

# Emergency Sealing of Breaches Phase II Operational Guidelines

Posford Duvivier

R & D Note 376



**NRA**

*National Rivers Authority*

2988

**EMERGENCY SEALING OF BREACHES**

Phase II

December 1994

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R&D Note 376

ENVIRONMENT AGENCY



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This R&D Note was commissioned by NRA to provide guidance on the initial management of breaches in river, estuarial and sea defences. It should be used by NRA operations and emergency staff as a guide to ensuring a safe, effective, consistent and rapid approach to the emergency sealing of breaches.

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**Additional copies**

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## **SUMMARY**

This report is derived from Phase II of research into the Emergency Sealing of Breaches.

The work carried out has led to the production of guidelines on best practice for sealing breaches in flood defences.

The guidelines form this report and include advice on the investigations that need to be undertaken on and off site so that a logical and consistent approach can be adopted to sealing flood defence breaches. In addition the guidelines give advice on possible methods of sealing the breaches taking into account various scenarios. Advice is also given on the format of a plan for sealing breaches, and a Post Mortem Report on the work. This Post Mortem Report is vital so that experience gained should not be lost. The lesson of each individual breach can then be gathered and used to enable any necessary adjustments to policy (design or maintenance) to be highlighted.

## **KEYWORDS**

Sea Defences  
Tidal Flood Defences  
Fluvial Flood Defences  
Breaches  
Emergencies  
Repairs

**PART A**  
**INTRODUCTION AND GUIDE TO THE USE OF THIS R&D NOTE**

## **1. INTRODUCTION**

This R&D Note describes the best practice on the Emergency Sealing of Breaches in flood defences as derived from Phase 2 of the project investigating the subject.

Fuller details of the findings of the project are described in R&D Note Project Record 431/4/A

The sealing of the breach will need to take account of the forthcoming CDM regulations which are due to come into force on 1st April 1995. At this stage insufficient guidance has been issued to enable the regulations to be fully taken on board in these guidelines. This needs to be addressed.

## **2. FORMAT OF THIS R&D NOTE**

In order to make the use of the R&D note as straightforward as possible its various sections are described here:

- The front of the document is the required 'housekeeping' which lists the titles, origin, etc. of the Note
- Part A (this part) is an introduction and general guide to the use of the Note
- Part B is a guide to deciding what to do in the event of a breach - repair or not.
- Part C gives some guidelines of plant, materials etc that may be required.
- Part D is a formalised way of carrying out a post mortem on a particular breach and recording the salient facts for future reference.

## **3. USING THE R&D NOTE**

It is intended that this Note should be a working document and therefore some guidance on its use is appropriate. This Note should lead the person in charge of a breach through many of the decisions that he will need to make. The fact that the decisions are laid out should ensure that suitable consideration is given to each with consequent savings in risk and cost.

It is emphasised that each breach is a unique event and that although lessons can and must be learned from previous events there is no necessarily unique 'correct' way of sealing any particular breach.

In the event of a breach this Note should be used in the following way:

- Decide by working through Part B of the Note **whether** to carry out an emergency repair.
- Decide by working through Part C of this Note **how** to carry out the repair (it is possible that several solutions may be suitable).
- Having sealed the breach **record** the salient facts about the breach by reference to Part D.

In sealing a breach the person in charge will be encouraged to travel through a logical sequence of decision. A detailed step by step guide is included as the rest of this R&D Note. Figure A, on the following page, shows the whole sequence of operations from breach occurring to post event review.

#### 4. DIVIDING BREACHES INTO TYPES BY WATER LEVEL AND FLOW CONDITIONS

Breaches have for convenience been divided into those occurring in fluvial, tidal or coastal sites. In fluvial breaches flow will be only limited by the available water upstream, between breach and the next control structure. The breach will have to be sealed with water still flowing. It must be appreciated that as the breach is sealed the head of water against the repair and hence speed of flow through the remaining gap will increase.

In coastal breaches water flowing through the breach comes from the sea and is therefore effectively unlimited in quantity. However owing to the large tidal variations in the UK the head of water passing through the breach will vary with time. In most cases there will each day be two periods where the tide has retreated and works to the breach can be undertaken with no flow in the breach.

In tidal breaches the situation is intermediate between fluvial and coastal breaches.

