Geo Factsheet

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Water in the American South West

Introduction

South West USA

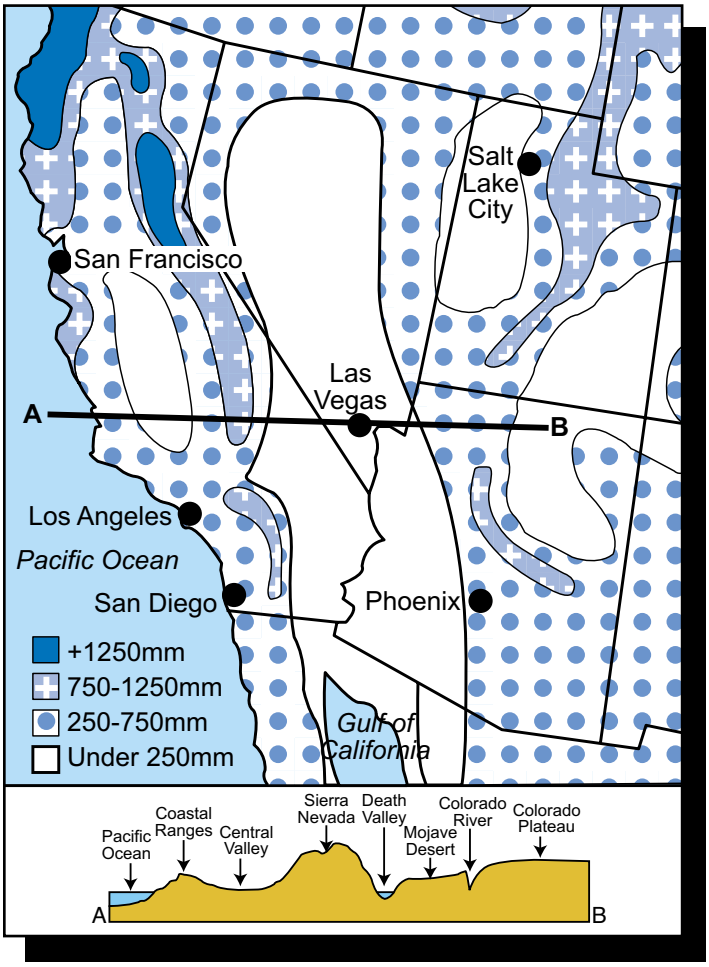
Fours States make up the south western part of the USA *(Fig. 1)*. The four states had a combined GDP of $2,300 billion in 2008 - the world's 7th largest economy. Their population of 48.5 million people is heavily concentrated along a coastal strip between San Francisco and San Diego in California. Further inland, population densities are very low except in major urban centres such as Las Vegas, Salt Lake City and Phoenix. In 2008 70% of Nevada's population lived in the metropolitan area of Las Vegas and 65% of Arizona's in metropolitan Phoenix.

Fig. 1 The South West USA.

Physical geography

Fig. 2 shows annual precipitation levels in the region. In general, levels are typically below 750m. Extensive desert areas average below 250mm per year. Upland and mountainous areas, such as the Sierra Nevada and Coastal Ranges, (see topographic cross section A-B) receive orographic precipitation. East of the Sierra Nevada mountains is the vast Great Basin. This region, really a high desert plateau bounded by the Sierra Nevada to the west and Rocky Mountains to the east, is isolated desert and semi-desert broken only by occasional minor mountain ranges. Rain bearing weather systems moving in from the Pacific tend to rain themselves out crossing the Sierra Nevada leaving regions to the east parched. The aridity of the region has long attracted people who believed a large scale technological fix could turn the deserts green. *Case Study 1* examines the consequences of the California Development Company's attempt to irrigate Imperial Valley.

Fig. 2 Annual precipitation and physical geography.



A problem area

The south west USA has a looming water crisis, there is even a Californian website dedicated to it *(www.calwatercrisis.org)*. The region's water supply is best stated as low and uncertain. This crisis results from the collision of human and physical factors, which taken together may well ensure an uncomfortable water future for the region *(see Table 1)*.

