

### Impact of Climate Change on the Desert Pupfish

**Region:** Desert Arid – Southwest

**Grade Level(s):** 5-8

**Time Required:**

- Activity 1: 1 to 2 class periods
- Activity 2: 1 class period (depending on set-up)
- Activity 3: 2 class periods
- Activity 4: variable

**Focus Question(s):**

- If the climate changes in the Southwest deserts, what possible effects might that have on the wildlife of the region? How would the process of adaptation help?
- In what ways can humans be seen as competitors with a region's endemic wildlife species for regional water resources? Explain how water in arid regions circulates between atmosphere, lithosphere and hydrosphere.
- How can data be used to show possible effects climate change might have on the wildlife populations in a region?
- What do you think the role(s) of humans can be/should be in areas that are forecast to experience a shift in their climate?

**Learning Objectives:**

**Content:**

- Students will make observations of a remotely sensed image and be able to interpret the terrain and construct a possible and reasonable climate profile of the area.
- Students will be able to explain how an underground aquifer can be affected by actions on the surface that are miles away.
- Students will draw conclusions from data (temperature) concerning possible consequences a region might face in the future if its climate changed, and they will back their ideas up using evidence.
- Students will construct a testable hypothesis around the relationship of climate change and the effects it might have on wildlife in the Southwest deserts. In addition, they will design a research project that would allow them to test this hypothesis.

**Skills**

- The students will learn how to interpret and identify the surface features from remotely sensed images.
- The students will learn how to locate specific areas on the earth using Google maps
- The students will learn to graph sets of data using Excel and learn how to analyze data using the trend line feature.
- The students will learn how to construct an interactive groundwater model and be able to demonstrate how water flows through the ground into the atmosphere and back.

### **Prerequisite Knowledge:**

- Basic computer skills
- Observational skills
- Knowledge of maps, topographic features and state locations.
- Basic graphing skills

### **Procedures/Instructional Strategies:**

Have students read the two-page selection on Devil's Hole Pupfish. Working in their group have them decide what statements are known (facts) about pupfish, as opposed to what is unknown about pupfish. Have the students record this in their notebook. Each group's "speaker" will give information as the teacher compiles two lists: "Known" and "Unknown".

### **Activity 1:**

In groups of two, students will work on computers to complete Activity 1 locating and comparing their school/house habitats to the Devil's Hole pupfish habitat. They will be using Google maps, remotely sensed images, and citing evidence that backs up the observations they record. See the worksheet entitled "Activity 1: Establishing a Sense of Place" for instructions to complete the activity.

### **Activity 2:**

Students will identify Devil's Hole pupfish habitat and record the topographic features which clue them into the climate of the area and how the pupfish exist in a habitat almost completely devoid of surface water and are consequently dependent on underground water sources for survival. While making observations of the area their attention will be drawn to the "crop circles" and the agricultural activity in the area. Where does the water come from to support farming? Students will working with a groundwater model to see the effects that surface activities have on the water table and the viability of the Devil's Hole pupfish population. See the worksheet entitled "Activity 2: Groundwater Flow Model" for instructions to complete the activity.

### **Activity 3:**

This is a graphing activity, ideally constructed to teach students how to use Excel. The data is from Devil's Hole pupfish area in Pahrump, Nevada and meant to show the gradual increase in temperature of the area over the last 60 years. After the graph is complete the student sheet guides the processing of all 3 activities and asks students to visualize what they think the area might be like in the future. They have initially looked at the area and identified it as a dry area with people using underground water for farming. They have seen what happens when groundwater is pumped from an underground aquifer in a desert and they have graphed temperature data showing a gentle but steady rise in the temperature over the past 60 years.

### **Activity 4:**

This activity involves comparing two images that were taken by satellites to observe how the

climate and human activity have impacted the landscape.

### Assessment:

When students complete these four activities they are expected to analyze them and come up with some predictions of changing habitat along with a testable hypothesis concerning climate change, people's actions and wildlife sustainability. This is an open exercise and is assessed on its relevance and testability.

### National Science Education Standards:

#### Life Science:

- A population consists of all individuals of a species that occur together at a given place and time. All populations living together and the physical factors with which they interact compose an ecosystem.
- The number of organisms an ecosystem can support depends on the resources available and abiotic factors, such as quantity of light and water, range of temperatures, and soil composition.
- Extinction of a species occurs when the environment changes and the adaptive characteristics of a species are insufficient to allow its survival.

#### Earth Science:

- Global patterns of atmospheric movement influence local weather. Oceans have a major effect on climate, because water in the oceans holds a large amount of heat.

#### Physical Science:

- The sun is a major source of energy for changes on the earth's surface. The sun loses energy by emitting light. A tiny fraction of that light reaches the earth, transferring energy from the sun to the earth.

### Extensions:

- Construct a testable hypothesis around the relationship of climate change and the effects it might have on wildlife in the Southwest deserts. Design a research project that would enable you to test your hypothesis.

### Internet Resources Needed for Activities:

- Google maps  
<http://maps.google.com>
- Academy for Academic Excellence (AAE) – Devil's Hole Pupfish Page  
<http://hegel.lewiscenter.org/users/mhuffine/subprojects/Student%20Led%20Research/pworld/index.php>
- Native Fish Conservancy Page

<http://www.nativefish.org/articles/pupfish.php>

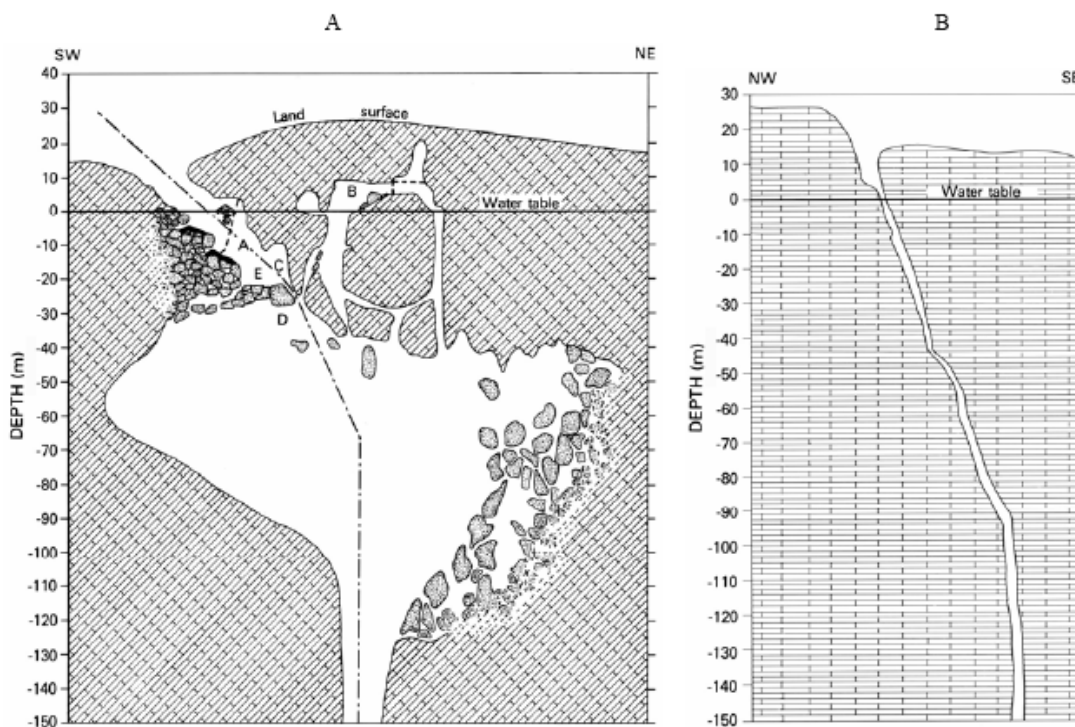
If you have never seen a groundwater flow model, look up in a science supply catalogue or look up on the web and you will get a picture of the “normal type” of model.

