Scale and Scum

Contents: Questions based on an advertising leaflet concerning water softening.

Time: 2 periods.

Intended use: GCSE Chemistry and Integrated Science. Links with work on hardness of water.

Aims:

- To complement and revise prior work on hardness of water
- To develop awareness of the use of science in advertising
- To develop a critical attitude to scientific advertising claims.

Requirements: Students' worksheets No. 607. This includes copies of the pages from the advertising leaflet.

The questions in Part 1 are designed to test understanding of the topic of water hardness. Part 2 encourages students to look critically at some of the advertising claims.

Notes on some of the questions

Q.5 See note on 'Practical work' below.

Q.6 See note on Q.8(b) below.

Q.8

(a) *Disadvantages of hard water:* Causes scale; wastes soap; causes scum; does not leave clothes and hair feeling soft after washing.

(b) *Advantages of hard water:* Many people prefer its stronger taste; provides calcium for teeth and bones; does not dissolve lead from pipes so quickly; there is some evidence that it may help prevent heart disease.

Q.11 It would take just over fifteen years.

Q.12 The percentage of fuel wasted due to scale will of course depend on the individual household, and in particular how well the hot water tank is insulated in the first place.

Q.20 Scum consists mainly of insoluble calcium soaps, for example, calcium stearate. It may be unsightly, but there is no reason why it should itself be unhygienic, though it might conceivably trap bacteria in the basin or bath.

Practical work

This unit could be usefully linked to practical work. In particular, students could carry out experiments to test the behaviour of soap and washing powder in hard and soft water, to investigate the claim that softened water saves waste. Experiments are described in Nuffield 13-16, *Making Molecules Work for Us,* in Science at Work, *Cosmetics,* and in a number of chemistry texts.

Acknowledgements We are grateful to ESTEC Ltd for permission to reproduce parts of their advertising leaflet.

SCALE AND SCUM

Advertisers sometimes use scientific ideas to encourage people to buy their products. One of the benefits of studying science is that you can look at these advertisements to see if their science is accurate and fair.

You will be given copies of parts of an advertising leaflet used by the firm ESTEC to encourage people to buy water softeners. Read the leaflet, then answer the questions. Your teacher will tell you which questions to answer.

Part 1 The scientific background to hard water

You may have to look at your work on hard and soft water to help you with these questions.

Questions

1 Look at the diagram on page 1 of the leaflet.
   (a) Which of the rocks dissolves in the water to make it hard?
   (b) Why does rain water dissolve this rock?

2 The leaflet describes two 'Terrors' — Scale (pages 2 and 3) and Scum (pages 4 and 5). What are scale and scum? Explain carefully how they are different.

3 The leaflet has a photograph of the inside of a hot water tank (page 2). Would you expect the inside of a *cold* water tank to get coated in the same way? Explain your answer.

4 (a) Why does soft water produce a better lather with soap than hard water?
   (b) Explain why 'hair looks and feels much better' when washed in soft water.

5 What experiments could you do to test the claim that softened water gives a better lather (page 5)?

6 When the water softener is installed it is possible to have a separate drinking tap delivering hard water. Why might this be desirable?

7 Scale is not the only cause of energy loss in a hot water system.
   (a) What are the other causes of energy loss?
   (b) How can these energy losses be reduced?

8 (a) List the disadvantages of hard water compared to soft water.
   (b) Are there any *advantages* of hard water?

Part 2 Looking at the advertising claims

Page 2: Scale in your tank wastes energy

9 How old do you think the tank in the photograph is? Is it:
A 5 years B 15 years C 30 years
D Impossible to tell?

10 Why do you think the age of the tank has not been given?

Page 2: Softened water saves energy

11 According to the leaflet, $\frac{1}{8}$" ($\frac{1}{8}$ of an inch) of scale on a hot water tank wastes £26 per year. How many years will it take to cover the cost of the water softener through this saving? Assume the softener costs £400 to buy.