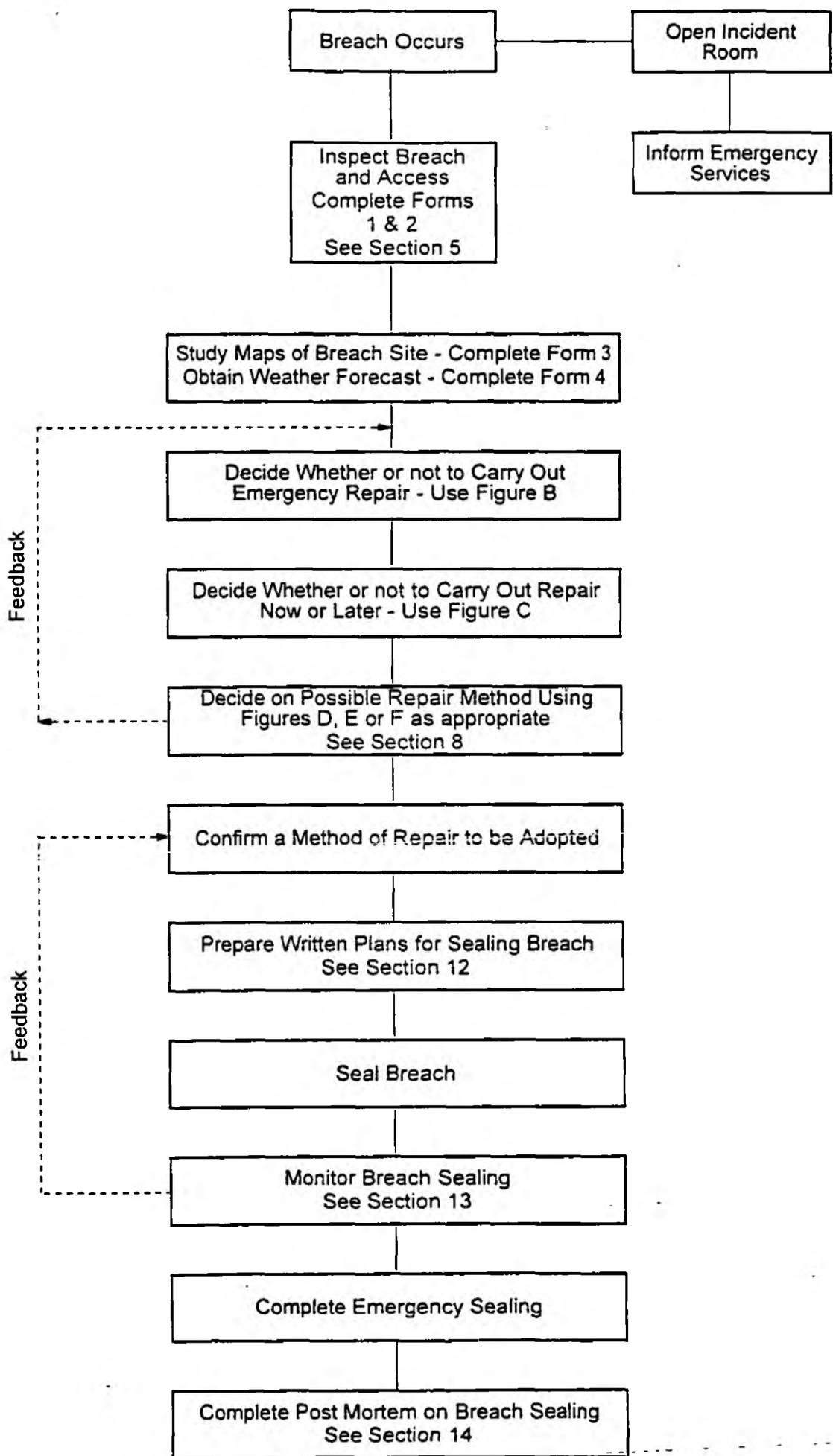


Figure A : Flowchart Outlining Sequence of Operations in Sealing a Breach

**PART B**  
**DECIDING WHETHER TO SEAL A BREACH**

## 5. ACTION TO BE TAKEN WHEN A BREACH HAPPENS

When a breach occurs the first actions to be undertaken are:

- open NRA incident rooms
- contact emergency services
- issue flood warnings as required
- give careful consideration as to whether to carry out an emergency repair (see below)

A breach can only be sealed if men, materials and plant can reach the critical areas and then have room to work safely.

In order to make a logical judgement on whether to carry out an emergency repair firstly.

