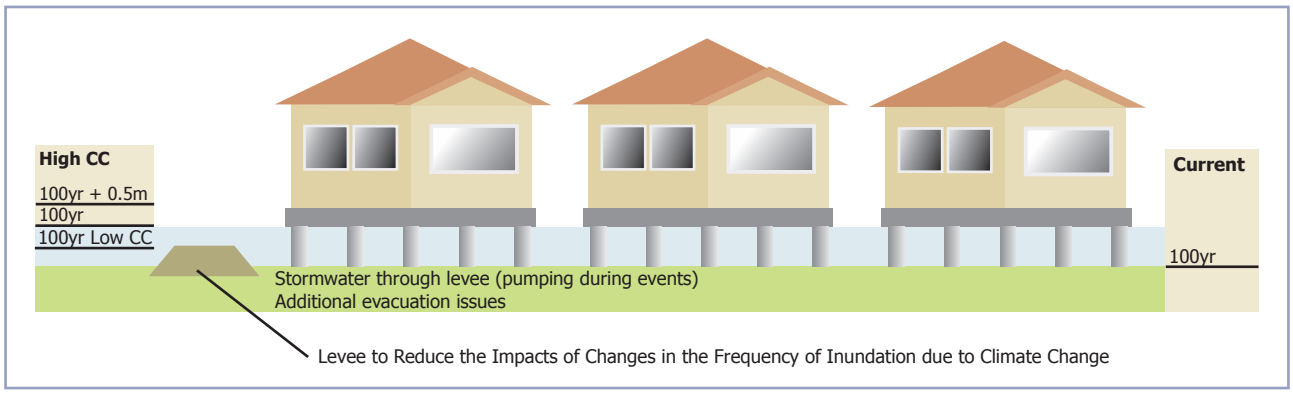
Strategy Future 5 — Fill to Current 100 year Flood Level. Floor Levels to High Climate Change Scenario

Provides protection to homes but will have increased frequency of inundation and therefore more emergency response issues. Depending upon frequency of inundation land may not be habitable in the long term.



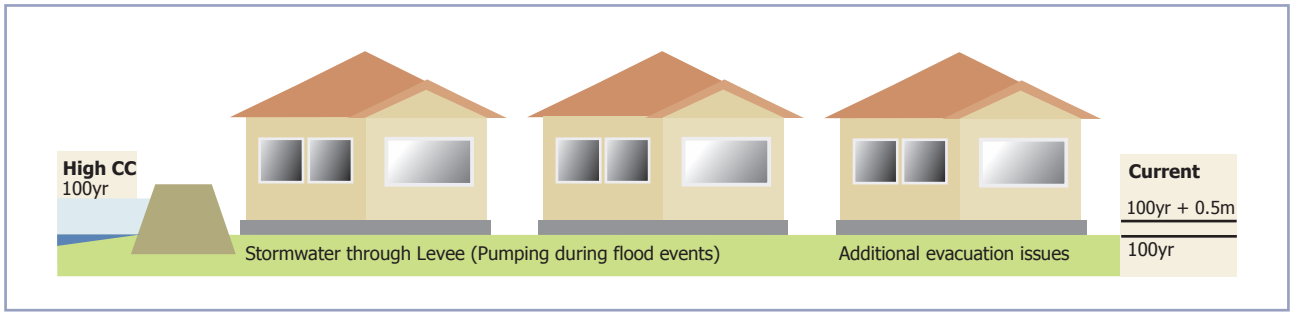
Strategy Future 6 — Minimum Fill Levels for Current 100 year. Floor Levels to High Climate Change. Levee to Reduce Frequecy of Inundation

Minimum Fill Levels for Current 100 year. Floor levels consider high climate change scenario. Levee built now or in the future to reduce frequency of inundation, possibly to low climate change scenario



Strategy Future 7 — Development Controls to Current Conditions. Levee Built to Manage Climate Change Impacts

Minimum fill and floor levels for current conditions. Levee built now or in the future to provide protection for climate change.