12 Do you think the figures in the chart apply to all households? Explain your answer.

Page 3: Scale in your pipes

13 How large do you think the pipe in the photograph is?

14 Why do you think the leaflet has not given the size of the pipe?

Page 3: Scale in your kettle

15 Does your kettle at home look like the one on the left or the one on the right?

16 Do you think the two kettles are the same age?

17 Why is it important that the kettles are the same age?

Pages 4 and 5: Scum in your bathroom

18 In what ways do the photographs try to show the advantages of softened water? (You should find 3 at least.)

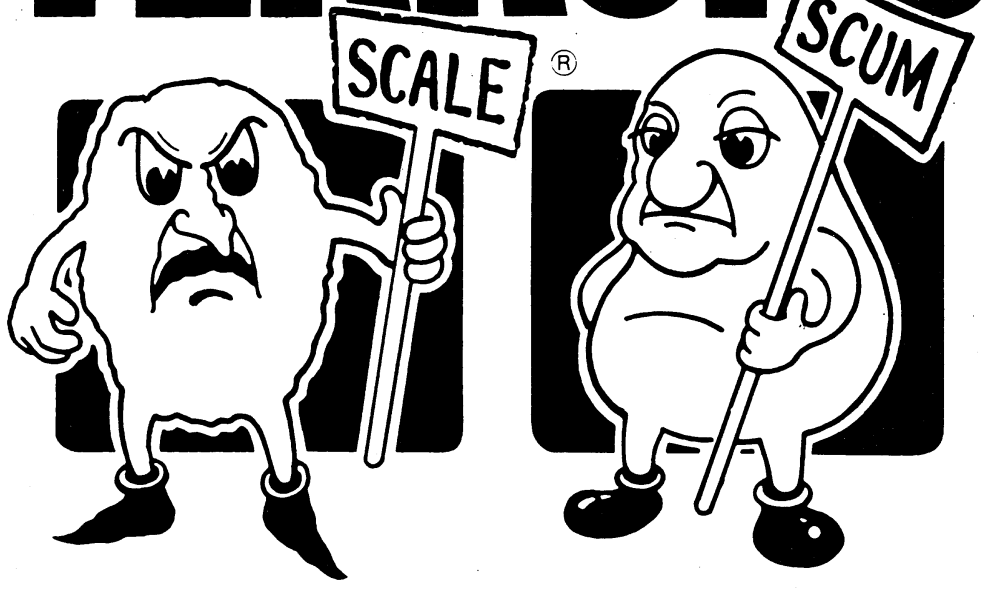
19 The basin on page 4 is a darker colour than the one on page 5. Suggest a reason for this.

20 Scum in your basin 'is also rather unhygienic'. Is this a reasonable claim? Explain your answer.

General questions to discuss

- Who do you think this pamphlet is aimed at? Why?
- Has it given a fair account of scale and scum? If not, what other points would you want to know?
- What questions would you ask the firm's representative if you were interested in buying a water softener?
- What changes, if any, would you make to the leaflet to try to encourage larger sales of water softeners?
- Would it be worthwhile sending the leaflet to all towns in Britain? Explain.
- What other types of firms might send leaflets to householders to encourage them to save energy?

The Tale of Two TERRORS

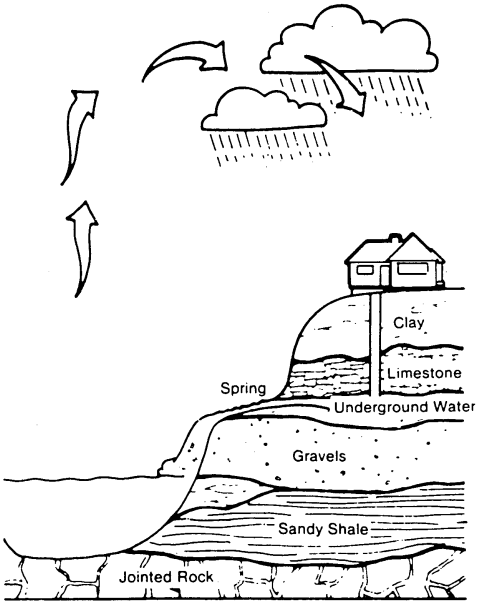


Dear Homeowner.

We apologise for approaching you in this manner but hope that you will spare us a few moments to glance through our brochure.

IN THE BEGINNING our water is pure and soft and gentle. but underground. deep down among the sedimentary rocks. lurk Scale and Scum. They dissolve in our water and are carried through the mains water pipes to our homes.

Once inside they cause all sorts of problems and needless expense. To find out more please read our tale.