- |  |  |
|--|--|
| ● inspect the breach site and its access               | On site fill in the Forms 1 and 2 on the following pages |
| ● study the location of the breach on maps of the area | fill in the Form 3 on the following pages                |
| ● obtain and consider the weather forecast             | fill in the Form 4 on the following pages                |

**FORM 1 INFORMATION TO BE RECORDED AT A BREACH SITE**

Location of Breach

**1. THE BREACH**

At what time was breach inspected

time

date

Who inspected the breach

Describe weather conditions

What was the breach width (judgement by eye)

metres

Does the breach appear to be getting wider

Yes
-----

No
----

at what rate

metres/minute

Do the defences adjacent to the breach appear to be in danger of failure

Yes
-----

No
----

What was apparent velocity of water flowing through the breach

metres/second

What was the apparent head of water at the breach

metres

Describe the breached defence eg. concrete wall, claybank

Describe

Where is the water passing through the breach spreading to

Describe

If defence is under attack by waves what are wave characteristics:

Wave height	
-------------	--

metres

Wave period	
-------------	--

seconds

What is at risk as flooding continues and how soon are these areas likely to be affected?

What is at risk? Describe	Time until affected/hours
(a) Property	
(b) Roads/Railways	
(c) Land	

This Form was completed by:

--

name, on

--

date and time

**FORM 2 INFORMATION TO BE RECORDED AT A BREACH SITE**

Location of Breach

**2. THE ACCESS**

How close does public highway reach to the breach

 metres

Is the public highway in danger of being flooded

Yes	No
-----	----

What is the nature of the location of the access

 rural/urban

What is the length of access from public highway to the breach

 metres

Are there overhead power lines over the access

Yes	No
-----	----

Are there underground services/pipes beneath the access

Yes	No	Not known
-----	----	-----------

Are there passing places along the access

Yes	No
-----	----

Note restrictions caused by the access

slope of access

1 in

min width of access

 metres

loading restrictions on access

Describe

**DESCRIBE ACCESS ROUTE**  
eg. turn right through gate and keep  
along top of bank

What is surfacing of access route

Describe

Is access likely to significantly deteriorate under use

Yes	No
-----	----

Is access likely to be cut by water flowing through the breach

Yes	No
-----	----

Tick those items of plant that currently would be able to use the access to reach the breach

loaded roadgoing lorries	
tracked excavators	
articulated dump truck	
cars/vans	
cranes/draglines	
landrovers	

This Form was completed by:

name, on

date and time

**FORM 3 INFORMATION TO BE RECORDED FROM STUDY OF MAPS OF BREACH AREA**

Location of Breach

What is the type of breach (tick one)

Fluvial	<input type="checkbox"/>
Tidal	<input type="checkbox"/>
Coastal	<input type="checkbox"/>

For **fluvial** breaches is there any obvious diversion/alternative route available for river flow eg. sacrificial breach, culverting flow past breach, flood diversion etc.

Yes	No
-----	----

Describe diversion route  
eg. via canal or land drainage system

Include below any other pertinent points:

This Form was  
completed by:

name, on

date and  
time

**FORM 4 FORECAST FOR BREACH SITE AND RIVER CATCHMENT**

Location of Breach

**Record Pertinent Details of Weather Forecast**

Date and time of forecast

date

time

Anticipated rainfall

mm in next

hours

Approximate length of daylight hours

from

am

to

pm

Anticipated minimum temperatures

°C in daytime

°C at night

For **tidal** and **coastal** breaches predicted high and low tide height for next 48 hours, levels to Ordnance Datum

Date	Time	Tide Height

Record below any other pertinent points

--

Predicted winds for next 48 hours

--

speed  
metres/seconds

--

direction  
(bearing)

This Form was  
completed by:

--

name, on

--

date and  
time

## 6. **DECISION ON WHETHER TO CARRY OUT EMERGENCY REPAIR**

The person managing the incident must now decide whether an emergency repair should (in principal) be carried out. He will base his decision on the results of the inspection of the breach and in particular the reports on what may be at risk if flooding continues and when those affects may come about.

Note the decision 'to repair' is described as 'in principle' as it is possible that no safe or practical method can be found immediately to seal the breach.

**USE DECISION TREE FIGURE B TO HELP DECIDE WHETHER TO PROCEED.**

The tick boxes following the decision tree should be completed to record the decision process.

Having decided in principal to carry out an emergency repair

**USE DECISION TREE FIGURE C TO HELP DECIDE WHETHER TO CARRY OUT REPAIR NOW OR LATER**

The tick boxes following the decision tree should be completed to record the decision process.

Note that this decision tree requires that methods of sealing the breach be considered to decide for instance whether it is necessary to construct access or stockpile materials. The decision on whether to seal now or later and on how to seal a breach depend on each other. An iterative approach is needed.

On completion of the breach sealing the decision tree figures B and C may be incorporated with the project Post Event Review.