Table 1 Factors behind the water crisis.

Human factors increasing demand	Human factors reducing supply
• Increasing domestic and industrial water footprints • Expansion of irrigated cropland • Rapid urbanisation in the desert sunbelt e.g. Phoenix & Las Vegas • Projected future population growth	• Over-abstraction from aquifers • Pollution, making some water sources unusable • Legal action reducing water transfers *(see Case Study 3)* • Ageing, leaking, water supply infrastructure
Physical factors reducing supply	
• Prolonged droughts, such as 1987-1992 and 2005-2008; possibly more frequent / severe in the future. • Worsening climate change, leading to less and / or more irregular precipitation • Reduction of Sierra Nevada snowpack, reducing spring meltwater	

Case Study 1: The Salton Sea

Migrants to California were quick to recognise the State's agricultural potential. Year-round sunshine would produce bumper harvests if only water could be found to irrigate potentially fertile lands.

Imperial Valley was one such location, situated below sea level east of San Diego. In 1901 the California Development Company began a plan to realise the agricultural potential of the flat land in Imperial Valley. Irrigation canals were dug linking the valley to the Colorado River to siphon off some of its water. These canals quickly became silted up, reducing the flow. In 1905 Engineers then breached the west bank of the Colorado River near Yuma, Arizona, to increase the water flow.

Disaster quickly ensued, as the entire flow of the river was diverted into Imperial Valley, rapidly creating the Salton Sea and flooding the town of Salton (population around 12,000 in 1905). It took 16 months to close the breach in the river and return the Colorado to its natural course, by which time the Salton Sea had formed – 45 miles long and 20 miles wide.

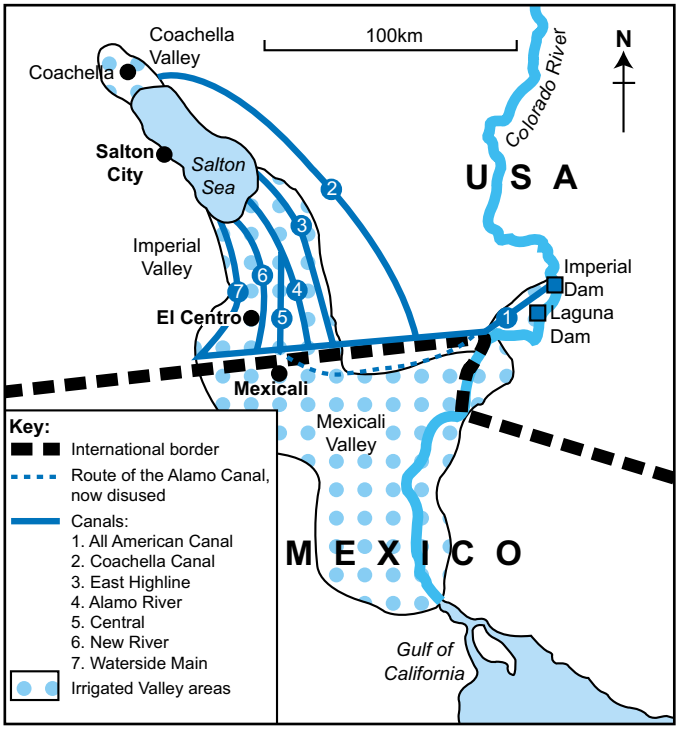
With water flow controlled, Imperial and Coachella Valleys quickly became centres for irrigated vegetables, fruit and cotton. 450,000 acres of farmland are irrigated via over 3000 miles of canals and ditches run by the Imperial Irrigation District. In 1942 the original canal from the Colorado River, the Alamo Canal, was abandoned in favour of the new All America Canal (see Fig. 3). As the name suggests this new canal runs within the USA, increasing water security compared to the Alamo Canal which passed through Mexico.