<http://www.uwsp.edu/stuorg/awra/h2omodel.html>



### Additional Resources:

Conference Proceedings. Spring-fed Wetlands: Important Scientific and Cultural Resources of the Intermountain Region, 2002.  
<http://www.wetlands.dri.edu>

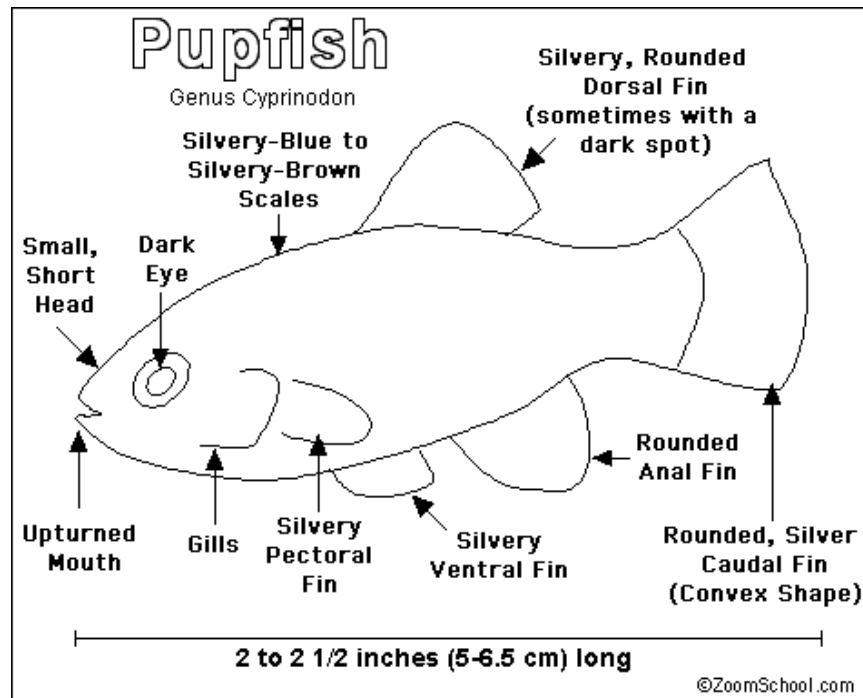


**Figure 4. Sectional views of Devils Hole.** Note the steeply dipping planar shape of the opening. Brick pattern represents Paleozoic carbonate bedrock; stippled pattern represents Paleozoic carbonate bedrock breakdown blocks. Dashed lines mark abrupt changes in chamber width. The dashed-dotted line in (A) marks the location of section (B). Elevation datum is the mean 1994 water table (2.03 ft below the copper washer used as an elevation reference for the water-level recorder); horizontal scale equals vertical scale. Below -30 m, sections are sketched from A.C. Riggs' memory, and represent the general form only.

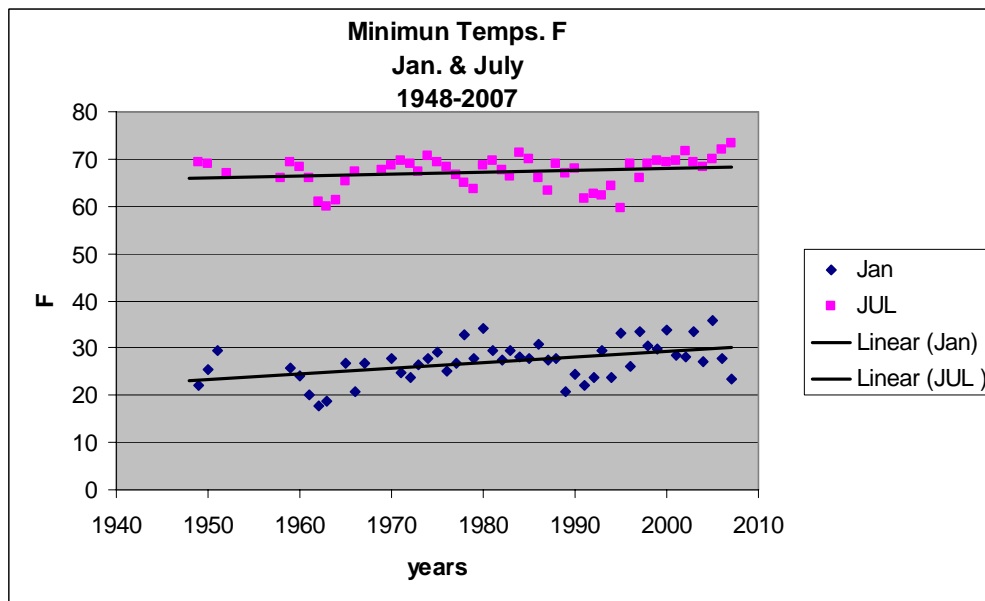
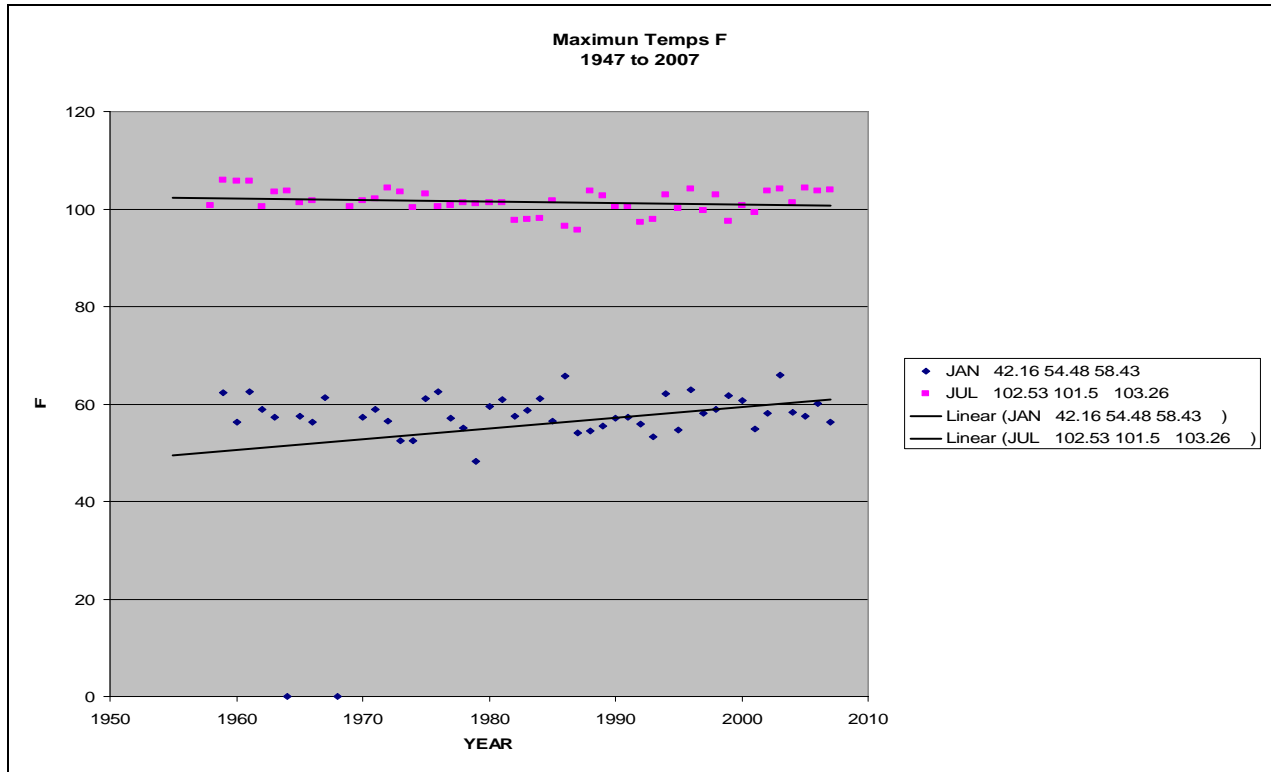
**A.** This SW-NE sectional view is modified from one by W.L. Acree, U.S. National Park Service, May 1973, library, Death Valley National Park, Death Valley, CA. Letters identify the location of important features: A - main chamber extending from the surface to about -23 m. B - Browns Room. C - area where big slabs and flakes were sheared off the NW wall by spreading of the opening; the largest sheared-off slab extended to the dashed line to the left of A and wedged in the opening. D - Anvil Rock, a sheared-off slab, is just above D. E - the floor of the main chamber below E is actually a plug of breakdown blocks, as is the shallow shelf (just barely submerged at the SW end of the pool) and the two other shelves stairstepping down to the floor of the main chamber. The black mantles on the shelves below the shallow shelf are piles of sediment and rock debris washed into Devils Hole by rainstorms. Battery Rock is the solitary block to the left (SW) of the dashed-dotted line at a depth of 40 m.