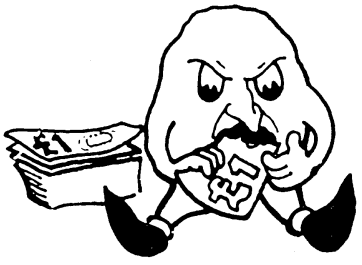
page 1

SCALE IN YOUR TANK

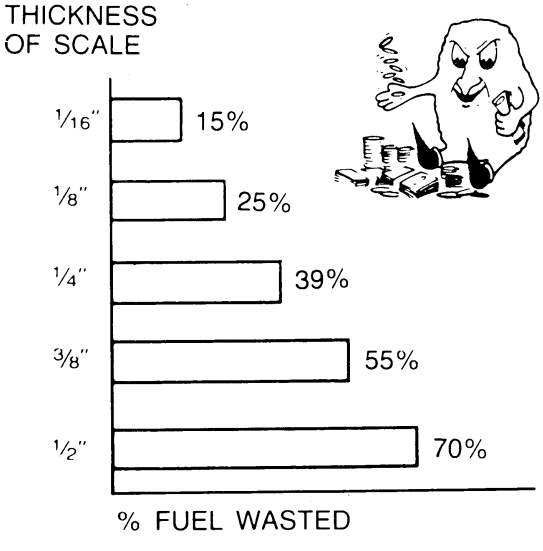
WASTES ENERGY

The picture shows what expensive things Scale does inside our hot water tanks. He covers the heat exchanger with a layer of limescale which makes it much less efficient so you burn more fuel to heat the water.

Eventually he clogs up the whole cylinder and it has to be replaced, but meanwhile he is making us spend more money on fuel bills to heat the water.



SOFTENED WATER SAVES ENERGY



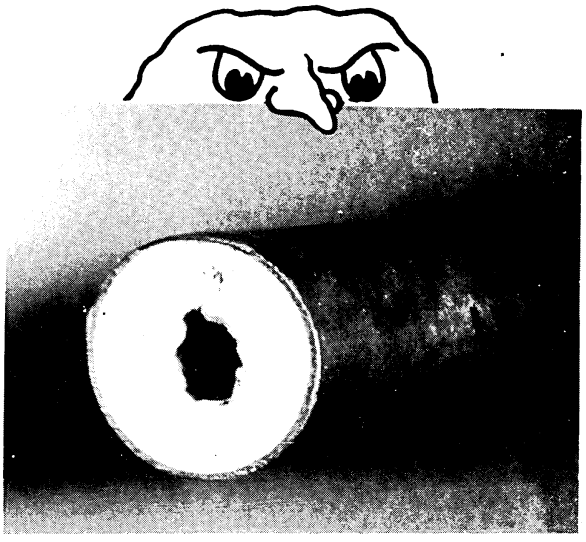
A family of 4 people spends about £2 a week to heat the hot water. If you have just a ⅛" of scale you waste up to 25% of your fuel, which is 50p a week. That's £26 a year - wasted.

If you fit a water softener before it is too late, the softened water will slowly dissolve away all the Scale and leave your cylinder completely clear.

SCALE IN YOUR PIPES

Scale gets in your pipes and slowly but surely blocks them up. Eventually you will have to replace them unless you do something now.

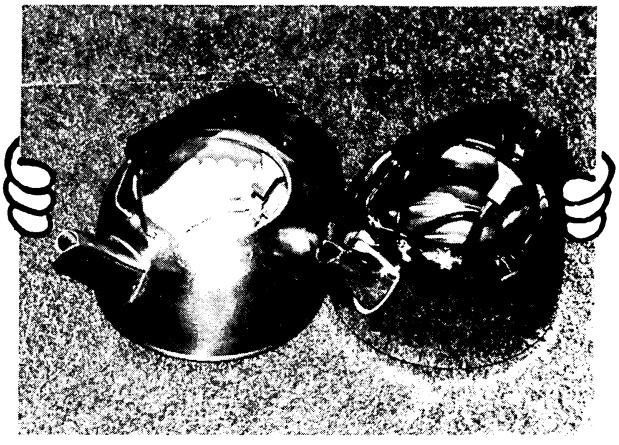
If you fit a water softener before it is too late, the softened water will slowly dissolve away all the Scale and leave your pipes completely clear.



SCALE IN YOUR KETTLE

On the left you can see the kettle that boils hard water. It's scaled up and it's the same Scale that stains your teapot and coffee mugs.
Horrible, isn't he!

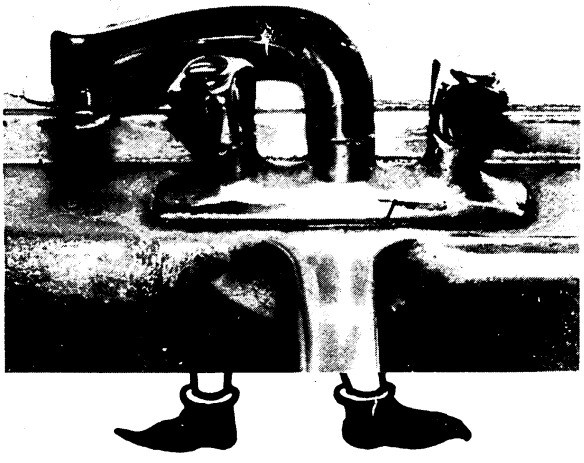
If you fit a water softener he will completely disappear.