FRM Guidelines are prepared to assist Councils in the preparation and implementation of their FRM plans
Queries can be directed to your local DECC floodplain risk management contact or duncan.mcluckie@dnr.nsw.gov.au
Version No: 1.0 Status: Final Issue date 25/10/2007 Authorisation: Director Coast & Floodplain Management

Section 4.3 Management Strategies For Existing Development Where Climate Change Ramifications Are Considered SIGNIFICANT

Figures Existing 1 to 6 provide examples of strategies that could be considered to manage climate change to existing development where the impacts are significant. These examples consider the variation in climate change ramifications dependant upon location and the potential to effectively and practically manage these impacts.

- Where no works are proposed to protect existing development, **do nothing**. The FRM study needs to consider whether climate change ramifications justify the need for works and if so the potential options for works in the long term, and their practicality and feasibility. This may enable land to be set aside now to address this issue as necessary in the future.
- If works are proposed to protect existing development consider the feasibility of **including a climate change allowance as part of the works**. This involves considering the practicality and cost versus benefit of allowing for changes either now or as a modification in the future. A decision could then be made to do nothing, do nothing now but allow for the potential to practically upgrade the works in the future, or to upgrade the protection as part of the current project.

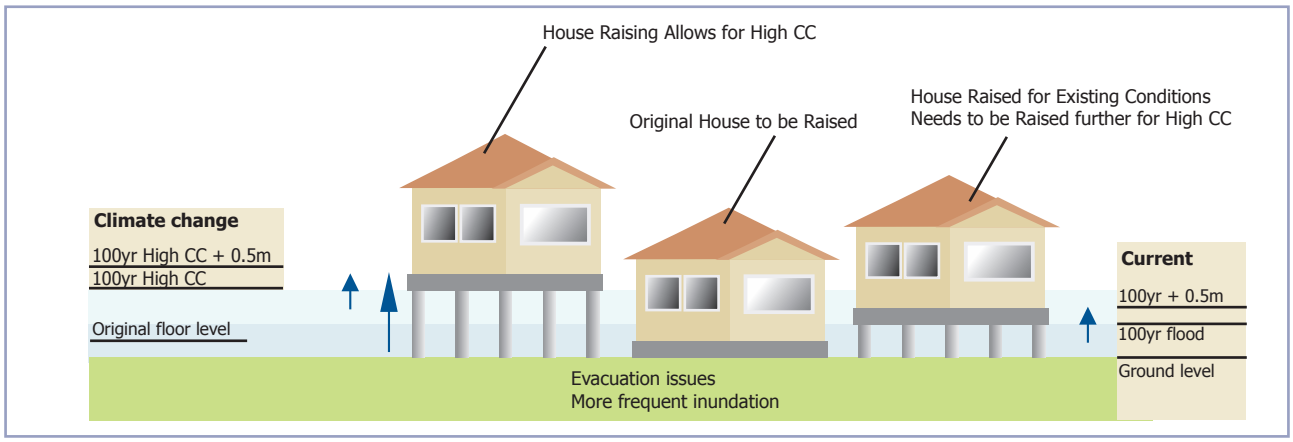
Some other possible climate change management strategies for existing development are outlined below: These need to consider:

- Whether existing management measures are in place or being developed to manage existing flood risk.
- Whether emergency response management planning considers the existing flood hazards in the areas.
- The following issues in deciding upon whether a strategy for managing climate change to existing development is appropriate:
  1. Does the option provide the community with the degree of protection it believes it should receive?
  2. Does the flood hazard in the planning flood alter with climate change? Is the additional hazard to people resulting from increased flood depths or velocities in the same ARI events significant? Can it be successfully and practically managed?
  3. Does the flood hazard in events greater than the planning flood up to PMF alter with climate change? Is the additional hazard to people resulting from increased flood depths or velocities in the same ARI events significant? Can it be successfully and practically managed?
  4. Does frequency of exposure of people to hazardous flood situations external to buildings alter with climate change? What are the associated extra emergency response management issues? Can the additional hazard and issues be effectively managed?
  5. Does regularity of inundation of land alter with climate change? What are the ramifications for habitability of the land particularly where sea level rise influences climate change? Can this be effectively managed?
  6. What extra flood damage is the community exposed to due to climate change? Is this acceptable or manageable?
  7. What is the extra cost involved in allowing for the future impacts?
  8. What additional emergency response management issues relate to evacuation once the levee overtops or due to increased frequency of inundation? How can these be managed?
  9. Can the area behind the levee be effectively drained given the potential water levels outside the levee with climate change? Is pumping infrastructure required? What are the additional costs of managing drainage?
  10. What are the practical, aesthetic and environmental issues and how can the potential resistance of existing residents to loss of amenity of property (water views or access) due to construction of the levee or due to house raising be dealt with?
  11. Can climate change impacts be effectively managed by a future strategy?
  12. What is the potential to adapt with changed climate change Information?
  13. If these issues cannot be addressed is this still the right option? Is there an alternative feasible option?

FRM Guidelines are prepared to assist Councils in the preparation and implementation of their FRM plans
Queries can be directed to your local DECC floodplain risk management contact or duncan.mcluckie@dnr.nsw.gov.au
Version No: 1.0 Status: Final Issue date 25/10/2007 Authorisation: Director Coast & Floodplain Management

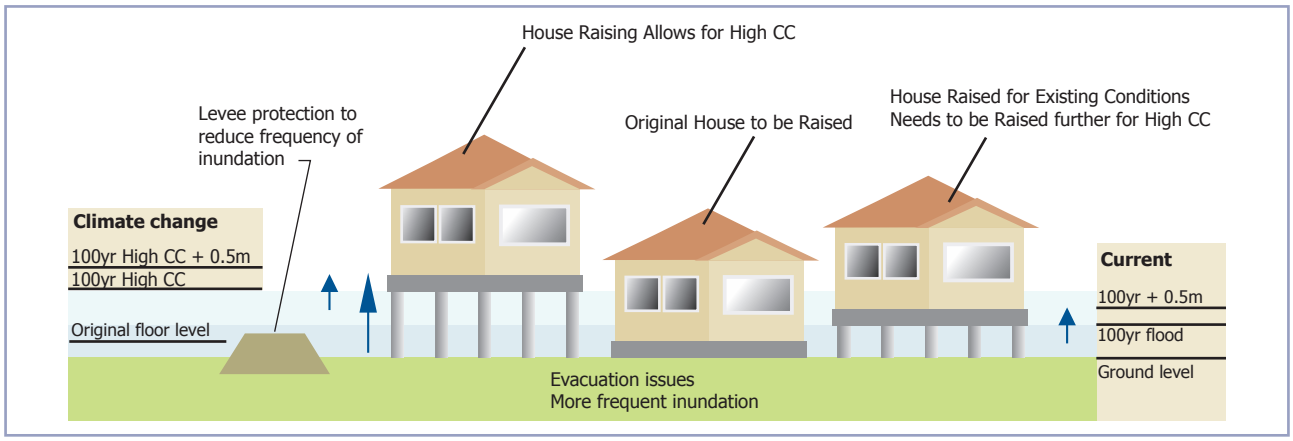
Strategy Existing 1 - New or Existing Voluntary House Raising (VHR) and Voluntary Purchase (VP). Extend Scheme to Allow for High Scenario Climate Change

VP properties are in most hazardous conditions. VHR reduces damage. No control of frequency of inundation and therefore depending upon the current ground level and climate change impacts land may become uninhabitable.