**B.** This NW-SE sectional view shows the narrow fissure form. The width of this section is typical of the width of most of the Devils Hole fissure except for the area to the right (NE) of the dashed-dotted line in Panel A of this figure and between -50 and -90 m, where the chamber is as much as 4 m wide.

- From Enchanted Learning  
<http://www.enchantedlearning.com/subjects/fish/printouts/index.shtml>



## Sample Answer for Activity 3:



### Thanks to:

1. **Bottle Biology**, (NSF and Kendall-Hunt)
2. **Project WET** (<http://www.projectwet.org/index.html>)



### Student Handouts:

#### Activity 1: Establishing a Sense of Place

- The Devil's Hole Pupfish you have just read about live in the Southwestern part of the US and more precisely in the Southwestern area of Nevada in the Ash Meadows National Wildlife Refuge. You will be using Google maps to see where this refuge is located. But before you travel to Nevada, you are going to locate your home and school areas to get a feel for how **Google** map works. (You can also use **Google Earth** for this if it is downloaded onto your computer.)
- Go to the **Google home page (www.google.com)**, click on **MAPS** in the upper left side of the screen. You will see a map of the U.S. Double click on your state and continue double clicking till you see an area of your town or city. While you are doing this, click between the different "Views"—**Map—Satellite—Terrain** (top right of the map) and notice what information is pictured.

#### Follow directions below to complete activity:

Find out what an AERIAL view of your neighborhood looks like:

1. Click on the TERRAIN view in the upper right hand of map. You should see a multi color green map for land and blue for water areas.

What do the darker green areas represent? \_\_\_\_\_

What do the lighter green areas represent? \_\_\_\_\_

2. Find your state and double click on it till it takes up the entire screen but not more. The White dotted lines are the state boundaries. (If you have a roller mouse you can use that instead of clicks.) Notice the zoom tool in the upper right on the map. Get comfortable using that to zoom in and out also.
3. Use the TERRAIN map to sketch the **topography** of your state.
  - a. Does your state have mountains, and if so, where?
  - b. Does your state have valleys, and if so, where?
  - c. Is your state landlocked or does it have a coastline?
  - d. Where are the rivers or bodies of water located?

Click between the SATELLITE view and TERRAIN view to sketch a complete view of your entire state.

4. Find the city or town or area where you live and click on it till the entire area is shown. Get the entire city on your screen and look at the TERRAIN view. Describe the topography of the area.
  - a. Is your area flat, hilly, or mountainous, and what do you see that tells you that?
  - b. Is there water in the form of a river, lakes or streams? Where does this water come from?
  - c. Is there farming in the area or any other industry you can point to? Remember to

zoom in and out to make as many clear and precise observations as you can.

My city (town or area)

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5. Type in your address in the box next to “search maps” and a green arrow will point to your house. If your street does not show up, type in the closest main road you know of.
6. Find your house and your school.
7. Click on Get Directions and in the boxes type in the addresses, click “Get Directions”. You will get a purple line.
  - a. Is this the way you go to school and home? \_\_\_\_\_
  - b. What are some of the major topographic features in your area? (mountains, rivers, flat area?) \_\_\_\_\_
  - c. When it rains, what direction does water flow? \_\_\_\_\_ (N S E W)
  - d. Is there a river or lake that the rain water flows into, and in what direction does the river flow? \_\_\_\_\_ (Remember all water on earth flows one way.....DOWN!)
  - e. Trace the source of the nearest river to your house and the direction it flows in. You will have to use your zoom skills here.

Now that you are comfortable with Google maps you are to go on a tour of someplace you have never visited and make as many observations of the area as you can from the map. For every observation you make you have to base it in evidence, so be careful and back up what you say!

You are going to be visiting Nevada and the area to the north west of Las Vegas. Find Nevada and have the TERRAIN map of the entire state on your screen.

1. Looking at the entire state of Nevada make some observations on the topography. (You may have to switch between maps here to get a complete idea.)
  - a. Is Nevada mountainous, and is there a pattern that is obvious?
  - b. Do you see evidence of rivers or lakes?
  - c. What do you think the climate might be here, and why do you think this?

Sketch and label the topography of the state.

