Lesson 1: Underwater

Narrative

Torbury Festival is due to start today! People have started to arrive but the clouds burst and rain hammers down. Mavis Broom, the festival site manager, is in her office. From her window she sees that the fields of her farm – shortly to be filled with 100 000 revellers – are completely flooded. Mental images of an underwater festival (complete with bubbles from the singers' mouths) flash before her eyes. There are just 90 minutes to go. Is there any way to get the fields dry in time and avoid having to hand out rubber rings to the crowd? Could teams from the Festival Support Squad (FSS) assist?

Problems

Main challenge

The squad teams know that the festival gates are due to open in 90 minutes. They are aware that there are four flooded areas and that four different ways of removing water will all be ready to go in half an hour. These options are:

- pumping the water into tanks to be airlifted away using the stand-by helicopter
- pumping the flood water into the underground pipe that runs to the river
- spreading straw from the farm over the squelchy ground to bind it together
- using the suction truck, normally used to empty the portaloos, to pump water away (making sure it is switched on 'suck' not 'blow' – raw sewage really did hit the fans in the Dance Tent in Glastonbury in 1998!)

The teams must decide how they will remove the water – and fast! Once work starts, there is only 1 hour to meet the deadline. The clock is ticking!

Further problem or homework (optional)

The meditation tent is flooded to a depth of 1.5 cm. The helicopter and a suction truck are available to remove the water. Which would you choose to use and why?

Skills required

In this lesson pupils will need to:

- interpret scale drawings
- find the areas of rectangles and right-angled triangles by using the formula for the area of a rectangle
- calculate volumes
- express a measurement in centimetres as decimal fraction of a metre
- calculate rates of change (e.g. cubic metres per minute)
- use a calculator effectively and efficiently to carry out more difficult calculations, interpreting the display in different contexts, including time
- work out a logical approach for a multi-step problem.

Torbury resources

1.1 Video clip: (02'15") Introductory film setting the scene at Torbury Festival. The rain starts and gets heavier. Mavis Broom is becoming increasingly agitated and appears unable to cope. But just as she is about to storm out of her office door she catches sight of an advertisement for the Festival Support Squad and is reminded of their services. She immediately regains

her sanity – something can be done! She gets on the phone to call the squad in.

1.2 A4 resource sheet of a plan to scale of the area near the entrance to the festival ground. This shows the small dance tent, the disabled parking area, one of the stages and an area for the audience (print one per pair).

1.3 Optional challenge (if you are using the problem for homework, print one copy per pupil). As an option, pupils could cut out the cards to help them to sort the information.

1.4 An optional slide showing the solution to the main challenge.

1.5 Audio clip**:** (24”) Walkie-talkie message to the teams from Mavis – many congratulations on saving the festival! Record queues have been spotted outside, and the gates are about to open!

Other resources scientific calculators; scissors to cut out the cards on Resource 1.4 (optional)

Main activity

Play **Resource 1.1** a video clip setting the scene (2’15”).

Tell the class that they are the Festival Support Squad and split them into teams of about four. Tell them that they will work in the same teams throughout the case study, often working as two pairs who then join forces.

Give out **Resource 1.2**, a plan of the festival grounds, one per pair, with two tables for the teams to complete.

Explain that four areas are shown on the plan. Each area has been flooded to a different depth. There is also a list of four possible ways of removing water.

► The festival gates are due to open in 90 minutes. The equipment needed to remove water will be ready in half an hour. What will you do?

Let the teams discuss this for a few minutes. They should draw the conclusion for themselves that they could calculate the volume of water in each flooded area. They could then work out which means of removing the water should be used in which area to produce the fastest overall drying out time.

As this is the first lesson, the teams may need more support to get going. If necessary choose one of the areas and remind them how to work it out in square metres. Then remind them how to calculate the volume of water in the area in cubic metres. Get them to write the area and volume of the selected area in the tables on Resource 1.2.

Ask the teams to calculate the remaining areas and corresponding volumes of water and to fill them in on the tables.

Before they start to calculate the times to remove the water, ask:

► Do you need to do all the calculations?

► Does each member of the group need to do all the calculations?

Establish that this is a cooperative team effort so that not everyone has to do everything. For example, each team member could choose one of the means of removing water and calculate how long it will take in each of the four areas.

Make sure that all the teams complete the necessary calculations in plenty of time to discuss their decision about how they will deploy the means of removing water.

Differentiation

If any teams finish quickly, you could ask them to convert the times they have calculated to 1 decimal place into minutes and seconds (e.g. 59.3 minutes is 59 minutes 18 seconds).