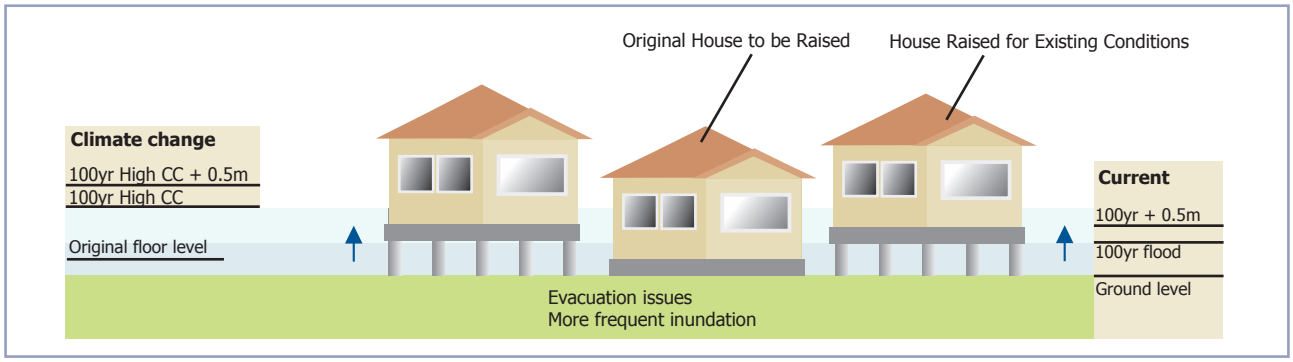
Strategy Existing 2 - New or Existing VHR and VP. Extend Scheme to Allow for High Scenario Climate Change. Include a Levee to Reduce Inundation Frequency.

VP properties are in most hazardous conditions. VHR reduces damage. Frequency of flooding reduced by a levee to enable land to remain habitable..



Strategy Existing 3 - New or Existing VHR and VP. Allow for Existing Situation and Accept Climate Change Impacts

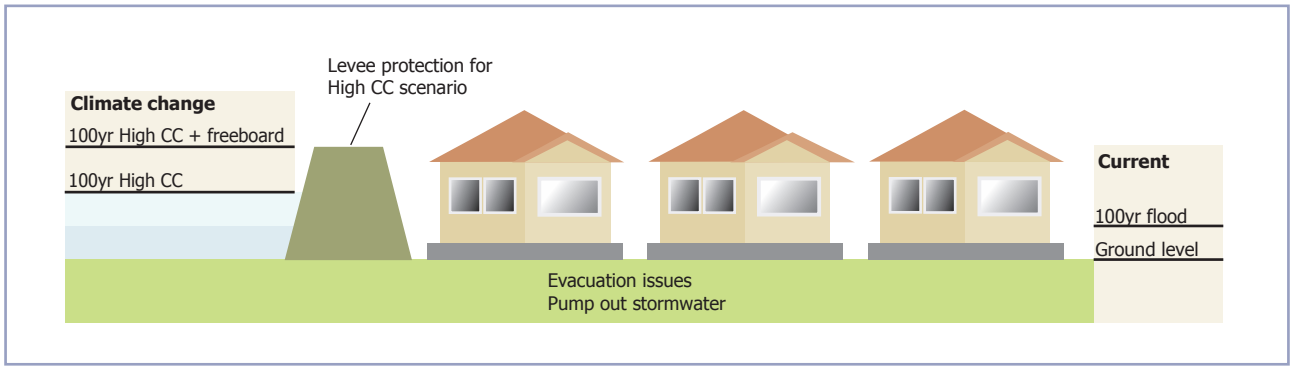
VP properties are in the most hazardous conditions. VHR reduces damage for existing conditions. Additional damage due to climate change accepted. No control of frequency of inundation and therefore depending upon the current ground level and climate change impacts land may become uninhabitable.