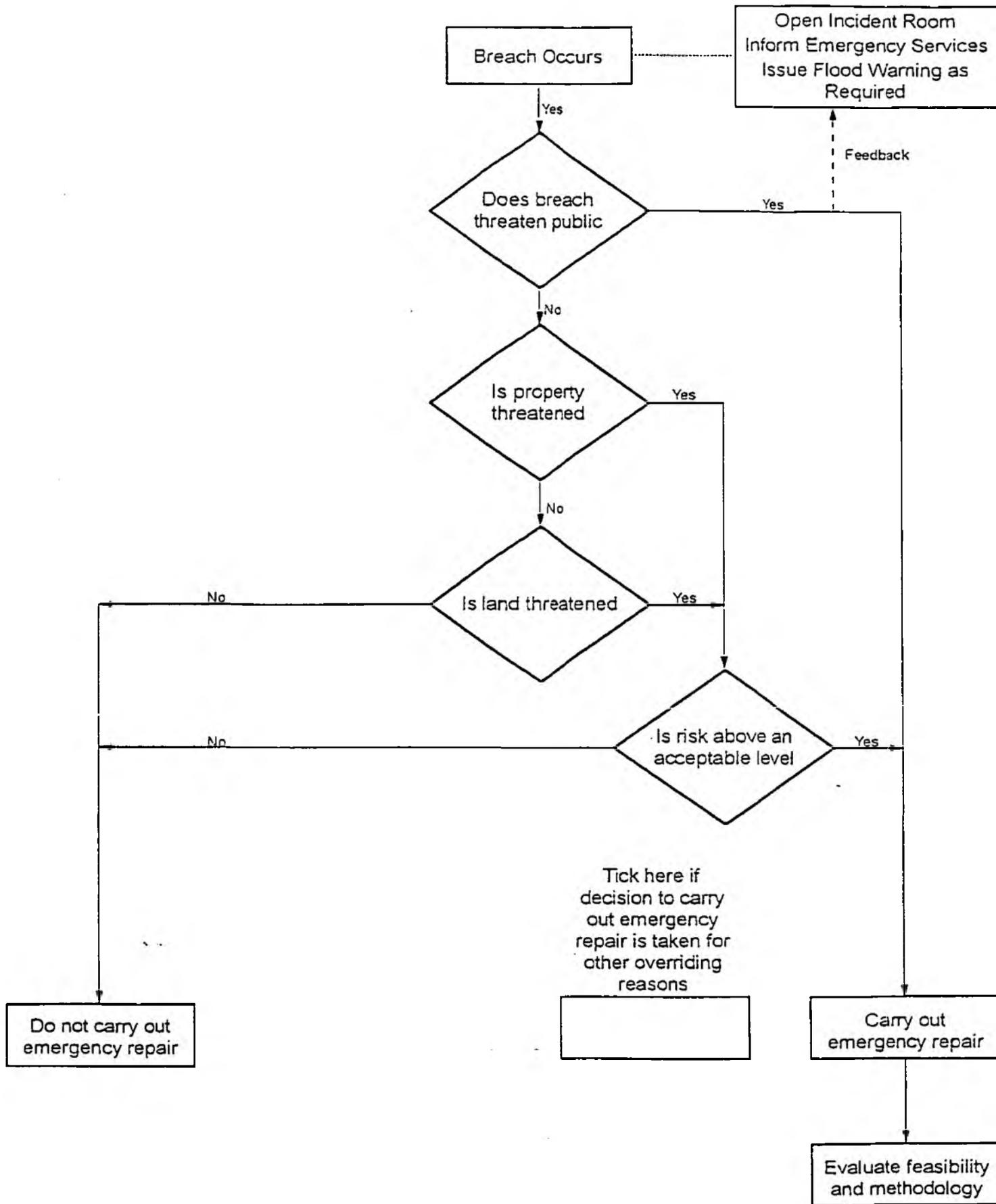


Figure B : Flowchart Outlining Decision to Carry Out Emergency Repair or not

PUBLIC IS THREATENED IF ANY OF THE FOLLOWING ARE LIKELY TO BE FLOODED

- Houses
- Residential Homes
- Medical Centres

PROPERTY THREATENED CAN INCLUDE

- Houses and the like
- Roads
- Railways
- Factories
- Electrical Sub-Stations
- Sewage Works