SCALE ON YOUR TAPS

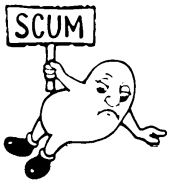
Scale sticks to your taps and ruins the chrome. He also sticks all around your kitchen sink.

When you have a softener fitted, you will never again have the chore of rubbing clean your stainless sink.



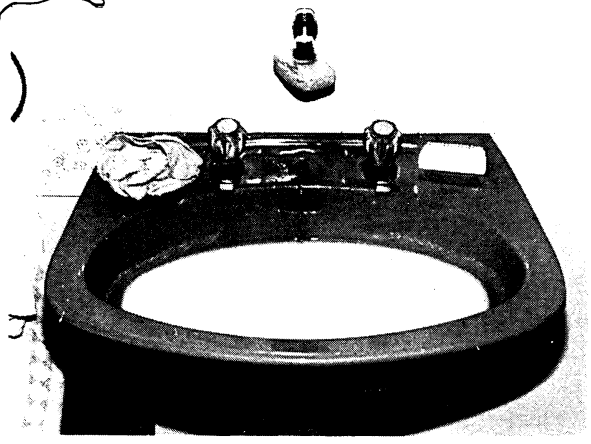
page 3

SCUM IN YOUR BATHROOM



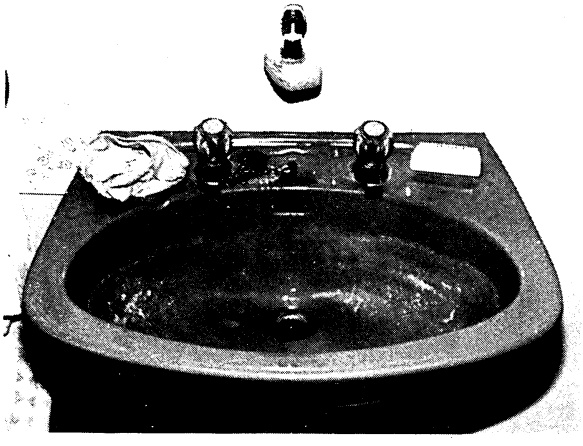
SCUM IN YOUR WATER

When you wash in hard water you always get a layer of Scum. It's rather nasty and unpleasant and sticks to the skin when you rinse. Many people suffer dry skin for this reason.



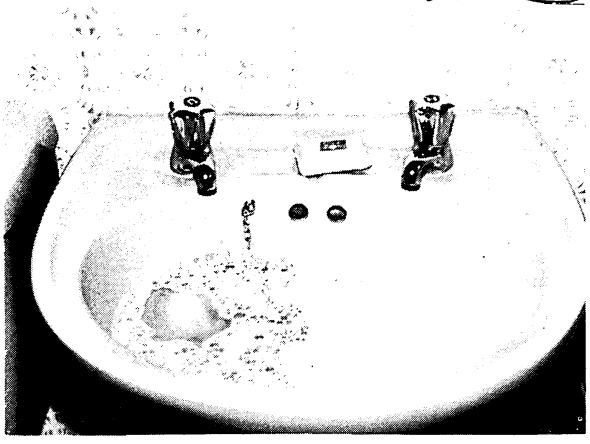
SCUM IN YOUR BASIN

Every time you wash you have to clean the basin afterwards. It's hard work and never ending, especially when there are children around. It is also rather unhygenic.



SCUM RINGS LEFT IN THE BATH

Taking a bath in hard water is not really the best way to get clean. You also have to scrub out the tub afterwards.



SOFTENED CLEAR WATER

With softened water you get a lovely clear lather. It is much nicer to wash in and noticeably kinder to your skin. Your hair looks and feels much better too.

NO CLEANING UP TO DO

After washing there is no scum left in the basin to clean up. That's right. No Scum to wipe away. **You only need clean the bathroom once a week.**

AND BUBBLES IN YOUR BATH

Bubbles in your bath are guaranteed with softened water. You get the best wash ever and you feel much cleaner afterwards.

Should we Build a Fallout Shelter?

Contents: A role-play exercise concerning the building of a nuclear fallout shelter.

Time: 2 periods. Homework time could be used for preparation.

Intended use: GCSE Physics and Integrated Science. Links with work on radiation.