2. Do you think that there are there many people living in Nevada? \_\_\_\_ What is the evidence for your answer? (switch to other maps)
3. Type in Devil’s Hole, Nevada. Click between the terrain and the satellite maps and zoom in and out to get ideas on the topography and climate of the area. The white

areas are low places that have minerals left behind from water runoff. What evidence do you see of water running in the area either past or present?

\_\_\_\_\_  
Sketch the evidence you think points to the presence of water in this area.

4. Look at the roads and locate Rt. 373. Switch to the satellite image. What do the large, green circles tell you about the area? \_\_\_\_\_.

Where do you think the water might come from to support this industry? \_\_\_\_\_

You have now learned how to use different types of maps and images as information gathering tools. Without ever visiting Devil's Hole, Nevada, you now know something about the area. Make comparisons between the area you live in and Devil's Hole, Nevada. Think back on what you found out about Nevada using evidence displayed on the images and maps.

What are two observations you made about the area around Devil's Hole and what evidence could you cite to support your ideas?

My Neighborhood

Evidence

1.

2.

Devil's Hole, NV

Evidence

1.

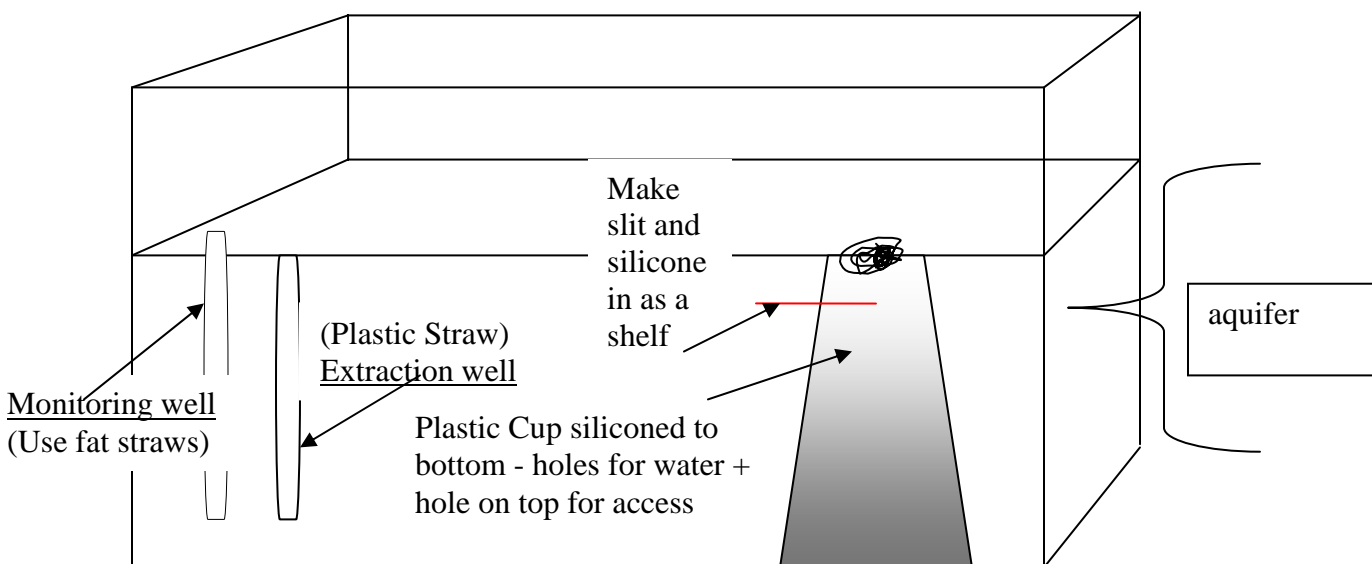
2.

### **Conclusion:**

You have completed this activity using maps to make observations. In the following activities you'll be checking your ideas and adding to your knowledge of Devil's Hole by: 1.) constructing a model of the area's water source, and 2.) completing a graph of the last 60 years of temperature data to see if the area is changing, and what that change could mean for the plants and animals living there.

### Activity 2: Groundwater Flow Model

This is a groundwater flow model built in an aquarium. It is slightly different from the normal groundwater models because the area of the aquifer in which the pupfish live is within a fissure created by tectonic movement. In the resources section there is a sketch of what this area truly looks like. The upside down cup is placed in the model to represent this fissure area.



Fill box with packing peanuts, marbles or pebbles so students can see water flow and consider coloring the water to aid in tracing its flow through the aquifer. Line the top inch with cheese cloth and arrange the surface to look like desert pavement with sand, dirt, and small pebbles.

The main threat to the Devil's Hole pupfish is the lowering of the groundwater table. This is a constant threat from a number of sources including: agriculture, changing precipitation patterns and evaporation due to the pupfish's location in one of the hottest deserts in the U.S. Most students do not know how groundwater travels or the effect wells have on a large area of nearby sites in an aquifer. This activity will demonstrate the effect groundwater pumping can have to the larger area of an aquifer and the potential danger agriculture has on the pupfish.

In this activity students will build a model and simulate what happens when water is withdrawn from the aquifer by a neighboring location. This can be a classroom demo set up by the teacher in a large aquarium, or pairs of students can build their own. Either way you choose to do this it is important that students have direct access to the workings of the model. Walk the students through the accompanying handout called "Groundwater Model: Student Sheet".

### Groundwater Model: Student Sheet

NAME \_\_\_\_\_

1. Pour enough water into your model so that the shelf is under water. This represents filling your aquifer, which would take place over many thousands of years. The source of this water is \_\_\_\_\_. (rain)

There are fish that live in your water hole and the cup area is their only home. The water level has to be kept above the shelf for them to spawn (reproduce) and the temperature of the water has to be kept constant. You will be altering their habitat, making observations and then be called on to report your findings on the dangers these fish face. Explain what occurs every time you alter their habitat, sketch and label all you see with each trial you conduct on the back of this paper.

2. You have 2 wells close to your fish habitat. One well is for monitoring (measuring) the below ground water level (called the “water table”), and the other is a pumping (extraction) well from which water is pumped to the surface and used for various applications (growing food, cooking, taking showers, etc.). Set up your model and record the water added, height of water table and shelf covered in the table below. (**Hint:** when measuring “depth to water” we are concerned about how far the water lies beneath the surface (groundwater). How deep the aquifer is in total is also important but not for this activity.) Record these measurements in the table labeled “Data Table” provided at the end of this sheet.
3. Brainstorm with students how they are to measure the “depth to groundwater”. Have them come up with a solution. (**Hint:** the easiest way is with absorbent paper/string that is pre-cut to entire depth of the monitoring well.
4. When water is added to your model where might this water come from?  
\_\_\_\_\_.
5. When water is withdrawn (use your syringe) from the model what might the water be used for? \_\_\_\_\_
6. What also may account for water being taken out of the fish’s habitat other than by pumping? \_\_\_\_\_ (evaporation)
7. Look at the close up of the Devil’s Hole area image from Activity 1. What else in the image gives you ideas on what might be affecting the water table?  
\_\_\_\_\_  
(**Hint:** What are the circles to the lower left?)
8. How would this phenomenon affect the water level in the fish’s habitat and why?  
\_\_\_\_\_
9. What would have to naturally happen to insure a stable habitat for the fish?