LAND THREATENED CAN INCLUDE

- Arable or Pastural Farmland
- Park Land
- Waste Land

RISK IS ABOVE ACCEPTABLE LEVEL IF THERE IS

Any chance of any Property or Significant Areas of Land being Flooded

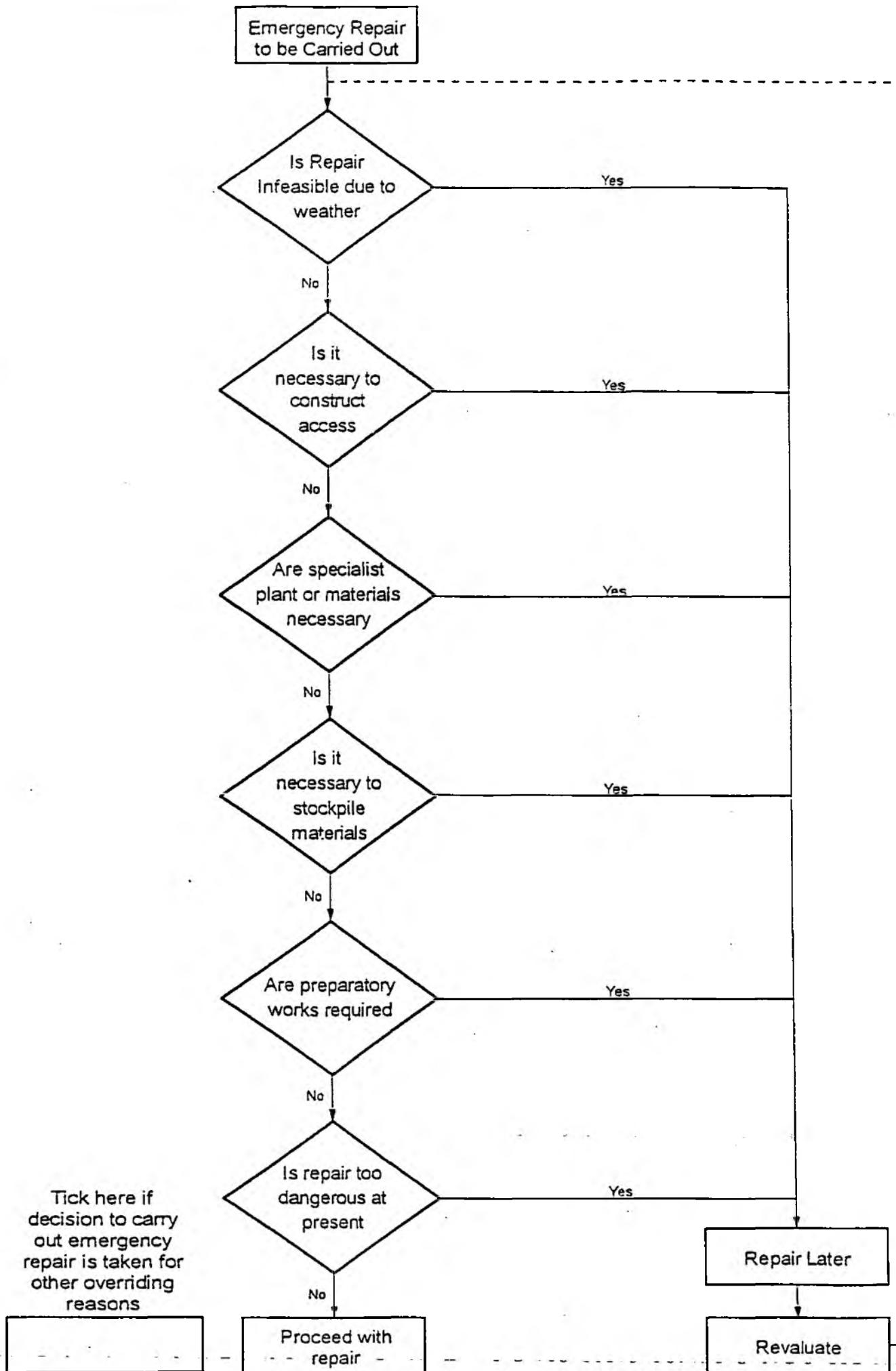


Figure C : Flowchart Outlining Decision to Repair now or later

**WEATHER IS TOO BAD AT PRESENT**

- Access is impossible
- Working Conditions are too bad
- Materials can not be transported

**NECESSITY TO CONSTRUCT ACCESS  
BASED ON KNOWLEDGE OF  
EXISTING ACCESS AND PROPOSED  
METHOD OF SEALING THE BREACH**

See Section 7

See Sections 8 and 9

**NECESSITY TO STOCKPILE BASED ON**

- Size of Breach
- Proposed Method of Sealing Breach
- Knowledge of what Materials are in Stock

See Sections 1 & 8

**PREPARATORY WORKS MAY INCLUDE**

- Improving Access (See Section 7)
- Diverting Flow or Making Sacrificial Breach (See Section 8)

**THE DANGER MUST BE ASSESSED  
BASED ON**

- Size of Breach and Flowrate Through it
- Condition of access to the Breach Site
- Proposed Method of Sealing the Breach