Aims:

- To complement prior work on characteristics of radiation and the shielding effect of different materials
- To develop awareness of the likely effects, both immediate and long term, of a nuclear explosion
- To develop awareness of certain issues relating to civil defence and the survival of a nuclear attack
- To provide an opportunity to practise skills in debate and communication of information and arguments.

Requirements: For each member of the class: copies of the General Briefing sheets. In addition, two copies of each of the Specific Briefing sheets B1, B2, B3, B4 and B5 will be needed.

Organization of the activity

Most members of the class will assume the role of members of Eastborough Council, meeting to decide whether a nuclear fallout shelter should be built. In addition, there are the following special roles:

Mayor/Mayoress of Eastborough
Brigadier A, Commander of the local army unit
Doctor B, the Borough Medical Officer
Ms/Mr C, the Borough Engineer
Ms/Mr D, the Coordinator of Emergency Services for Eastborough.

The Mayor/Mayoress will run the meeting, and should be chosen for appropriate personal qualities. Preferably the role should be played by a student, but if necessary the teacher could do it.

It is recommended that each of the other roles be taken by **pairs** of students, working together to prepare the role and answer the questions.

Suggested procedure

1 Allow 15 minutes or so for students to study their briefings. Some of this preparation could be done before the lesson, using homework time. They should all read the General Briefing first. Those in special roles should then read their Specific Briefings. Meanwhile, the remainder of the class (the councillors) can be preparing the questions they wish to ask at the meeting.

2 Bring the class together for the meeting, with seating arranged appropriately. The rest of the proceedings are handled by the Mayor/Mayoress, following the outline on Briefing Sheet B1.

Further resources

Nuclear Issues in Education: a Teaching Guide is a comprehensive teaching pack compiled by a working group of the Newcastle-upon-Tyne Education Committee. Available from: Pendower Hall Educational Development Centre, West Road, Newcastle-upon-Tyne NE15 6PP.

The Nuclear Issue: a Source Book for Education, by J. J. Wellington (Blackwell) includes a range of teachers' and students' materials.

SHOULD WE BUILD A FALLOUT SHELTER?

General Briefing

In this activity you will be taking part in an imaginary meeting of Eastborough Borough Council. The purpose of the meeting is to decide whether the Council should build a nuclear fallout shelter, in case of nuclear attack.

The map in Figure 1 shows the Eastborough district (population 30 000).

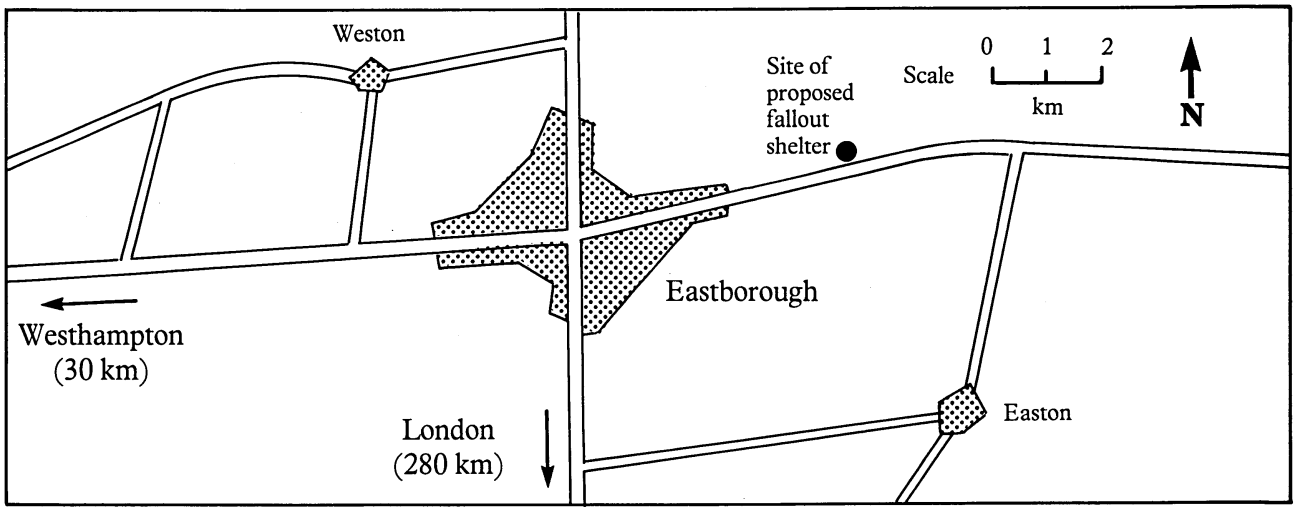


Figure 1 Map showing the Eastborough district

After a nuclear attack, Council workers would try to organize help for the survivors. The purpose of the Council fallout shelter would be to protect these organizers.

