

ACID IN THE WATER

Student/Class Goal

Students have seen water that is polluted and want to understand how one type of pollution could affect the water in their community. They desire to engage in activities that will help them pass the GED test and this gives them an opportunity to build their scientific content knowledge.

Outcome *(lesson objective)*

Students build their vocabulary development and create a flowchart that depicts the process of acid mine drainage.

Time Frame

2-3 hours

Standard *Read with Understanding*

NRS EFL 4-5

Purpose	Benchmarks	Word Knowledge	Benchmarks	Comprehension	Benchmarks
Purpose for reading	4.1, 5.1	Decoding skills		Strategy use	4.11,5.11
Select text		Word parts	2.4, 3.4	Text structural elements	4.12
		Context clues	4.5, 5.5	Genres	
		Reference materials		Literary analysis	
		Word relationships		Drawing conclusions	4.15, 5.15
		Content vocabulary	3.8, 4.8, 5.8	Making connections	4.16, 5.16
		Figurative language			
		Fluency			

Materials

Acid Mine Drainage Photos
 Anticipation Guide
What Is Acid Mine Drainage? Handout
Introducing New Vocabulary Teacher Resource & Chart
 Highlighters, 2 x 2 post-it notes, large paper, note cards
Flowcharting Teacher Resource

Learner Prior Knowledge

Awareness of how pollution affects their community and use of graphic organizers, especially flowcharts and matrixes. Students will have begun to collect new words and have a system for keeping these vocabulary words.

Instructional Activities

Step 1 - Ask students if they have seen a stream that has turned orange. Show photos of streams affected by acid mine drainage. Each student chooses a picture and writes a brief description of what they see or what they think is going on.

Ask what they know about why this has happened to the water. Give students the Anticipation Guide to complete as a pre-reading activity.

Step 2 -The teacher might want to provide a short study of suffixes as a mini-lesson to increase their scientific vocabulary understanding. Science terminology, such as: acidic, base, neutralize, effluent, sulfur, sulfuric acid, sulfides, sulfate, pyrite, copper, iron, lead, mercury and aluminum are Tier 3 words and should be explained as part of the reading content.

- ic "relating to"
- ent, -ant "one who"
- ence, -ion, -tion, -ation "state or quality of"
- ide "chemical compound"
- ate "substance"
- ite "mineral or rock"

Step 3- Explain to students that they will encounter scientific content words and other words that may be unfamiliar as they read the *What is Acid Mine Drainage?* handout (text is 9.2 grade level). Write down any unfamiliar words while reading the article.

Have students form pairs to compare vocabulary lists and talk with their partners about what the words might mean. Have pairs share their words and possible meanings. Write the words on the board or chart paper as students share. Add any Tier 2 words to the list as necessary.

TEACHER NOTE Possible Tier 2 words found in this reading include: region, react, expose, occur, proceed, approximate, environment, impact, species and method.

Give each student the *Introducing New Vocabulary* chart, where they can choose up to 10 vocabulary words. They can write student-friendly definitions and complete the context sections of the chart after class discussion. Daily vocabulary strategies will engage and support students in thinking about and using the words in a variety of formats and contexts.

Students revisit their picture descriptions and revise their writing using new vocabulary words.

Step 4 - Pass out highlighter and note cards. Suggest that students highlight, take notes on, and number the steps in the process that causes this type of pollution. Ask students to pay particular attention to cause and effect relationships in the text. Observe the students as they apply the strategies to the handout. When students are finished reading, have them revisit their anticipation guides and discuss if they have changed their answers and why.

Step 5 - Show examples of flowcharts. The creation of simple flowcharts on a computer is fairly easy with any vector-based drawing program such as Microsoft Word. Remember these key points about flowcharts and that they are simple diagrams that map out a process so that it can be easily communicated to other people.

1. To draw the flow chart, brainstorm process tasks, and list them in the order they occur. Ask questions such as "What really happens next in the process?" and "Does a decision need to be made before the next step?" or "What approvals are required before moving on to the next task?"
2. Then map these out in flow chart format using appropriate symbols for the start and end of a process, for actions to be taken and for decisions to be made. Start the flow chart by drawing the elongated circle shape. Then move to the first action or question, and draw a rectangle or diamond appropriately. Write the action or question down, and draw an arrow from the start symbol to this shape. Work through your whole process, showing actions and decisions appropriately in the order they occur, and linking these together using arrows to show the flow of the process.
3. Finally, challenge your flow chart to make sure that it's an accurate representation of the process, and that that it represents the most efficient way of doing the job.