10. The climate is changing worldwide. What are some ways that these fish, in a small isolated area of Nevada, will be affected?

**Putting it all together:**

Using your experience with the model, what have you learned about:

- a.) Groundwater?
- b.) How groundwater travels underground?
- c.) Some effects wells have on the surrounding area they are in?
- d.) The effects on the habitat of the fish living in this water hole called Devil's Hole?

Climate change has both direct effects - higher temperatures in some locations - and indirect effects - animals and plants will need more water. What are some other direct and indirect effects of a changing climate you can come up with? (List in the tables provided below)



Direct effect	Indirect effect
1. Higher temperature	Animals and plants use more water
2.	
3.	
4.	

### Data Table

Trial	H2O added in ml.	H2O removed in ml.	Depth to water table in cm.	Shelf exposed or covered?
1. set up		XXX		
2. Add ___ml				
3. Withdraw ___ml				

### Activity 3: Teacher and Student Sheet

The following is an activity having to do with graphing temperature data over time (60 years). This enables you to see what changes have occurred, if any. The goal of this activity is for students to chart data using Excel.

For those of you who are not familiar with Excel- directions follow. You can print these out for students. The raw data is from the National Weather Service site. The data sheet has been cleaned up and saved on a separate sheet(s) so it can be copied and pasted into Excel columns. Sites below were the origin of the data and meant to be used in the exercise only as reference.

<http://www.wrh.noaa.gov/vef/regionalclimate.php> Nevada statistics

<http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?nvpahr>

<http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?nvpahr>

### Instructions for using Excel and completing Activity 3:

1. Open Excel and have it on the left hand side of your screen. Open "Pahrump min-max TEMP. 1948 TO 2007" doc. data and display that on the right hand side of your screen so the two are next to each other.
2. Left click on top line of Years column, a small arrow appears, click again and the entire column goes black, right click, and copy.
3. Go to column An in Excel, left click, small arrow appears, right click, paste. Click OK. The data should transfer. Go to Excel toolbar FILE, Save As, give your name to document and save in your folder.
4. Double left click on JAN, small arrow appears, and column turns black, right click, and copy.
5. Go to column C or D, click, arrow shows up, right click, paste. SAVE work.
6. You now have to get rid of the blank columns between YEAR and JAN. Right click on the letter B, then click delete. Do this till the two columns are next to each other.
7. Left click on JUL, arrow, black, right click, copy. Go to Excel, click on column E and paste. SAVE.
8. You now have to get rid of the blank columns. Right Click on the letter C, then click delete. Do this for all the bank columns till the 3 columns of data are next to each other. Make sure the headings (YEARS, JAN, JUL) only take up 1 column. AVE.
9. IMPORTANT: go to cells that have -----(dashed) lines and delete the lines by using your DELETE KEY on your keyboard. (Do NOT use the delete in your drop down menu). SAVE.
10. Place your cursor on column A, left click, column will highlight and drag cursor over B and C, all 3 will be highlighted.
11. You will now make your graph in Excel. Go to Excel toolbar, INSERT, CHART (you can also find the icon on the tool bar).
12. Click on XY (SCATTER).
13. Click on first graph type that is darkened, double click on it. You should see a graph with 2 areas of data.

14. Click NEXT, fill in title, X and Y axis info, click NEXT.
15. Click on sheet, FINISH.
16. You now have your graph. Take a good look and see if you can see any Trend....Are the temperature data points going up? Are the temperature data points going down? The computer will do the calculations but first make your observations.
17. Go the CHART, TRENDLINE and click on Linear, OK (Notice Jan. is highlighted in the dropdown box). Go to Chart, TRENDLINE and highlight JUL, and click OK.
18. Where you able to correctly see the trend? If not do you see it now?

Repeat these directions for the other (MAX or MIN) data sheet and print out both your graphs and remember to save them into your folder.

### Data sheets for Activity 3 (you will be graphing this data)

#### PAHRUMP, NEVADA

#### Monthly Average Minimum Temperature (Degrees Fahrenheit)

(265890)File last updated on Jul 25, 2006

\*\*\* Note \*\*\* Provisional Data \*\*\* After Year/Month 200603

a = 1 day missing, b = 2 days missing, c = 3 days, ..etc.,

z = 26 or more days missing, A = Accumulations present

Long-term means based on columns; thus, the monthly row may not sum (or average) to the long-term annual value.

MAXIMUM ALLOWABLE NUMBER OF MISSING DAYS : 5

Individual Months not used for annual or monthly statistics if more than 5 days are missing.

Individual Years not used for annual statistics if any month in that year has more than 5 days missing.

YEAR(S)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
1948	-----	-----z	-----z	-----z	-----z	-----z	-----	-----z	-----z	43.74l	31.76a	26.80a	29.28
1949	22.13	28.36	38.52	49.03a	54.13	64.34a	69.13	63.81	59.43	44.19	37.39b	27.32	46.48
1950	25.58	35.88b	35.79b	46.59a	51.19	58.33f	69.07	63.57a	57.04b	50.00e	39.24e	33.85d	46.16
1951	29.35	31.68	34.42l	-----z	-----z	-----z	-----	-----z	-----z	-----z	-----z	-----z	30.52
1952	-----	-----z	-----z	46.15c	55.32f	55.46b	66.89	68.38b	59.33f	49.16	32.32e	28.33p	53.06
1953	-----	-----z	-----z	-----z	-----z	-----z	-----	-----z	-----z	-----z	-----z	-----z	9999.00
1954	-----	-----z	-----z	-----z	-----z	-----z	-----	-----z	-----z	-----z	-----z	-----z	9999.00
1955	-----	-----z	-----z	-----z	-----z	-----z	-----	-----z	-----z	-----z	-----z	-----z	9999.00
1956	-----	-----z	-----z	-----z	-----z	-----z	-----	-----z	-----z	-----z	-----z	-----z	9999.00
1957	-----	-----z	-----z	-----z	-----z	-----z	-----	-----z	-----z	-----z	-----z	-----z	9999.00
1958	-----	-----z	-----z	-----z	-----z	-----z	65.92	82.85d	58.40e	47.50e	32.17g	25.85e	53.65
1959	25.76	29.83e	34.62e	44.69d	48.43h	61.32h	69.31	61.88e	53.08e	40.46e	30.38f	24.72m	47.70
1960	24.00	26.12m	41.44f	47.71f	51.23e	63.36e	68.32	63.41d	57.20e	44.04e	33.54f	22.93d	50.36
1961	20.04	27.87e	33.67d	40.08d	47.15e	60.62d	66.04	64.35e	49.76e	38.38e	24.61g	20.81e	40.27
1962	17.85	29.22e	27.85d	45.04d	46.73e	55.73d	60.84	60.88e	54.00g	46.48d	31.29f	21.88f	41.22
1963	18.81	33.29d	30.04e	33.07c	51.23e	52.56e	59.81	62.52d	56.96f	46.15d	30.19d	17.78d	39.59
1964	-----	-----z	27.85e	36.85d	46.78d	52.92d	61.33	63.86c	55.36e	50.22d	28.78g	27.40f	49.40
1965	26.92	30.30e	35.37d	46.23d	51.20f	56.15d	65.15	63.38e	50.44e	44.41d	38.85d	27.85d	45.81
1966	20.77	23.60c	34.36c	39.96d	50.77e	61.42d	67.44	68.11c	55.88e	44.31e	34.65d	26.63d	43.99
1967	26.79	31.30e	34.30d	32.92e	45.25g	-----z	-----	-----z	-----z	-----z	-----z	-----z	32.84
1968	-----	-----z	-----z	-----z	-----z	-----z	-----	-----z	-----z	-----z	-----z	-----z	9999.00
1969	-----	31.14	33.40a	41.11b	54.20a	58.27	67.74	68.24b	61.83	43.14b	31.32b	25.39	46.89
1970	27.84	33.86	36.45	38.57	51.06	59.40	68.58	68.61	51.47	42.13	34.23	28.29	45.04