The Salton Sea is basically a sink for agricultural runoff. Having irrigated the farms of Imperial and Coachella Valleys water flows into the Sea, which has no natural outlet. The Salton Sea quickly became a centre for recreation and sport fishing, as well as a haven for wildfowl. Despite its un-natural origin, it is by far the largest body of freshwater in California. As Table 2 shows, environmental issues in the Sea have reached crisis point.

Table 2 Environmental issues in the Salton Sea

Problem	Cause	Consequences
Salinity Salt levels of 44,000mg/l; 25% higher than the Pacific Ocean. Salinity rising by 1% per year.	Natural salts concentrate over time by evaporation. Farm drainage entering the sea has a salinity of 4,500 mg/ l.	Death of freshwater birds and fish as salinity has risen. Resort towns such as Bombay Beach have become salt encrusted and abandoned.
Nutrient Load Phosphates and nitrates are leading to widespread eutrophication.	Farm fertilisers, sewage and industrial waste increase nutrient load. The New River is polluted in Mexicali before flowing across the border and into the sea.	Algal blooms have choked the sea, reducing dissolved oxygen. This is linked to major fish die-offs and to lower wildfowl numbers. Avian botulism thrives in the sea. Only 1 edible fish, the tilapia, survives.
Pollution Pesticides, selenium and heavy metals are found in the Sea.	As a farm drainage sink, pollution leaching from fields drains into the sea and is concentrated.	Some pollutants, such as selenium, are a human health hazard due to bio magnification in fish. Sewage from the New River is a hazard to swimmers.

Fig. 3 The Salton Sea and surrounding area.



Saving the Sea?

Supporters of this man-made sea point to its importance for bird life. Over 350 species of birds use the sea, with many using the sea as an important migration stop-over. Efforts to stem the tide of pollution and salinity date back to the 1950s. The recent Salton Sea Revitalization and Restoration plan was released in 2008. Under the plan the Salton Sea Authority would:

- *Divide the sea into two; an outer lower salinity lake surrounding an inner high salinity salt pond. The two lakes would be separated by a rock and earth dike.*
- *Water treatment plants to reduce pollution levels*
- *Enhanced wetlands to act as a sink for nitrates and phosphates*
- *Parks, open spaces and wildlife areas increasing the total area of these land uses from 4% to over 50%.*

This plan could cost $9 billion over 75 years, but might prevent the sea from simply dying due to ever increasing pollution and salinity levels.

Transboundary issues

The Salton Sea problem has a transboundary element. New River flows from Mexico into the Salton Sea. In the 1980s it was regularly cited as North America's most polluted river. The US Environmental Protection Agency contributed $25 million to improve sewage treatment in Mexicali in the 1990s, but not all sewage entering the New River is treated even today.

Perhaps more significantly, 37km of the All American Canal has been lined with concrete to reduce leakage, estimated at 8 million cubic metres per year. This leakage flows south into aquifers around Mexicali in Mexico where 30,000 people depend on groundwater for farming. Estimates suggest 12% of the Mexican groundwater pumped up every year actually leaked from the US canal. This freshwater leakage also helps reduce groundwater salinity. Plugging the leaks in Imperial Valley's water supply may have negative consequences across the border.

Water challenges

Today, the south west USA has a number of significant water challenges:

- In much of Nevada and Arizona there is simply no significant surface water supply either via rivers or precipitation.
- Supply is high in northern California, but low in central and southern California where demand is located.
- The most obvious source of freshwater, the Colorado River *(see Fig. 1)*, is far from areas of high demand. It is increasingly a source of conflict.
- Groundwater aquifers are being used unsustainably as abstraction exceeds annual recharge.