TEACHER NOTE Flowcharts describe a sequence of events, stages, phases, actions and outcomes. See *Flowcharting* Teacher Resource for more information and an example.

Students get into pairs and create a flowchart that explains the relationship between mining and stream pollution using 2 x 2 Post-It notes on large paper. Have students present and explain their flowcharts to the class.

STUDENT ADAPTATION For Visual/Nonverbal learners, learning is most efficient when material is presented visually, in the form of diagrams, pictures, graphs or charts. Encourage students to draw these visual graphics to represent and reinforce concepts and to illustrate relationships between concepts. You can use several different colors to organize and highlight information when using the whiteboard or chalkboard.

TEACHER NOTE Molly Bang's book [*Nobody Particular*](#), a true story about water pollution, could be used as a supplemental reading for this lesson. After reading the book students could do a Discussion Web strategy on whether Diane's friend Blackburn made a good choice to join the Formosa corporation. Teachers will find many open ended questions for discussion and writing (Why did Diane's family dislike her activism?) Since Diane was a good problem solver, students could make a list of the steps that Diane followed. Next, they could choose a local environmental problem, research it using the problem-solving steps (where to go for information, whom to talk to, whom to ask for help, etc.) and then choose an action to implement.

SCIENCE EXTENSION Interested students might like to complete the experiment on Acid Mine Drainage. Provide materials as needed.

Assessment/Evidence *(based on outcome)*
class discussion
completed anticipation guides
vocabulary charts

highlighted handout and reading notes
student created flowchart

Teacher Reflection/Lesson Evaluation

Not yet completed.

Next Steps

Technology Integration

Anticipation Guide http://literacy.kent.edu/eureka/strategies/agree_disagree_why.pdf

Graphic Organizers

<http://www.cod.edu/people/faculty/drafke/Graphic%20organizers.htm#Simple%20Argumentation%20Structure>

Acid Mine Drainage Experiments <http://pubs.usgs.gov/of/2000/of00-369/>

Abandoned Mine Drainage Glossary <http://www.geocities.com/~paulstan/glossary.html>

Acid/Abandoned Mine Drainage (AMD) - water that is affected by passage through, or alteration by, coal or abandoned coal mine environments. Acid mine drainage can have acceptable water quality, but often it is contaminated. Contaminated mine drainage lowers water quality and kills aquatic life (fish, insects, etc.). Contaminated acid mine drainage most often has these characteristics: 1) Low pH (high acidity) 2) High metals concentrations 3) Elevated sulfate levels 4) Excessive sediment and siltation. Acid concentrations in streams can kill many life forms and stunt the growth of others. Acidic water also can break down the metallic compounds of iron, sulfur, manganese and aluminum found in nearby rock or earthen waste piles.

Sulfates – compounds containing sulfur and oxygen as SO_4 . Elevated sulfate levels are common in contaminated mine drainage. Sulfates can bond with hydrogen ions to form sulfuric acid, or bind to calcium atoms to form gypsum solid.

Yellow Boy - an orange/red residue and staining which is iron in its solid form.

Purposeful/Transparent

Students are using skills necessary for real life and passing the GED – building vocabulary, reading and comprehending non-fiction text.

Contextual

Students are concerned about the quality of their drinking water. Students may need to read non-fiction text outside the classroom for their roles as family members, workers, and community members.

Building Expertise

Students will practice using a flowchart to understand the steps in a process. Students will practice reading non-fiction text. Students have been building their vocabularies by systematically being given 10 new words a week.



Acid Mine Drainage Photos

Acid Mine Drainage Anticipation Guide

- ▶ Read the following statements concerning problems associated with acid rain.
- ▶ Put a check next to each statement with which you agree in the first column.
- ▶ Be prepared to support your views about each statement by thinking about what you know about acid rain and its effects. You will be sharing this information with other members of your group when you discuss the following six statements.

Pre-Agree	Statement	Post-Agree
	Our community has a safe water supply.	
	There is enough clean water in nearby areas to support all the people living here now and in the future.	
	What gets dumped into or taken out of local streams and rivers is more important than what happens to the land surrounding the rivers.	
	Acid mine drainage problems are not yet serious in our region of the United States.	
	Acid mine drainage is made up of sulfur oxides.	
	If acid mine drainage is not controlled, we will experience a major environmental disaster.	