1971	24.81	29.57	34.03	41.17	48.55	57.77	69.65	71.19	54.83	40.84	30.63	26.35	44.12
1972	23.68	30.64 a	39.74	45.40	51.10	61.90	68.81	65.03	58.20	47.84	34.57	25.23	46.01
1973	26.39	34.96	36.52	43.43	54.23	60.93	67.13	64.77	53.63	44.42	35.63	27.71	45.81
1974	27.77	29.86	43.58	42.97	54.90	62.87	70.77	64.65	62.13	49.32	36.47	30.87	48.01
1975	29.16	34.75	38.68	41.90	50.68	62.03	69.45	64.87	59.33	44.19	32.20	27.84	46.26
1976	25.19	36.72	37.29	42.30	56.61	60.90	68.29	60.52	58.93	43.39	32.57	19.97	45.22
1977	26.81	31.00	32.97	45.00	48.84	62.77	66.74	67.26	55.40	43.55	31.93	29.81	45.17
1978	32.97	35.57	42.10	42.77	49.35	60.47	64.94	65.03	53.00 a	46.32	33.53	24.84	45.91
1979	27.71	28.32	36.37 a	42.57	52.45	57.40	63.74	61.35	57.20	45.06	28.63	26.19	43.92
1980	34.00	37.21	36.26	43.17	48.00	57.43	68.55	64.35	54.07	-----z	-----z	28.90	47.19
1981	29.55	31.75	38.71	48.50	54.23	65.30	69.55	67.10	61.60	44.10	38.46 d	-----z	49.89
1982	27.39	35.00	40.16	44.10	53.61	60.10	67.65	68.90	59.47	46.06	34.67	28.16	47.11
1983	29.58	36.79	38.48	36.67	46.55	58.90	66.35	66.55	62.63	47.32	38.47	32.61	46.74
1984	28.16	30.03	37.48	42.50	55.58	61.43	71.42	67.97 a	61.90	42.45	35.40	30.87	47.10
1985	27.68	29.85 a	36.13	45.97	53.13	61.43	69.97	63.16	54.20	44.42	32.41 a	26.68	45.42
1986	30.94	35.75	41.61	44.70	53.77	63.80	65.81	68.74	53.93	43.39	36.93	27.45	47.24
1987	27.45	33.57	36.94	46.67	53.16	62.40	63.19	65.84	58.33	49.97	36.60	27.42	46.79
1988	27.87	31.62	35.84	44.43	51.06	61.03	69.00	-----z	51.90	47.00	34.40	22.16	43.30
1989	20.74	27.64	39.65	47.20	50.16	59.20	67.06	60.81	51.40	40.65	29.07	20.87	42.87
1990	24.32	27.11	35.81	44.57	50.03	58.43	67.84	62.55	56.53	40.87	31.07	15.48	42.88
1991	22.19	30.50	32.68	39.17	46.29	56.03	61.71	61.19	55.07	43.42	30.53	24.65	41.95
1992	23.74	34.52	40.58	45.37	54.16	56.47	62.58	63.81	54.13	44.74	27.67	25.16	44.41
1993	29.39	34.07	38.84	41.90	53.42	56.37	62.39	62.52	50.60	41.61	28.53	22.48	43.51
1994	23.87	27.82	38.74	45.00	51.03	61.10	64.26	62.90	53.50	40.06	24.90	25.61	43.23
1995	33.16	33.89	-----z	40.57	47.00	54.43	59.42	61.74	53.53	39.94	34.87	26.00	44.05
1996	26.03	33.10	35.26	41.20	51.32	58.37	68.90	63.84	54.50	41.39	34.67	33.86 i	46.23
1997	33.32	32.79	39.39	45.90	59.29	64.87	65.87	68.26	63.27	45.74	38.73	28.00	48.79
1998	30.58	34.96	38.61	40.50	49.58	58.63	68.81	69.68	60.03	43.84	34.87	26.29	46.37
1999	29.81	33.11	39.65	42.47	54.74	61.04 b	69.74	65.81	60.30	48.00	38.89 b	28.74	47.69
2000	33.90	36.14	40.77	49.17	58.68	66.80	69.41	70.10	58.23	49.13	31.93 c	28.82 c	49.42
2001	28.48	32.50	42.39 c	45.17	60.26	65.93	69.65	70.39	60.59 a	50.26	39.57 b	29.43 a	49.55
2002	28.03	30.64	36.19	48.67	53.48	64.33	71.71	66.42	59.97	46.45	37.27	29.29	47.70
2003	33.32	34.79	42.06	44.90	55.52	63.90	69.13	67.81	61.07	52.10	35.10	30.39	49.17
2004	27.03	33.10	44.58	48.47	55.90	63.67	68.29	66.87	57.43	51.86 j	38.06 m	30.16	49.55
2005	35.77	36.36	40.26	42.27	54.71	60.97	69.90	68.74	55.60	48.65	38.20	28.19	48.30
2006	27.87	32.39	36.39	44.62 i	57.70 a	61.00 d	71.94	-----z	-----z	-----z	-----z	-----z	43.07
2007	23.3	33.1	41.6	48.0	56.2	63.5	73.3	70.7	59.7	46.3	38.9	27.4	48.5



### PAHRUMP, NEVADA

#### Monthly Average Maximum Temperature (Degrees Fahrenheit)

(265890)

File last updated on Jul 25, 2006

\*\*\* Note \*\*\* Provisional Data \*\*\* After Year/Month 200603

a = 1 day missing, b = 2 days missing, c = 3 days, ..etc..,

z = 26 or more days missing, A = Accumulations present

Long-term means based on columns; thus, the monthly row may not sum (or average) to the long-term annual value.

MAXIMUM ALLOWABLE NUMBER OF MISSING DAYS : 5

Individual Months not used for annual or monthly statistics if more than 5 days are missing.