Method / Access / Plant Matrix for Fluvial Breach <sup>1</sup>							
Access <sup>2</sup> Type	Sealing Method						
	Sandbags	Sheetpiles	Trench Sheets Stakes Posts	Bulkfill	Mass Concrete	Gabions	Big Bags
GOOD	lorries excavator filling machine loader	excavator lorries crane	excavator lorries	excavator dozer lorries	Concrete pump lorries excavator	lorries crane excavator	lorries crane excavator loading plant
AVERAGE	artic dumpers excavator filling machine loader	artic dumpers excavator	artic dumpers excavator	excavator dozer artic dumpers	excavator artic dumpers	excavator artic dumper crane	excavator artic dumpers crane
POOR	artic dumper excavator loader	artic dumper excavator	artic dumpers excavator	excavator dozer artic dumpers		excavator artic dumper	excavator artic dumper
BAD	dumper hand plant		JCB dumper				

<sup>1</sup> For definition of fluvial see section 4

<sup>2</sup> For definition of access type see section 7

Figure D : How to undertake emergency repair - Fluvial Breach

Method / Access / Plant Matrix for Tidal Breach <sup>1</sup>							
Access Type <sup>2</sup>	Sealing Method						
	Sandbags	Sheetpiles	Trench Sheets Stakes Posts	Bulkfill	Mass Concrete	Gabions	Big Bags
GOOD	lorries excavator filling machine loader	excavator lorries crane	excavator lorries	excavator dozer lorries	Concrete pump lorries excavator	lorries crane excavator	lorries crane excavator loading plant
AVERAGE	artic dumpers excavator filling machine loader	artic dumpers excavator	artic dumpers excavator	excavator dozer artic dumpers	excavator artic dumpers	excavator artic dumper crane	excavator artic dumpers crane
POOR	artic dumper excavator loader	artic dumper excavator	artic dumpers excavator	excavator dozer artic dumpers		excavator artic dumper	excavator artic dumper
BAD	dumper hand plant		JCB dumper				

<sup>1</sup> For definition of tidal see section 4

<sup>2</sup> For definition of access type see section 7

Figure E : How to undertake emergency repair - Tidal Breach

Method / Access / Plant Matrix for Coastal Breach <sup>1</sup>							
Access Type <sup>2</sup>	Sealing Method						
	Sandbags <sup>3</sup>	Sheetpiles	Trench Sheets Stakes Posts	Bulkfill	Mass Concrete	Gabions	Big Bags <sup>3</sup>
GOOD	lorries excavator filling machine loader	excavator lorries crane		excavator dozer lorries	Concrete pump lorries excavator		lorries crane excavator loading plant
AVERAGE	artic dumpers excavator loader	artic dumpers excavator		excavator dozer artic dumpers	excavator artic dumpers		excavator artic dumpers crane
POOR	artic dumper excavator loader	artic dumper excavator		excavator dozer artic dumpers			excavator artic dumper
BAD	dumper hand plant						

<sup>1</sup> For definition of coastal see section 4

<sup>2</sup> For definition of access type see section 7

<sup>3</sup> Sandbags and Big Bags only suitable for  
(i) including in core of mound or  
(ii) raising freeboard

Figure F : How to undertake emergency repair - Coastal Breach

**RECORD OF DECISION USING FIGURE B**

Does the breach threaten public?

Yes	No
-----	----

Is property threatened?

Yes	No
-----	----

Is land threatened?

Yes	No
-----	----

Is risk above on acceptable level?

Yes	No
-----	----

This Form was  
completed by:

name, on

date and  
time

RECORD OF DECISION USING FIGURE C

Is repair infeasible due to weather?

Yes	No
-----	----

Is it necessary to construct access?

Yes	No
-----	----

Are specialist plant or materials necessary?

Yes	No
-----	----

Is it necessary to stockpile materials?

Yes	No
-----	----

Are preparation works required?

Yes	No
-----	----

Is repair too dangerous at present?

Yes	No
-----	----

This Form was completed by:

name, on

date and time



**PART C**  
**UNDERTAKING EMERGENCY SEALING OF BREACH**

## 8. HOW TO UNDERTAKE EMERGENCY REPAIR

Refer to method/access/plant matrices for possible methods of sealing breaches.

For fluvial breaches see Figure D  
tidal breaches see Figure E  
coastal breaches see Figure F

(the concept of fluvial, tidal or coastal situations is introduced in *Section 4*)

On the relevant figure D, E or F the user should read along the line of the relevant access type to read off possible breach sealing methods.