What is Acid Mine Drainage?

Adapted from Mid-Atlantic Acidification http://www.epa.gov/region3/acidification/what_is_amd.htm

Acid mine drainage is runoff from abandoned coal mines and active mining. Acid mine drainage is caused when water flows over or through materials containing sulfur. This forms an acidic solution. Acid mine drainage affects more than 4,500 stream miles in the mid-Atlantic region. It causes the loss of aquatic life, and restricts stream use for recreation, public drinking water and industrial water supplies.

What is Mine Drainage?

- Mine drainage is formed from a chemical reaction between water and rocks containing sulfur-bearing minerals.
- The runoff formed is usually acidic and frequently comes from areas where ore or coal mining activities have exposed rocks containing pyrite, a sulfur bearing mineral.
- Acidic drainage can also occur in areas that have not been mined.

How does Mine Drainage Occur?

- Mine drainage is formed when pyrite, an iron sulfide, is exposed by mining and reacts with air and water to form sulfuric acid and dissolved iron.
- This iron can precipitate (settle out) to form the red, orange, or yellow sediments in the bottom of streams containing mine drainage.
- The acid runoff further dissolves heavy metals such as copper, lead, mercury into water
- The rate and degree by which acid-mine drainage proceeds can be increased by the action of certain bacteria.

Problems Associated with Mine Drainage

- Contaminated drinking water
- Disrupted growth and reproduction of aquatic plants and animals
- Corroding effects of acid on parts of bridges

Acid Mine Drainage

- Mines built as early as the 1800's were developed in a manner which utilized gravity drainage, to avoid excessive water accumulation in the mines
- As a result, water polluted by acid, iron, sulfur and aluminum drained away from the mines and into streams



Results of Acid Mine Drainage

- Acid mine drainage is one of most serious water pollution problems
- It is not only an ecological concern to the states but an economic concern as well

Economic Concerns Resulting from Acid Mine Drainage

- A region impacted by acid mine drainage often has a decline in recreational fish species such as trout as well as a decline in outdoor recreation and tourism along with contamination of drinking water



Acid Mine Drainage

Adapted from Exploring the Environment: Water Quality <http://www.cof.edu/ete/modules/waterq/wqacidmine.html>

Acid mine drainage refers to water with high concentrations of sulfuric acid draining out of surface or subsurface coal mines. The sulfur-laden (acidic) water originates from rainwater percolating through numerous fractures in crushed sulfur-rich coal left in the mines.

Acid mine drainage is a problem on Wheeling Creek watershed because of its [history of coal mining](#) dating back to approximately 1810. Energy from coal was critical to the development of Wheeling's industrial base and the expansion of European settlement west of the Ohio River. Coal mining remains one of West Virginia's most important industries and the basis for energy resources that continue to drive all industry in the Ohio River Valley.



Prior to the 1950s, coal mining was conducted with little regard for its environmental impact. Recent developments in environmental regulation, coal mining methodology, and treatment of effluent from mining operations have greatly changed the impact of mining on streams. Today, the greatest problem with acid mine drainage in West Virginia streams stems from abandoned deep mines. Effluent from abandoned mine sites continues to be the leading water quality problem in West Virginia's river and stream ecosystems.

Mine drainage in streams can be detected using field measures of water chemistry, such as [pH](#), [conductivity](#), [hardness](#), and [dissolved oxygen](#). [Acid mine drainage chemistry](#) provides an in-depth discussion of the chemical reactions leading to the formation of acid mine drainage.

Headwater stream carrying effluent from abandoned mine lands.

What is Acid Mine Drainage? Handout

INTRODUCING NEW VOCABULARY TEACHER RESOURCE

The number of vocabulary words students need to learn is immense and therefore impossible to teach all words directly. It is critical to recognize that not all words need the same attention. To assist teachers in making word-choice decisions, researchers have proposed several criteria that focus on these considerations:

- Words that are important to understanding a specific reading selection or concept.
- Words that are generally useful for students to know and are likely to encounter with some frequency in their reading.

Beck and McKeown (1988) propose that teachers should place major consideration on words' usefulness and frequency of use. To help in this endeavor, they categorized words into three tiers:

Tier 1 Basic words that commonly appear in spoken language. Because they are heard frequently in numerous contexts and with nonverbal communication, Tier 1 words rarely require explicit instruction. Examples of Tier 1 words are *clock, baby, happy and walk*.