Roles

Most students will be playing the parts of councillors, but there are also some special roles:

The Mayor/Mayoress of Eastborough. This person will run the meeting. He or she will call expert witnesses in turn. Each witness will be questioned by members of the Council for a limited time. It will be necessary for councillors to decide beforehand who will ask questions on particular points. The Mayor/Mayoress will then allow a short general discussion, before taking a vote on the proposal.

The expert witnesses:

Brigadier A, Commander of the local army unit, will answer questions on the likely effects on Eastborough of a nuclear bomb explosion. This might be locally, or at Westhampton 30 km away.

Doctor B, the Borough Medical Officer, will answer questions on the medical effects on human beings of nuclear explosions and radioactive fallout.

Ms/Mr C, the Borough Engineer, will answer questions on the ability of different materials to give protection in a nuclear attack, and the equipment needed in the shelter.

Ms/Mr D, the Coordinator of Emergency Services for Eastborough, will answer questions on the effect of a nuclear attack on the work of the emergency services.

The proposal

The Proposal before this meeting of Eastborough Borough Council is that the Council should approve the building of a nuclear fallout shelter, in order to safeguard communications with emergency services after a nuclear attack.

The arguments for and against building the shelter can be summed up as follows.

FOR	AGAINST
It is our duty to save lives wherever possible	After a nuclear war, conditions would be so bad it would not be worth surviving anyway.
Many people who were not killed by a nuclear explosion would die from radiation sickness afterwards if there were no Civil Defence preparations.	A country which has taken Civil Defence precautions will not be so worried about becoming involved in a nuclear war.
If they have enough information, survivors can organize in groups and make plans for long-term survival.	Suggesting that people could survive a nuclear war will make them less ready to protest against nuclear weapons.
Survivors can best be helped if there are people to organize the rescue services and repair teams. These people would have to be protected by a shelter.	It is immoral for those in power to be protected, if there are only enough shelters for very few people.

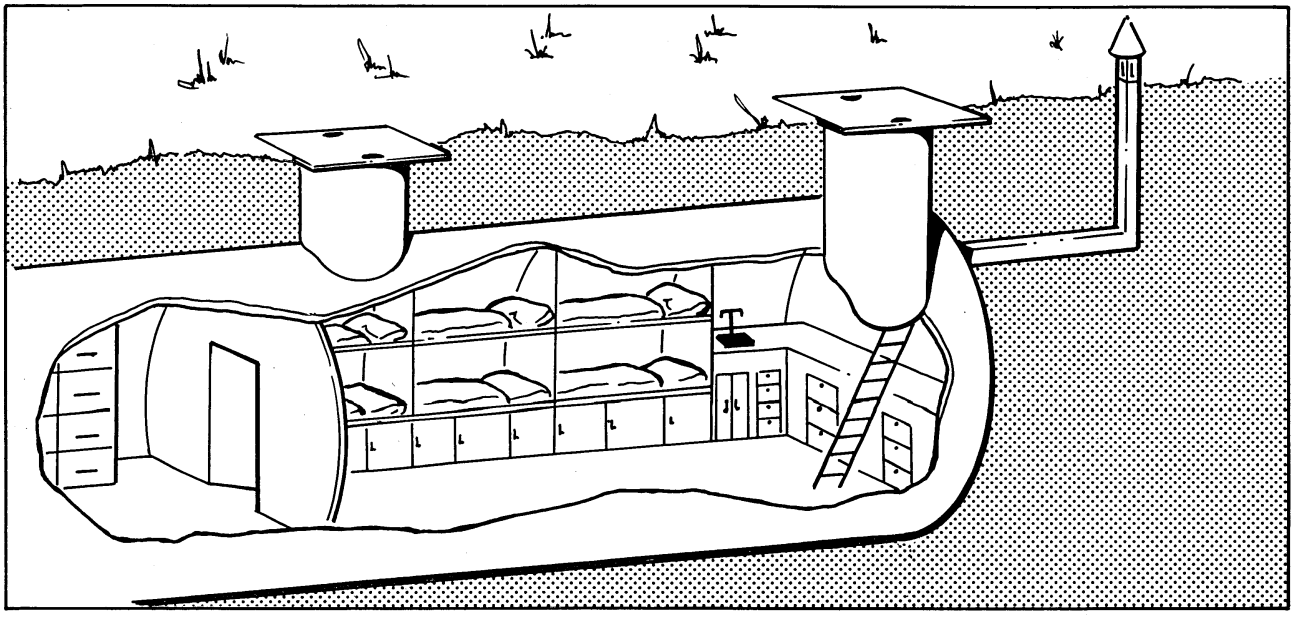


Figure 2 Part of a fallout shelter, made of steel and concrete and buried underground

Briefing Sheet 1

The Mayor/Mayoress of Eastborough

First make sure that you have read the General Briefing, then you can concentrate on your part in the proceedings.