FRM Guidelines are prepared to assist Councils in the preparation and implementation of their FRM plans
Queries can be directed to your local DECC floodplain risk management contact or duncan.mcluckie@dnr.nsw.gov.au
Version No: 1.0 Status: Final Issue date 25/10/2007 Authorisation: Director Coast & Floodplain Management

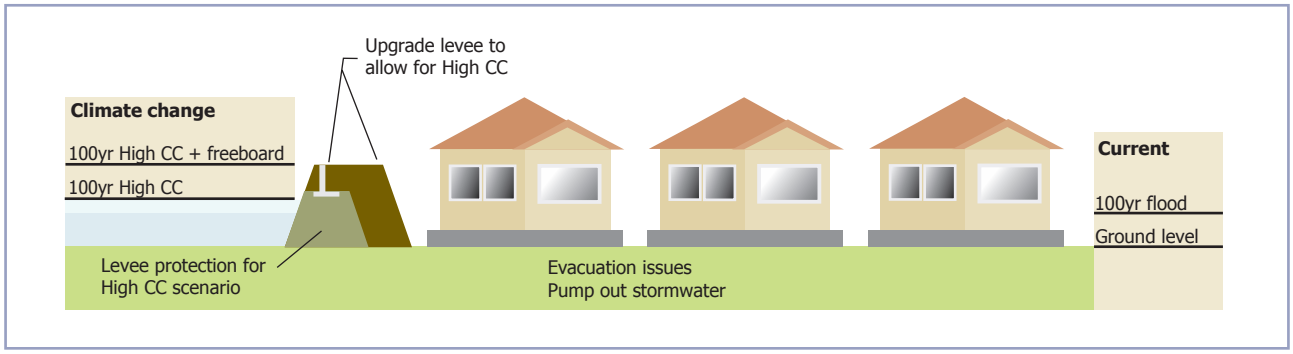
Strategy Existing 4 – Build New Levee or Upgrade Levee Now to Allow for High Climate Change scenario

Levee provides protection to property for high climate change impacts and existing flood risks.



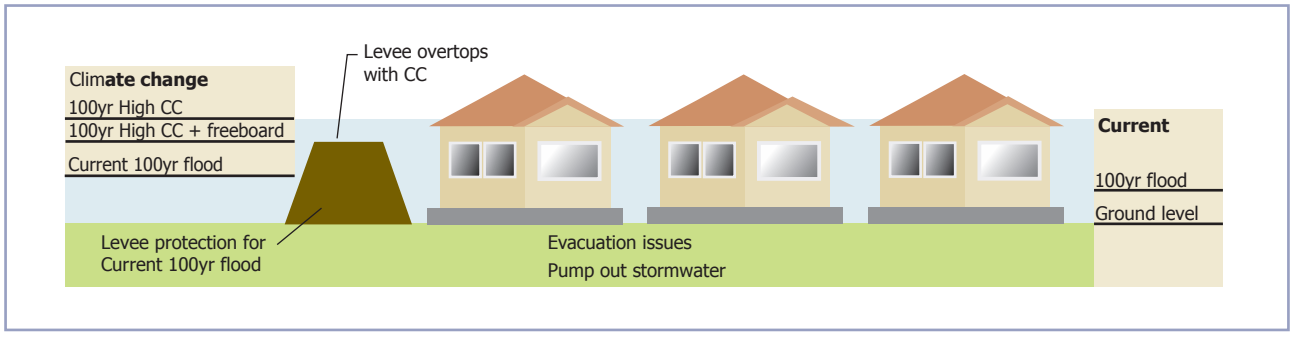
Strategy Existing 5 – Build New Levee for Existing Flood Situation but Design to Enable Upgrading for Climate Change or Examine the Ability to Upgrade an Existing Levee for Climate Change

Levee provides protection to property for high climate change impacts and existing flood risks once upgraded.



Strategy Existing 6 – Build New Levee for Existing Flood Situation Without Climate Change Allowance

Levee provides protection to property for existing flood risk but protection reduces overtime due to climate change impacts.



FRM Guidelines are prepared to assist Councils in the preparation and implementation of their FRM plans
Queries can be directed to your local DECC floodplain risk management contact or duncan.mcluckie@dnr.nsw.gov.au
Version No: 1.0 Status: Final Issue date 25/10/2007 Authorisation: Director Coast & Floodplain Management