For example for a coastal breach with poor access two of the possible methods are:

- i. sheet piles using articulated dump trucks and hydraulic excavator
- or
- ii. bulkfill using articulated dump trucks, hydraulic excavator and bulldozer

In nearly all circumstances the first objective in sealing a breach is to ensure it does not widen. Therefore secure the edges of the breach first. The breach is then constantly narrowed by working from the edges.

If the middle of the breach is sealed first the flow will be diverted to the edges and as the sealing continues the flow will become faster and faster. The likelihood is therefore that the edges will erode.

Note that in some circumstances it may be possible to reduce the flow and therefore head of water through a breach by:

- diverting flow through an alternative course
- creating a sacrificial breach in a defence to allow flooding in a less critical location

The lower the speed and amount of flow in the breach the easier it will be to seal.

Once the sealing of the breach is underway more time will be available for considering the environmental aspects of the situation. Should the site of the breach be at or local to an environmentally sensitive area the statutory body responsible for the site should be given a copy of the plan of how to seal the breach.

The breach sealing method derived will later be incorporated with the Plan of how to Seal Breach (*see Section 12*).

## 9. MATERIALS TO BE USED

Various materials that may be used to seal breaches are described below. In general the NRA do not stock or store materials. When they are required enquiries will be sent to manufacturers, stockists, quarries etc. It is not considered appropriate to have standing arrangements with these bodies for the supply as the arrangements will very rarely be used and so they would inevitably not be kept up to date. A procedure that does not work correctly is worse than no procedure at all.

It is however important that CONTACT NAMES, ADDRESS, TELEPHONE NUMBERS ETC, SHOULD BE KEPT BY NRA AT OPERATIONAL AREA LEVEL

**Sand bags** The NRA keep large numbers of sand bags and their use is well understood. They are filled two thirds full with sand and placed by hand. The bags can be filled on site or before delivery.

Although in the past sandbags have been used to seal major breaches the enormous labour involved now makes this approach generally impractical.

**Sheet Piles** The NRA do not store large quantities of sheet piles. However they often have some piles in stock. These piles may have been used for temporary works on completed jobs or may have been pre-ordered for forthcoming contracts. Should sheet piles be required to seal a breach the NRA would first check their depot, to see what is available and then if more are required enquiries would be sent to local contractors and stockholders.

**Trench sheets/stakes/posts** The situation with trench sheets etc. is as for sheet piles

**Bulkfill** Clearly the NRA do not stock bulkfill. Should large quantities be required to seal a breach enquiries would be put out to local quarries. In some cases fill may be available by excavating local to the breach. Enquiries for fill should always be specific to what type is required eg. granular gravel, granular sand, clay, hoggin etc.

**Concrete** The NRA do not run batching plants. If concrete is required to seal a breach enquiries would be sent to local batching plants. The type of mix required should be specified but not over specified.

**Gabions** The NRA do not store gabions. If they are required enquiries would be sent to manufacturers.

**Big Bags** The NRA do not store big bags at present. However consideration should be given to the purchase and storing of them. This is because of the delivery time from manufacturers (upto 3 weeks). As they are inert and light and come folded they do not need a lot of storage space.

## 10. PLANT REQUIREMENTS

The NRA may hire in plant from outside firms. CONTACT NAMES ADDRESSES, TELEPHONE NUMBERS ETC SHOULD BE KEPT AT NRA OPERATIONAL AREA LEVEL

Typical plant that is commonly used is:

Cranes	eg.	RB22	rigged as a crane
Cranes	eg.	RB22	rigged as a dragline
Tracked hydraulic excavator			typically 16 tonne machine
Wheeled backacters			typically JCB 3CX
Roadgoing lorries	eg.	metal sided tipper wagons	15 tonne capacity
Articulated dumptrucks	eg.		typically 15 tonne capacity

## 11. LOGISTICAL ARRANGEMENTS

In an emergency NRA staff and operatives have been shown to be selfless in their response to crises and will work willingly in harsh conditions. However the sealing of a breach can take several days and so suitable logistical arrangements should be made.

- Shifts should be limited to a maximum of 12 hours and for each shift there should be a clear staff hierarchy with one named individual in charge. Staff numbers on each shift should be adequate to ensure safe working. Each team member should know and understand his role in sealing the breach.
- Easy communication, by either radio or telephone, is required between the site and operational headquarters to facilitate requests for more materials, plant etc.
- Arrangements must be in place to quickly deal with any mechanical problems on site. It would not be satisfactory for example for only one dragline to be available at the breach site and for it to then break down.
- Men work best when warm and dry and not hungry although it may be inevitable that they become dirty wet and cold. Therefore adequate clean cabins to shelter in are to be supplied with spare dry clothes and protective gear.
- Arrangements should be set in hand to provide hot drinks and food.
- Although a shift may be 12 hours and the men will be very keen to work, it is important that suitable breaks are taken at sensible intervals.