Much of the success of this activity depends on you. Remember that *you are in charge.* Insist upon being addressed as Mr Mayor or Madam Mayor. Make sure that nobody speaks until you ask them to. You must not give your own opinion. Make sure that an equal chance is given to those For and Against the proposal. In private life you run your own business. You are a down-to-earth person, more interested in facts than fancies.

Here is what you should do when the meeting starts.

1 Call the meeting to order and read out the Proposal from your General Briefing Sheet.

2 Announce the order in which you will be calling the expert witnesses: first Brigadier A, then Dr B, Ms/Mr C, Ms/Mr D.

3 Before calling any witnesses, you should ask for questions. First, ask which councillors would like to question Brigadier A. Ask for the subjects of their questions. If there are too many (say, more than four) you will have to choose the most relevant. If a really important point seems to have been missed, you may remind them of it.

   Do the same with respect to questions for the other witnesses.

4 Call your first witness. Introduce him or her to the Council and ask for the first question. If the answer is not perfectly clear, the questioner may ask a follow-up question. Otherwise, pass on to the next question.

   After all the questions to this witness, ask if the witness wishes to make a statement about any important point not covered. Then thank the witness and ask him or her to stand down.

5 Deal with the other witnesses in a similar way.

6 Announce that the Proposal is open for discussion. Any councillor in favour may state his or her reasons. Then any councillor who is against it may do likewise. Then, depending upon time available, take others in turn. Do not allow interruptions.

7 When the general discussion seems to have gone far enough, read out the Proposal again and ask for votes. First take votes For, then Against. Finally announce the result.

Briefing Sheet 2

Brigadier A, Commanding Officer of an army unit based on Eastborough

You may be asked questions about the probable effects of nuclear explosions. Carefully study the following information, which you may quote in your answers.

The atom bomb exploded over Hiroshima in 1945 had a power of about 15 kilotons. This is the same as 15 000 tons of TNT.

A modern nuclear weapon might have the power of 1 megaton — 1 million tons of TNT. If exploded high over Eastborough it would have these effects:

- A brilliant *flash of light* lasting for about a tenth of a second.
- *Radiation* of neutrons and gamma rays. This would last about ten seconds and travel about 2.5 km from the explosion.
- A *fireball* producing intense heat. It would be enough to make trees catch fire about 10 km away and cause *winds* of hurricane force.
- A *blast wave,* which would destroy buildings up to 3 km away and form a crater 30 metres deep.
- An *electromagnetic pulse,* which could travel through aerials and telephone wires to destroy unprotected electronic equipment.

A nuclear explosion nearer ground level (a 'ground burst') would also suck up earth and turn it into a cloud of radioactive dust. This would drift down-wind and gradually fall as **radioactive fallout.** A 'ground-burst' on Westhampton, 30 km away, could cause fallout on Eastborough. The fallout would occur an hour or more later, depending on wind speed and direction.

Fallout would settle as dust and give out harmful radiation. The strength of this radiation would decrease rapidly. It would become a tenth as strong after 7 hours and a hundredth after 2 days. The time for the radiation to decrease to a safe level would probably be measured in weeks. Military and civil-defence workers have instruments which can measure the strength of radiation from fallout.

Radiation kills living cells, but it cannot make other things radioactive. The radioactivity stays with the dust on ground or rooftops, unless it is washed off by rain or blown away by the wind. It is particularly dangerous if the dust is breathed in or eaten.

When weapons of different sizes are compared, it is important to remember that a lot of the energy from an explosion goes upwards. A 1000 times more powerful bomb affects an area only 100 times greater.

Briefing Sheet 3

Doctor B, Medical Officer for Eastborough

You may be asked questions about the effects on humans of the results of a nuclear explosion. Carefully study the following information, which you may quote in your answers.

The atom bomb exploded over Hiroshima in 1945 had a power of about 15 kilotons, the same as 15 000 tons of TNT.

A modern nuclear weapon might have the power of 1 megaton — 1 million tons of TNT.

It is impossible to make accurate estimates of casualties from a nuclear explosion. Up to 5 km from the Hiroshima bomb 68 000 were killed and 76 000 injured out of a population of 256 000. A reasonable guess for a 1 megaton explosion is that about half the people with a 3 km radius would be killed. In the case of Eastborough, this would mean 15 000 would be killed.