If a lot of time remains, they could start to solve the problem on **Resource 1.3.** Pupils could cut out the cards so that they can sort the information (including removing the superfluous information), or they could work from the information on the sheet as it stands.

In trials of this lesson, many teams found it difficult to get started. Encourage them to persevere but if necessary prompt them by providing one or both of the tables like the ones below. Remind them that they do not necessarily need to complete all the boxes.

	Area (m^2)	Volume of water (m^3)
Stage		
Audience area		
Parking area		
Dance tent		

	Volume of water (m^3)	Time (min) at 1.18 m^3/min using helicopter	Time (min) at 1.2 m^3/min using straw	Time (min) at 1.25 m^3/min using drain	Time (min) at 1.3 m^3/min using suction
Stage					
Audience					
Parking					
Dance tent					

For any teams that need extra support, you could make a hint card to explain how to calculate the drying out rate by dividing the total volume to be removed by the volume that can be removed each minute.

Review

Bring the whole class together to discuss and compare methods and solutions.

If you want to discuss with the class the neatest solution, use **Resource 1.4**, a slide (optional). For the underlying reasoning, see the Solutions.

Round off by playing **Resource 1.5,** an audio clip of Mavis congratulating the squad (24”).

Optional homework

If you are setting homework, ask pupils to do the problem on **Resource 1.3**. They can if they wish cut out a set of clue cards. (Note that some of the clue cards contain superfluous information.)

Solutions for Lesson 1

Main challenge (Resource 1.2)

The teams should realise that the four means of removing water can run simultaneously and, with the important proviso that the water in each area must be removed in 1 hour or less, it may not matter which method of removal is used in which area. Sometimes in real life it could be more important to find a solution that will work and get on with implementing it, than to waste time finding the optimum solution. The neatest solution is to match the fastest method of emptying to the greatest volume of water to be removed.

Tabulating results helps to identify a solution.

	Area (m^2)	Volume of water (m^3)
Stage	50 × 30 = 1500	1500 × 0.05 = 75
Audience area	70 × 110 = 7700	7700 × 0.01 = 77
Parking area	$\frac{1}{2}$ (60 × 60) = 1800	1800 × 0.04 = 72
Dance tent	70 × 40 = 2800	2800 × 0.025 = 70

	Volume of water (m^3)	Time (min) at 1.18 m^3/min using helicopter	Time (min) at 1.2 m^3/min using straw	Time (min) at 1.25 m^3/min using drain	Time (min) at 1.3 m^3/min using suction truck
Stage	75	63.6	62.5	**60.0**	57.7
Audience	77	65.3	64.2	61.6	**59.2**
Parking	72	61.0	**60.0**	57.6	55.4
Dance tent	70	**59.3**	58.3	56.0	53.8

For a solution within an hour, one line of reasoning goes like this. The helicopter can only be used for the dance tent. The straw could be used for the parking area or dance tent, but as the dance tent is accounted for, the straw must be used for the parking area. The drain could be used for parking area, dance tent or stage, but as the parking area and dance tent are accounted for, it must be used for the stage, leaving the suction truck for the audience area. Other lines of reasoning are possible.

So the squad could clear all four flooded areas in 60 minutes.

Optional further problem or homework (Resource 1.3)

The area for meditation can be worked out either by counting squares (each small square represents 25 m^2) or by recognising that the area is half of an 8 cm by 8 cm (i.e. 40 m by 40 m) square. So its area is 800 m^2.

The volume of water to be pumped out is 800 × 0.015 = 12 m^3.

The maximum load of the truck is 9 m^3 so the truck must make two journeys.
The pump of the suction truck removes 1 m^3 water every 3 minutes.
It will take the pump 9 × 3 = 27 minutes to remove the first load of water.

The drive to empty the suction truck and return takes 12 minutes.
Removing the last 3 m^3 will take 9 minutes.
Using the suction truck, the meditation area is free of water after a total of **48 minutes**.

The helicopter can pump 0.9 m^3 per minute into its tank.
To remove 3.6 m^3, one load, will take 3.6 ÷ 0.9 = 4 minutes,
plus 11 minutes to fly to empty the water and return, a total of 15 minutes.
3 lots of 3.6 m^3, or 10.8 m^3 takes 45 minutes.
The remaining 1.2 m^3 can be pumped out in 1 minute 20 seconds.
Using a helicopter, the meditation area is free of water after **46 minutes 20 seconds**.

It would be quicker to use the helicopter.