Perhaps the greatest challenge is the population and lifestyle of the south west. Back in 1970 the population of the four south western states was a mere 23 million but this had increased by 110% to over 48 million by 2008. Much of the increase is accounted for by migration to the sunbelt states which promise an ideal climate as well as jobs in growth sectors such as IT and the media. Median incomes in the region were $56,000 in 2008, compared to the USA average of $52,000. The population places significant demands on water resources. Some demands are related to lifestyle. Swimming pools, spas and irrigated golf courses and gardens are part of the sunbelt lifestyle. Almost all arable agriculture in the region is irrigated, because precipitation levels are too low and too seasonal to support crops of their own. California alone accounts for over 20% of all irrigation water use in the USA. Agriculture, which accounts for only 3% of the Californian economy, uses 80% of the States water. Hi-tech industry is also a major water user, for instance in the production of silicon chips.

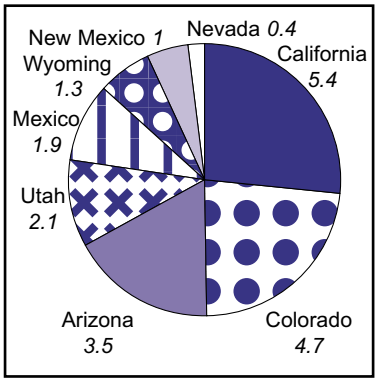
Case Study 2: Colorado in Crisis?

The use of Colorado River water was agreed between States in 1928 when the Colorado River Compact (also know as the 'Law of the River'), shown in [Fig. 5], was signed. Mexico was included in this agreement in 1944. At the time anticipated river discharge was 640m³/sec. Modern estimates of average discharge are in the 500-550m³/sec range.

In 2007 the Compact was renegotiated so that water withdrawals are linked to the water level in Lake Mead, behind the Hoover Dam. Low levels will reduce water availability. The 2007 revision was prompted by prolonged drought in the south west and falling lake levels in Lake Mead – a crucial store or river water. The Colorado Compact is problematic as it involves 7 States, as well as a foreign country. It was agreed in a different age, when Arizona, Nevada and New Mexico had tiny populations and cities such as Phoenix and Las Vegas did not exist. Today the river has to supply 27 million people and 1.2 million hectares of farmland.

Since the 1920s California has taken most of the unallocated Colorado River water so that the State's actual withdrawal in 1999 was 6.4km³ rather than its legal allocation of 5.4km³. In 1999 the Federal Government in Washington ordered California to cut its withdrawal to the legal allocation by 2015.

Fig. 4 The Colorado River Compact (annual water withdrawals in km³)



Conflicting demands on the Colorado River have to be set within the context of the long-term drought which has afflicted the region since the late 1990s.

By 2009:

- *The level of Lake Mead was lower than at any time since 1965.*
- *River discharge had averaged 66% of expected flow since 1999.*
- *Lake levels were approaching the point at which withdrawals would be reduced for each State, under the renegotiated Colorado Compact.*

The great unknown for the Colorado is climate change. Many climate change models suggest a 10-30% reduction in runoff into the river system by 2050. Even 10% less runoff would mean the Colorado would fail to supply the expected volume of water in 6 out of 10 years by 2050.

Faced with this sort of future, states such as Nevada are planning radical actions.

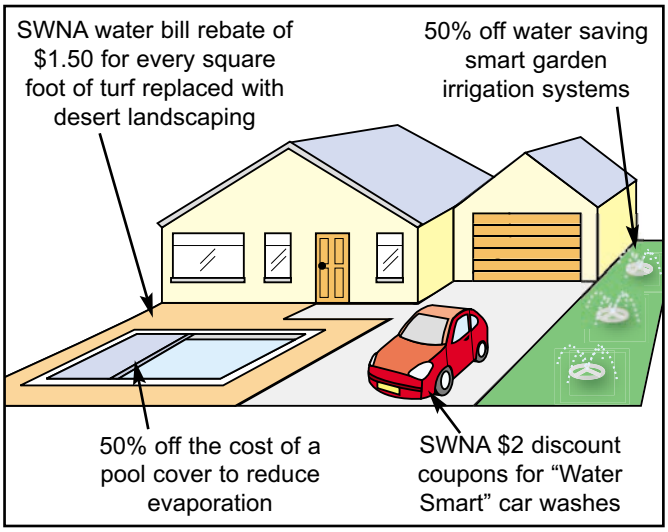
Nevada's dilemma

Water for Las Vegas in Nevada is drawn directly from Lake Mead. Should the water level continue to fall, it could leave some water intakes high and dry. The 40 million annual visitors to Las Vegas would not take kindly to water shortages, so Nevada has some radical actions up its sleeve which involve both water conservation and new water infrastructure.