Many people within a few kilometres of the explosion would be killed by the heat or blast effects. Unprotected survivors could be injured by flying debris, or badly burnt or temporarily blinded by the flash.

Survivors might also suffer from **radiation sickness.** This would be caused either by being near the explosion or by being near to radioactive fallout. The effect would depend on the strength of radiation and how long they were exposed to it. A large 'dose' may be fatal. A smaller dose would cause unpleasant symptoms, like a combination of flu and food-poisoning. A very small dose may seem to have no immediate effects. However, it may possibly cause illness such as cancer many years later. None of these effects is 'catching' — they cannot be passed on from one person to another. Scientists are unsure how much the children of survivors are affected by their parents having been exposed to radiation.

Many scientists believe that the long-term effects of a major nuclear war would make survival worthless anyway. Law and order would break down, and there would be chaos throughout the country. After a major nuclear war, clouds of dust would fill the sky, cutting out much of the Sun's heat and light. This might result in several months of very cold 'nuclear winter', making survival even more difficult.

Briefing Sheet 4

Ms/Mr C, Borough Engineer of Eastborough

You may be asked questions about the way building materials can protect against the effects of a nuclear attack, and the equipment needed in the shelter. Carefully study the following information, which you may quote in your answers.

The atom bomb exploded over Hiroshima in 1945 had a power of about 15 kilotons, the same as 15 000 tons of TNT.

A modern nuclear weapon might have the power of 1 megaton — 1 million tons of TNT.

The main job of a fallout shelter is to provide protection against the radiation given off by fallout. Fallout gives off three kinds of radiation: alpha, beta and gamma. Alpha and beta radiation can easily be stopped by an ordinary building, but the dust carrying them would be very dangerous if breathed in. Fallout shelters therefore need a filtered air supply. Gamma radiation is much more penetrating. A depth of at least three feet of earth or two feet of concrete is needed to stop it. An ordinary cellar could be adapted to make a fallout shelter.

At one kilometre or less from a 1 megaton nuclear explosion the blast would be extremely powerful. Only a very deep and expensive shelter would give protection. But 4 or 5 kilometres away, three feet of earth would be enough to resist both blast and radiation.

It is important to realize how much equipment a shelter would need, even for a few people. They would probably have to stay there until the radiation had reduced to one-thousandth of its original strength. This would take several days, possibly as long as two weeks. During this time the air pump would have to be kept going, driven by batteries or even by hand.

The people inside the shelter would need:

- Water supplies. Fallout would not contaminate water so long as dust did not settle on it. However, water mains would probably be broken, so canned supplies would be needed.
- Food Supplies. Any food in unbroken containers, from which any fallout dust was washed off, would be safe to eat.
- Lighting, heating, toilet facilities, etc.
- Communications, rescue and first-aid equipment.
- Protective clothing and radiation measuring equipment.

Briefing Sheet 5

Ms/Mr D, Coordinator of Emergency Services in Eastborough

You may be asked questions about the effect of a nuclear attack on communications with emergency services. Carefully study the following information, which you may quote in your answers.

Each of the emergency services (fire, police, ambulance and engineers) has their own building. Part of each building has been designed to protect them and their equipment in a nuclear attack.

After a nuclear attack, Council workers would have to organize when and where the various emergency services would be sent. The Council's fallout shelter would be to protect these workers.

Radiation-measuring instruments would be used to see how much radiation there was in Eastborough after the attack. If radiation was high, the emergency services would have to wait for it to fall before trying to help people in Eastborough. But it is thought that even in a severe nuclear attack about one-fifth of the country would probably receive no radiation. If the instruments showed little or no radiation in Eastborough itself, the emergency services would be able to start work immediately. They could help nearby areas which were not so fortunate.

The emergency workers would have to wear protective suits and rubber boots, so that fallout dust could be washed off. They would also have to carry personal 'radiation dosemeters'. These would tell them when the total dose of radiation they had received was nearing the danger limit. They would then need to take shelter and be replaced by new workers.

The Council fallout shelter would need the following:

- A local leader, with the knowledge and authority to decide what actions should be taken.
- A scientific adviser with maps and instruments, to use information to forecast local conditions in the Eastborough area.
- Communications equipment, protected from the various effects of a nuclear explosion. There would also need to be a person to receive messages about damage, weather conditions and radiation levels in different parts of the country. A network is already set up to report this information.
- Supplies for these people to keep working for several weeks, such as water, food, lighting and toilet facilities.