Individual Years not used for annual statistics if any month in that year has more than 5 days missing.

Years	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
1948	-----	----z	----z	----z	----z	----z	-----	----z	----z	79.74l	64.90a	54.90a	59.90
1949	42.16	55.61	64.81	80.93a	82.68	95.30	102.53	99.10	96.17	78.94	75.90	56.77	77.57
1950	54.48	67.08b	69.76b	81.90a	86.74	94.25f	101.50	102.33a	89.93b	86.38e	71.77d	66.37d	79.84
1951	58.43	61.39	63.32l	----z	----z	----z	-----	----z	----z	----z	----z	----z	59.91
1952	-----	----z	----z	75.33c	90.48f	93.21b	103.26	103.38b	93.04f	90.06	62.32e	59.87p	87.93
1953	-----	----z	----z	----z	----z	----z	-----	----z	----z	----z	----z	----z	9999.00
1954	-----	----z	----z	----z	----z	----z	-----	----z	----z	----z	----z	----z	9999.00
1955	-----	----z	----z	----z	----z	----z	-----	----z	----z	----z	----z	----z	9999.00
1956	-----	----z	----z	----z	----z	----z	-----	----z	----z	----z	----z	----z	9999.00
1957	-----	----z	----z	----z	----z	----z	-----	----z	----z	----z	----z	----z	9999.00
1958	-----	----z	----z	----z	----z	----z	100.69	102.19d	94.85d	89.08e	68.17g	67.77e	90.91
1959	62.31	60.17e	73.76f	83.46d	85.00h	100.76i	106.00	99.88e	93.52e	86.96e	72.36e	61.69o	83.08
1960	56.35	61.44k	75.00e	82.12f	88.12e	101.80e	105.64	102.74d	97.44e	81.65e	67.17f	59.78d	86.65
1961	62.52	65.74e	70.81d	76.96d	87.50e	100.62d	105.68	99.27e	90.20e	81.23e	63.83g	55.31e	80.85
1962	58.96	61.04e	63.41d	85.69d	81.65e	95.62d	100.52	101.88e	93.30g	81.07d	72.12f	61.08f	78.67
1963	57.27	70.67d	67.65e	66.56c	89.81e	89.80e	103.54	100.93d	93.75f	84.19d	66.31d	57.81d	77.68
1964	-----	----z	61.08e	75.12d	83.15d	93.23d	103.78	99.96c	92.52e	87.74d	58.61g	54.84f	87.07
1965	57.52	63.61e	65.85d	70.58d	81.62e	92.72e	101.23	100.27e	88.96e	88.07d	69.08d	55.70d	79.79
1966	56.38	57.36c	71.00c	81.50d	90.04e	95.65d	101.63	102.96c	92.56e	82.23e	70.58d	60.52d	80.20
1967	61.40	65.30e	71.41d	66.44e	86.12f	----z	-----	----z	----z	----z	----z	----z	67.72
1968	-----	----z	----z	----z	----z	----z	-----	----z	----z	----z	----z	----z	9999.00
1969	-----	55.32	65.10a	76.71b	87.87a	90.93	100.58	103.55b	95.17	75.38b	66.25b	60.10	79.72
1970	57.26	63.93	64.26	69.70	85.29	94.70	101.77	100.42	90.13	78.00	68.03	54.58	77.34
1971	58.97	64.00	69.13	73.97	77.55	93.37	102.06	100.42	90.30	75.26	64.87	51.03	76.74
1972	56.52	66.11a	78.48	76.73	86.68	94.83	104.29	98.26	89.77	73.10	61.30	53.71	78.31
1973	52.55	58.79	59.48	73.27	88.61	96.77	103.45	98.81	91.40	81.19	65.17	59.87	77.45



1974	52.45	62.57	70.58	75.00	88.52	101.23	100.29	100.00	97.10	82.07 <sup>a</sup>	68.40	57.61	79.65
1975	61.06	63.54	65.71	67.77	84.97	95.67	103.16	100.81	96.07	79.23	67.47	62.10	78.96
1976	62.48	62.97	66.97	73.37	89.26	95.40	100.52	96.23	88.13	77.84	70.93	59.90	78.67
1977	57.16	70.36	64.32	81.03	75.45	97.97	100.77	98.10	87.67	81.45	67.93	61.03	78.60
1978	55.00	60.93	69.13	71.10	83.39	95.90	101.32	99.52	89.67	85.39	63.33	52.94	77.30
1979	48.23	59.82	65.93 <sup>a</sup>	75.70	86.71	96.13	101.13	95.84	98.57	83.45	65.57	62.32	78.28
1980	59.48	64.17	63.26	75.70	78.29	92.80	101.35	98.68	92.33	----- <sup>z</sup>	68.90	64.23 <sup>a</sup>	78.11
1981	61.00	62.75	63.84	78.77	82.97	98.50	101.35	100.42	92.97	74.77	68.36 <sup>b</sup>	----- <sup>z</sup>	80.52
1982	57.42	62.79	62.81	71.63	82.52	90.73	97.65	97.97	88.80	78.57 <sup>c</sup>	63.70	55.17 <sup>b</sup>	75.81
1983	58.68	60.25	62.65	62.83	79.35	92.97	97.81	93.03	93.63	80.00	65.57	59.00	75.48
1984	61.03	64.59	72.16	73.97	89.94	93.83	98.00	96.10	93.83 <sup>a</sup>	73.81	65.17	52.32	77.89
1985	56.52	60.54	65.10	80.57	86.77	98.69 <sup>a</sup>	101.61	99.13	86.41 <sup>a</sup>	80.35	61.70	60.35	78.15
1986	65.81	65.07	72.94	76.00	87.19	97.63	96.39	100.81	84.47	77.61	68.50	56.87	79.11
1987	54.10	61.61	64.61	80.77	83.48	96.37	95.71	98.74	92.90	83.65	63.57	52.06	77.30
1988	54.48	65.59	69.55	74.13	83.35	94.33	103.68	----- <sup>z</sup>	90.97	88.84	66.90	57.42	77.20
1989	55.55	60.93	73.10	84.13	84.74	94.70	102.81	96.87	91.93	80.42	72.43	63.10	80.06
1990	57.03	59.11	71.94	80.47	82.71	94.37	100.55	97.61	92.50	83.58	69.03	54.81	78.64
1991	57.32	70.71	59.74	73.80	79.61	90.27	100.45	98.16	93.90	85.45	68.23	57.84	77.96
1992	55.97	63.10	65.13	80.50	88.39	92.97	97.23	100.39	95.07	83.81	65.10	53.19	78.40
1993	53.35	57.64	69.94	76.63	86.00	90.87	97.87	98.35	92.93	81.29	65.07	58.94	77.41
1994	62.16	57.71	73.32	77.67	84.23	98.43	102.90	102.13	93.03	78.77	60.20	58.97	79.13
1995	54.61	70.79	----- <sup>z</sup>	73.70	78.71	90.30	100.19	99.94	95.57	83.52	75.93	62.45	80.52
1996	62.97	65.66	70.48	78.97	87.77	97.20	104.03	102.97	91.93	79.55	67.40	58.05 <sup>i</sup>	82.63
1997	58.13	63.50	75.97	75.57	92.03	94.20	99.74	101.42	91.27	78.71	68.00	54.06	79.38
1998	58.90	55.79	66.13	70.20	77.48	88.93	102.94	102.68	90.67	77.42	66.50	59.06	76.39
1999	61.74	62.04	70.71	68.83	83.26	93.17	97.52	98.19	92.10	85.84	73.14 <sup>a</sup>	60.52	78.92
2000	60.77	62.17	67.19	81.03	89.84	97.90	100.65	100.00	92.07	78.13	61.63	61.10	79.37
2001	54.90	57.25	70.19	73.20	92.81	97.10	99.35	102.35	95.80	85.06	69.56 <sup>c</sup>	55.42	79.42
2002	58.00	65.36	66.55	78.87	84.81	97.63	103.77	100.00	93.13	78.42	68.70	55.84	79.26
2003	65.84	59.64	67.68	70.43	85.52	97.10	104.06	98.52	96.13	88.90	60.53	56.81	79.26
2004	58.29	56.76	76.81	77.37	86.45	97.00	101.29	98.77	92.30	82.67 <sup>j</sup>	64.76 <sup>m</sup>	57.19	80.22
2005	57.58	59.21	67.23	73.63	86.42	92.37	104.29	98.90	89.93	79.61	70.27	59.68	78.26
2006	60.19	65.82	62.10	74.24 <sup>i</sup>	90.07 <sup>a</sup>	98.96 <sup>d</sup>	103.65	----- <sup>z</sup>	----- <sup>z</sup>	----- <sup>z</sup>	----- <sup>z</sup>	----- <sup>z</sup>	75.43
2007	56.3	64.1	74.4	79.1	89.1	97.4	104.0	100.5	90.1	78.7	72.6	53.0	80.0