- *One option is desalinisation of sea water; this would involve constructing a desalinisation plant on the California coast, plus a pumping and pipeline system to Nevada. Construction costs in 2009 were estimated at $9-10 billion with annual energy costs of $400 million.*
- *More likely is the development of groundwater resources in Snake County, southern Nevada. Plans to extract and transfer enough water for around 100,000 Las Vegas homes are in the $2-3 billion range.*

Both of these schemes are energy intensive and questionable in terms of sustainability. Is there another way? The Southern Nevada Water Authority has aggressively pursued water conservation, with some success (see Fig. 6) using rebates and discount coupons. In 2004 the SNWA achieved its target of a 25% reduction in water use per person between 1990 and 2010. Current conservation targets aim to reduce water use to 200 gallons per person per day by 2035, down from 345 gallons in 1990.

Fig. 5 Save water, save cash in Nevada



Long term, it is likely that all Colorado Compact states will have to follow Nevada's lead and drastically reduce water use to ease the pressure on Colorado River.

Pivot Points

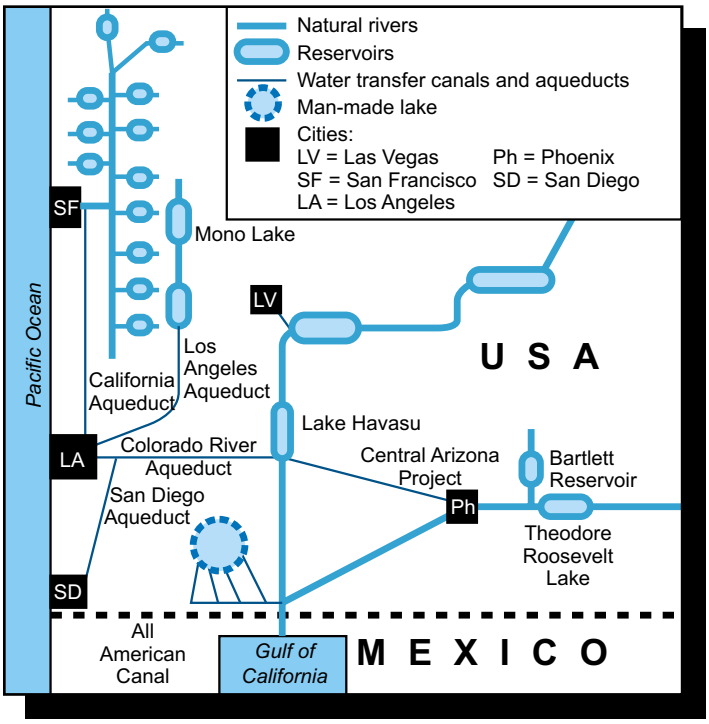
There are two pivotal locations on the water supply of the south west. The region has gradually constructed a highly sophisticated water transfer system aimed at securing supply for irrigation and cities *(see Fig. 6)*. Rivers, swollen with seasonal snow melt in the Sierra Nevada, are dammed in the foothills and reservoirs gradually release water throughout the year.

- The delta of the Sacramento and San Joaquin Rivers close to San Francisco is one pivot point. Here water is transferred south via the California Aqueduct (constructed 1963-1997) and Central Valley Project.

- The second pivot point is Lake further east at Hoover Dam. Here the Colorado River dammed creating Lake Mead. Water released from this reservoir is diverted west to L.A and San Diego via the Colorado River Aqueduct (opened in 1939) and east to Phoenix via the Central Arizona Project, completed in 1993. So much water is diverted from the Colorado that is does not consistently reach the sea at the Gulf of California.