Tier 2 High frequency words used by mature language users across several content areas. Because of their lack of redundancy in oral language, Tier 2 words present challenges to students who primarily meet them in print. Examples of Tier 2 words are *obvious, complex, establish and verify*.

Tier 3 Words that are not frequently used except in specific content areas or domains. Tier 3 words are central to building knowledge and conceptual understanding within the various academic domains and should be integral to instruction of content. Medical, legal, biology and mathematics terms are all examples of these words.

Beck et al. (2002) suggest that for instructional purposes, teachers should ignore Tier 1 and Tier 3 words and concentrate on Tier 2 words. Their argument is that most students already know Tier 1 words and that Tier 3 words should be taught at point of contact, or as they occur in reading. Tier 2 words, however, appear often in student texts, so they are the words that can add most to students' language knowledge. Some questions to consider when selecting Tier 2 words for instruction include:

- How important and generally useful is the word? Is it a word that students are likely to meet often in other texts?
- What is the instructional potential of the word? How does the word relate to other words or ideas the students know or have been learning?
- What does the word bring to a text or situation? What role does the word play in communicating the meaning of the context in which it is used?

To begin selecting Tier 2 words for instruction from a text, students should list all of the words that are likely to be unfamiliar. Analyze the list of words and identify which words can be categorized as Tier 2 words. Further analyze the list of indicating which of these Tier 2 words are most necessary for comprehension of the text. Also consider which of these Tier 2 words students already have ways with which to express the concepts associated with the words. The final determination is which words will receive brief attention and which words will require more elaborate attention.

Introduce new words using these steps. The following chart is a tool for students to collect vocabulary words:

1. Tell what the word means using everyday language. If the word has more than one meaning just introduce one meaning.
2. Provide a context for the word.
3. Help the students find a prompt that will connect a personal context for the word.

WORD	DEFINITION	CONTEXT	PROMPT
region	An extensive, continuous part of an area or space.	A part of the earth's surface (land or sea) of considerable and usually indefinite extent: <i>a tropical region</i> .	What region of the world would you like to visit?

Tier 2 Word List

accelerate	demonstrate	initial	region
achieve	denote	innovation	require
adjacent	derive	intense	respective
alternative	design	interpret	restrict
analyze	devise	intuitive	reverse
approach	devote	involve	role
approximate	dimension	isolate	section
arbitrary	distinct	magnetic	segment
assert	distort	magnitude	select
assess	element	major	sequence
assign	emphasize	manipulate	series
assume	empirical	mathematics	shift
authorize	ensure	method	signify
automatic	entity	minimum	similar
chapter	environment	modify	simultaneous
compensate	equate	negative	sophisticated
complex	equivalent	notion	species
complicate	establish	obtain	specify
comply	evaluate	obvious	stable
component	evident	occur	statistic
comprehend	expand	passive	status
conceive	expose	period	structure
concentrate	external	perspective	subsequent
concept	feasible	pertinent	suffice
conclude	fluctuate	phase	sum
consequent	focus	phenomena	summary
consist	formulate	portion	technique
constant	function	portion	technology
construct	generate	potential	tense
consult	guarantee	precede	theory
context	hypothesis	precise	trace
contrast	identify	presume	tradition
contribute	ignore	prime	transmit
convert	illustrate	principle	ultimate
create	impact	proceed	undergo
criterion	implicit	publish	usage
crucial	imply	pursue	valid
data	indicate	random	vary
define	individual	range	verbal
definite	inhibit	react	verify
			vertical

See STAR Toolkit <http://www.startoolkit.org/> for more information about Tier 2 words.

Acid Mine Drainage Experiments Table of Contents

<http://pubs.usgs.gov/of/2000/of00-369/>

Make your own litmus paper	AMD-Activity #1
What is acid and how do you know it?	AMD-Activity #2
If your creek water is clear - Is it clean?	AMD-Activity #3
Why does acid mine drainage form?	AMD-Activity #4
What plants love acid water?	AMD-Activity #5
Who is very small and living in your creek?	AMD-Activity #6
What is in your creek water?	AMD-Activity #7
How many colors does iron (Fe) have?	AMD-Activity #8
What is that black stuff on the rocks?	AMD-Activity #9
Is the groundwater acid also?	AMD-Activity #10
What is the white stuff in the creek?	AMD-Activity #11
How can acid mine drainage be fixed?	AMD-Activity #12
Using stinky bacteria to treat acid mine drainage	AMD-Activity #13

Why does acid mine drainage form?