**B. Answer the following question after you have successfully graphed the above data with Excel.**

**Are areas heating up????**

**Can you still fry eggs on the desert surface?**

Answer these questions after you have printed your graphs.

1. The minimum temperatures are recorded between the hours of approximately \_\_\_\_\_ to \_\_\_\_\_.
2. The maximum temperatures are recorded between the hours of \_\_\_\_\_ and \_\_\_\_\_.
3. Why do you think the months of Jan and July were chosen instead of other months?
4. Fill in the information from your graphs:

Years 1948-2007	Trend line		Difference
	Low	High	
January			°F
July			°F

a.) Between the years \_\_\_\_\_ and \_\_\_\_\_ the data shows that the minimum (night time) temperature in January near Devil's Hole NV. \_\_\_\_\_ by \_\_\_\_\_°F.

b.) Between the years \_\_\_\_\_ and \_\_\_\_\_ the data shows that the minimum (night time) temperature in July near Devil's Hole NV. \_\_\_\_\_ by \_\_\_\_\_°F.

5.

Years 1948-2007	Trend line		Difference
	Low	High	
January			°F
July			°F

a.) Between the years \_\_\_\_\_ and \_\_\_\_\_ the data shows that the maximum (day time) temperature in January near Devil's Hole NV. \_\_\_\_\_ by \_\_\_\_\_°F.

b.) Between the years \_\_\_\_\_ and \_\_\_\_\_ the data shows that the maximum (day time) temperature in July near Devil's Hole NV. \_\_\_\_\_ by \_\_\_\_\_°F.

6. Compose 2 statements about what you found out about the climate of the area near

Devil's Hole, NV, and give evidence to support your thinking.

7. What effect might this have on the plants and animals, including the pupfish that inhabit this area?
  
8. What effects might this have on the people who live in this area?
  
9. Who might have the better chance of survival and why?

### Activity 4: Landsat Images

#### What can students learn and do with Landsat Satellite Images?

Since 1972, satellites have been circling the earth taking specialized photographs called Landsat images. These digital images of the earth's surface allow people to analyze the impact of events on our landscape, whether they are man made or natural. Analysis of these images can be as informal as two people looking at several images side by side, or as formal as integrating the images into a Geographic Information Systems (GIS) computer model for in-depth scientific analysis. All of this information is revolutionizing the way we understand, manage, and protect our natural resources and plan for the future. For this reason, analyzing satellite images of the Earth from space is rapidly becoming an important and valuable skill in a multitude of workforce areas. According to the U.S. Department of Labor, jobs using geospatial technologies are among the fastest-growing in the country. About 20 NASA's Earth-observing satellites now monitor changes in land, water, ice, air, and life at regional, continental, and global scales, providing a new and powerful perspective on our planet.

Students in Grades 6-10 can get an introduction to interpreting Landsat satellite images through the classroom activity, Quantifying Changes in the Land Over Time at this URL: [http://landsat.gsfc.nasa.gov/education/resources/Landsat\\_QuantifyChanges.pdf](http://landsat.gsfc.nasa.gov/education/resources/Landsat_QuantifyChanges.pdf) This activity uses Landsat images of Phoenix, AZ.

Students learning about climate change in the Desert Arid ecoregion should work with Landsat images of Nevada found below.

#### Preparation:

Teachers do not have to be experts in satellite imagery to conduct this activity with students, whether with image of Phoenix or of Prairie Grasslands. But before teaching the activity it is advisable for teachers to develop a basic level of understanding and familiarity by reviewing the Landsat activity mentioned above, Quantifying Changes in the Land Over Time. Be sure to review the sections of the Quantifying Changes activity, "What you need to know about Landsat Satellites for this Activity," and, "About Color in Landsat Images."

To learn more about Landsat education resources, go to this URL:  
<http://landsat.gsfc.nasa.gov/education>

#### About the Desert Arid Satellite Image Pair:

This pair of satellite images shows Lake Meade, NV on two dates about three years apart: May 3, 2000, and April 19, 2003. Water appears dark blue in the images; the dry landscape is in shades of brown, tan, and gray; and vegetation is red. Comparing the images to one another, one can see a dramatic reduction in water levels of the reservoir from 2000 to 2003. Lake Meade has been drying up.

The loss of water in Lake Meade matters a great deal because it is the largest reservoir

in the United States and provides Colorado River water to places as far away as San Diego, California. Countless households and farms depend on this water for survival. Not only the Lake Meade area but the American Southwest region has been experiencing a long-term severe drought, affecting not only human lives but also those of many plants and animals such as the Devil's Hole pupfish, *Cyprinodon diabolis*.

### **Procedures/Instructional Strategies:**

Using the classroom activity, Quantifying Changes in the Land Over Time, students will be able to quantify how much of the Lake Meade water surface has been lost to drought from 2000 (first picture) to 2003 (second picture).

To learn more about these images and the satellites, visit NASA's Earth Observatory Web site, at: <http://earthobservatory.nasa.gov/IOTD/view.php?id=3556>