Case Studies 2 (page 3) and 3 explore the problems and conflicts that these two locations face.

Fig. 6 Water transfers.



Case Study 3: Delta Blues

In 2007 the flow of water from the Sacramento / San Joaquin River Delta into the California aqueduct was suddenly cut by 33%. The cause was the delta smelt, an endangered fish was being mashed up in the pumps. Federal law mandates that such endangered species must be protected.

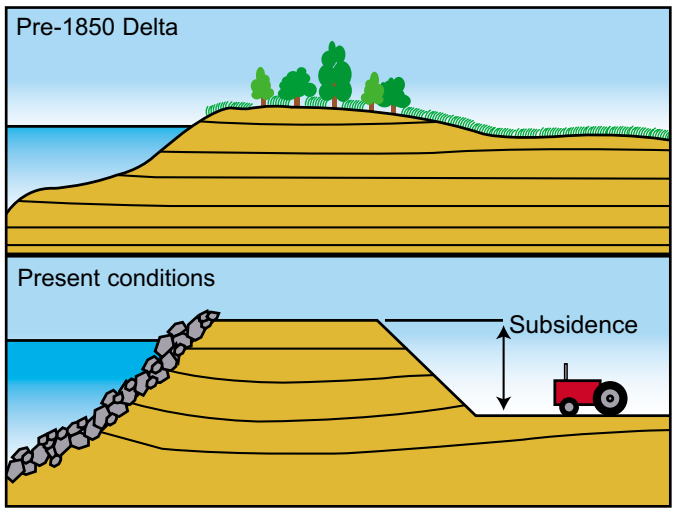
The reducing in pumping was a victory for environmentalists. For the urban population of southern California the ruling means more pressure to conserve water and possibly higher water bills. For farmers in California's Central Valley the decision was a disaster. Combined with existing drought orders and restrictions, the reduction in irrigation supply meant that some areas received only 10% of their normal water allocation. Unemployment in the worst affected areas reached 40% on 2009 and farm income losses exceeded $500 million. Some farmers were luckier, paid by the Metropolitan Water District (which supplies L.A. and San Diego) to give up their water allocations and leave their land unfarmed to help urban supply.

The delta smelt is only one relatively minor issue affecting the delta region, which is generally under immense pressure:

- *The region is under pressure to supply water to two-thirds of California's population.*
- *The delta is critical to supplying 80% of commercial and 25% of sporting fisheries in California.*
- *As global warming raises temperatures, the Sierra Nevada snowpack is shrinking, reducing annual meltwater supply to the delta.*
- *Increased flows of freshwater into to the delta have reduced salt water habitats and allowed freshwater invasive species to thrive.*
- *The network of levees that protect low-lying delta islands from flooding is old and in desperate need of renewal.*

As Fig. 7 shows, the delta has suffered from subsidence. As fertile farmland has been drained, the peat soil has dried out causing falling land levels. Rising sea levels make this problem even more pressing. The 'perfect storm' for the delta region would be a major earthquake combined with high tides. Old, weak levees would collapse, sea water would flood in, water pumping infrastructure would be damaged. California's key water supply hub could be out of action for 2 or more years.

Fig. 7 Subsidence in the Sacramento/San Joaquin River Delta.



Across the delta there is recognition that conservation and water supply can work together, such in the management plans for the Salton Sea. In the Sacramento Delta the CAL-FED Bay Delta Program, begun in 2006 is working to:

- *implement conservation strategies to improve the overall ecological health of the Delta*
- *implement ecologically friendly ways to move fresh water through the delta system, and improve water supply*
- *reduce toxic pollutants, invasive species, and improve water quality*
- *maintain and improve flood protection levees in the delta*

These actions will help sustain the delta, but increasingly the delta will require careful management, and lots of funding, to keep one step ahead of rising demand, rising sea levels and falling freshwater supply.

Who's in charge?