**12. PLAN OF HOW TO SEAL BREACHES**

Having considered the access and size of breach etc. the person in charge would now appear to be in a position to begin sealing the breach. However before commencing site work or ordering materials etc. The person in charge **MUST WRITE A PLAN** on how the breach will be sealed including a **RISK ASSESSMENT**.

The plan should be general and not in detail and can be altered with time to take account of events. The plan should be written as below:

Location of Breach

Date plan is written

Plan written by

Resources (list) required:

Plant		Labour		Materials	
Type	No.	Grade	No.	Type	Quantity

Work required to improve access (describe)

Outline method of sealing breach (describe)

This Form was  
completed by:

name, on

date and  
time

The Plan should be copied to the work team and/or verbally described before work commences:

**FORM 5 CHECK FORM TO BE COMPLETED BEFORE SEALING BREACH**

**A GATHERING INFORMATION**

**1. THE SITE**

- 1. Has the site been visited
- 2. Has Form 1 been completed describing the breach
- 3. Has Form 2 been completed describing the access

<input type="checkbox"/>
<input type="checkbox"/>
<input type="checkbox"/>

Tick boxes

**2. BACKGROUND**

- 1. Have maps of the area of breach been studied and Form 3 been completed?
- 2. Has forecast for the beach site been gathered and Form 4 been completed?

<input type="checkbox"/>
<input type="checkbox"/>

Tick boxes

**B. MAKING DECISIONS**

- 1. Has Figure B been followed to decide whether to carry out Emergency Repair or not?
- 2. Has Figure 4 been followed to decide to repair now rather than later?
- 3. Has the access been graded according to Table 1 page 25?
- 4. Have Figures D, E or F as appropriate been used to decide on possible sealing method?

<input type="checkbox"/>
<input type="checkbox"/>
<input type="checkbox"/>
<input type="checkbox"/>

Tick boxes

**C. PLAN**

- 1. Has a plan of how to seal the breach been written as on page 25?
- 2. Has the plan been copied to the work team or verbally described?

<input type="checkbox"/>
<input type="checkbox"/>

Tick boxes

This Form was completed by:

name, on

date and time

NOW PROCEED WITH SEALING THE BREACH

### **13 MONITORING THE SEALING OF THE BREACH**

Once a method has been decided on and the sealing proceeds the work must be carefully monitored to ensure that

- a. it is done safely
- b. if progress is slow the reasons can be determined.

It is possible that it will become apparent that the first approach taken to the sealing of the breach is proven not to be practical or even possible to implement. In this case **CONSIDER ALTERNATIVE METHODS.**

The Plan to seal the breach should be updated as any changes are made and conveyed to the work team.

**PART D  
POST EVENT REVIEW**

**14. WHAT CAN BE LEARNED FROM BREACHES AND THEIR SEALING**

In order that the experiences can be collected in an organised format whoever seals a breach in a flood defence should complete the attached proforma and copy it to ..... of NRA..... Region.

**EMERGENCY SEALING OF BREACHES**  
**BREACH REPAIR POST EVENT REVIEW**

If you have recently been involved in the sealing of breach you are requested to complete this form.

- i. Location of Breach
  
- ii. In which NRA Region was breach
  
- iii. Date of breach
  
- iv. Type of defence (coastal/tidal/fluvial)
  
- v. Type of construction earth embankment/sheet  
piled wall/concrete wall/other (specify...)
  
- vi. Antecedent conditions (weather/river flow/tide etc.)
  
- vii. Reasons for the breach (eg. design or maintenance problems?)
  
- viii. Length of breach (metres)
  
- ix. Maximum head of water through the breach (metres)

- x. Repair procedure (temporary or permanent works, type of construction etc)
- xi. Type of plant used
- xii. Materials used and were they available from stockpiles
- xiii. Manpower involved
- xiv. Cost of Sealing Breach
- xv. Site access (permanent/temporary, landside/waterside etc)
- xvi. Consideration of environmental or conservation aspects in repairs
- xvii. Involvement of other parties (local councils etc)
- xviii. Approximate extent of property/people flooded
- xix. Property/people evacuated if any
- xx. How many days did it take to seal the breach
- xxi. Other comments
- xxii. Please attach a location sketch to show extent of breach, access routes and areas flooded.

xxiii. What lessons have been learned from the breach and the sealing.

This proforma was completed by (name) .....

Signed .....

Date .....