Managing water in the south west is especially difficult due to the sheer number of players who have a say over how water is used and who gets to use it. Federal (national), State and County government are all involved. At the Federal level, water issues are handled by a number of organisations as *Table 3* shows.

Table 3 Federal Government water players.

United States Geological Service (USGS)	Has responsibility for managing groundwater
Bureau of Reclamation	Regulates surface water
Army Corps of Engineers	Manages navigation and flood control
Environmental Protection Agency (EPA)	Responsible for water quality
Fish and Wildlife Service	Responsible for aquatic ecology
Department of Agriculture	Regulates irrigation and rural water use

Added to this Federal list are private water supply companies, State water and irrigation boards, influential conservation organisations such as the Sierra Club and government agencies such as the National Parks Service. Consumers, both domestic and commercial, are key players too.

Emerging Consensus?

The last decade has seen a coming together of conservationists and water supply engineers in the American south west. It is generally accepted that what is good for conservation is usually good for the long term sustainability of water supply. There is also a realisation that climate change represents a real threat to water supply and that the decade of drought since the late 1990s may actually represent the 'new normal' for the region.

California is likely to set tough targets for water conservation, possibly aiming for a 20% cut in per capita water use by 2020. That would bring it in line with Nevada and at least allow some breathing space to sort out the long term future of the Colorado River and Sacramento Delta. Water recycling is also crucial. It is currently not very common in the south west but increasingly the concept of treating used water and returning it to where it came from to be reused, is gaining ground. Conservation, recycling and improved management of the physical systems that supply the south west's water might just be enough to avert a water supply crisis.

Student Focus Questions

1. Explain the physical and human factors that are contributing to reduced water supply but increased demand in the south western States of the USA.

2. Draw up a table of key players and their roles in water issues in the southwest of the USA.

3. With reference to the Salton Sea and Delta area, evaluate the contribution that poor water resource management has made to the water crisis facing California.

4. Produce a 5 point plan entitled 'Sustainable south west water'. Identify 5 key actions that need to be taken to increase the sustainability of water resources in the region. Take time to identify specific targets and the players who must implement them. You might like to complete this activity as a Powerpoint presentation or even author a webpage.

Answer Guidelines

1. Remember a physical factor is to do with physical geography such as rainfall amount and drainage and geology whereas a human factor is to do with human actions such as water use for agriculture and industrial and domestic purposes. Climate change can be seen as an indirect human factor in recent times.

2. Players include suppliers such as the water companies, managers such as federal and state governments and consumers such as farmers and native indians, as well as environmentalists opposed to mega schemes.

3. See specific text boxes in *Factsheet*.

4. Define sustainable water supply - sufficient amounts of clean water. Think about conservation of supplies for the future, fair access for all users, especially the poor, minimal environmental damage, and involvement and consultation of all local people in decision making.

Key Resources

- Website of the Salton Sea Authority *www.saltonsea.ca.gov*, tasked with restoring the sea.
- The Southern Nevada Water Authority website. www.snwa.com. Very useful information of water conservation.
- This website *www.calwatercrisis.com* is sponsored by the Association of California Water Agencies. It has links to some very useful resources.
- This website relates to *Case Study 3* and outlines plans to conserve and manage the Delta region *www.baydeltaconservationplan.com*
- *'Aquashock; the water crisis in America'* by SJ Marks (Bloomberg, 2009) is a detailed backgrounder of water issues in the USA.
- *'The Atlas of Water'* by Robin Clarke and Jannet King (Earthscan, 2004) is essential contextualising background on a wide range of water issues.

Acknowledgements
This Factsheet was researched by Cameron Dunn, Chief Examiner and teacher at Westfield School, Newcastle. ***Curriculum Press, Bank House, 105 King Street, Wellington, TF1 1NU. Tel. 01952 271318.*** *Geopress Factsheets may be copied free of charge by teaching staff or students, provided that their school is a registered subscriber. No part of these Factsheets may be reproduced, stored in a retrieval system, or transmitted, in any other form or by any other means, without the prior permission of the publisher.* ***ISSN 1351-5136***