The Weathering Process

In many areas, acid drainage forms naturally when certain minerals come into contact with water, air and bacteria. This contact and the chemical reactions that take place are part of the weathering process. The weathering of the rocks and minerals in the creek slowly releases the acids, salts, metals and sulfates into creeks, rivers, lakes and wetlands. Weathering is a natural process, but many times human activities interfere and can increase the amounts. When too much of these acids and minerals enter creeks, they become polluted and can no longer support animals.

Tools and Things you will need

Limestone	Tap water	Litmus paper
Gloves	Rubber boots	Pieces of ore (2)
Bottles	Rocks or solid materials (1)	Coal chunks

1. Use small pieces
2. Iron, aluminum, or magnesium ores are available at local science and nature supply stores such as, the World of Science <http://www.worldofscience.com/>.

What to do.

1. Collect solid materials that are found where you live.
2. Add tap water to bottles. Measure the pH with litmus paper.
3. Add one type of solid material to each of the water bottles. You may want to crush the solid materials into small pieces to get better results.
4. Put water but no solids in one bottle. (This is called your control.)
5. Measure the pH over time and write down what you see.

What did you see?

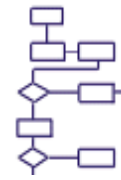
1. What materials lowered the pH of the water?
2. What materials raised the pH of the water?
3. How long did it take for acid to form?
4. What else did you see?

What do you conclude?

1. What materials in your area do you think can cause acid mine drainage?
2. How could you prevent acid mine drainage from forming?
3. What are your conclusions? Write down what you think.

Flowcharting

Teacher Resource



Definition A *flowchart* (also flow-chart and flow chart) is an easy-to-understand diagram showing how steps in a process fit together. Flowcharts are useful tools for communicating how processes work and allow you to break any process down into individual events or activities then display them visually to show the logical relationships between each part. Furthermore, the act of mapping a process out in flowchart format helps you clarify your understanding of the process, and helps you think about where the process can be improved. Flowcharts tend to provide people with a common language or reference point when dealing with a project or process.

Types of Flowcharts There are four basic types of flowcharts:

- ❑ **Basic** flowcharts quickly identify all the major steps in a process. They are used to orient a team with the major steps by just giving a broad overview of the process.
- ❑ **Process** flowcharts examine the process in great detail. They provide a comprehensive listing of all major and sub-steps in a process.
- ❑ **Deployment** flowcharts are similar to Process flowcharts in that they are very detailed but also indicate the people who are involved in the process. This could be very useful when the process involves cooperation between functional areas.
- ❑ **Opportunity** flowcharts highlight decision steps and check points. They are used for very complicated processes because they highlight specific opportunities for improvement.

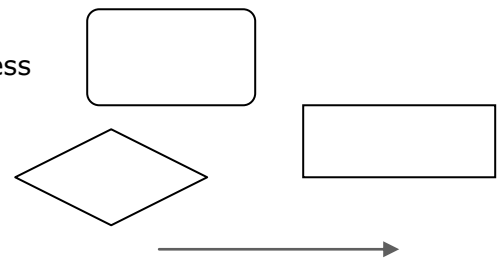
How to Draw Flowcharts There are no hard and fast rules for constructing flowcharts, but there are guidelines which are useful to bear in mind. Here are six steps which can be used as a guide for completing flowcharts:

- ❑ describe the process to be charted clearly with a one-line statement
- ❑ start with a 'trigger' event
- ❑ note each successive action concisely and clearly
- ❑ go with the main flow and use the simplest symbols possible
- ❑ make cross references to supporting information and make sure every feedback loop has an escape
- ❑ follow the process through to a useful conclusion - end at a 'target' point

Basic Shapes Flowcharts use standard symbols to represent a type of operation or process to be performed. The use of standardized symbols provides a common language for people to visualize problems and also makes flowcharts easier to read and understand. Within each symbol, write down what the symbol represents. This could be the start or finish of the process, the action to be taken, or the decision to be made.

Most flow charts are made up of three main types of symbols:

- ❑ elongated circles, which signify the start or end of a process
- ❑ rectangles, which show instructions or actions
- ❑ diamonds, which show decisions that must be made
- ❑ connections between events are represented by lines, usually with arrowheads to show the flow of the process

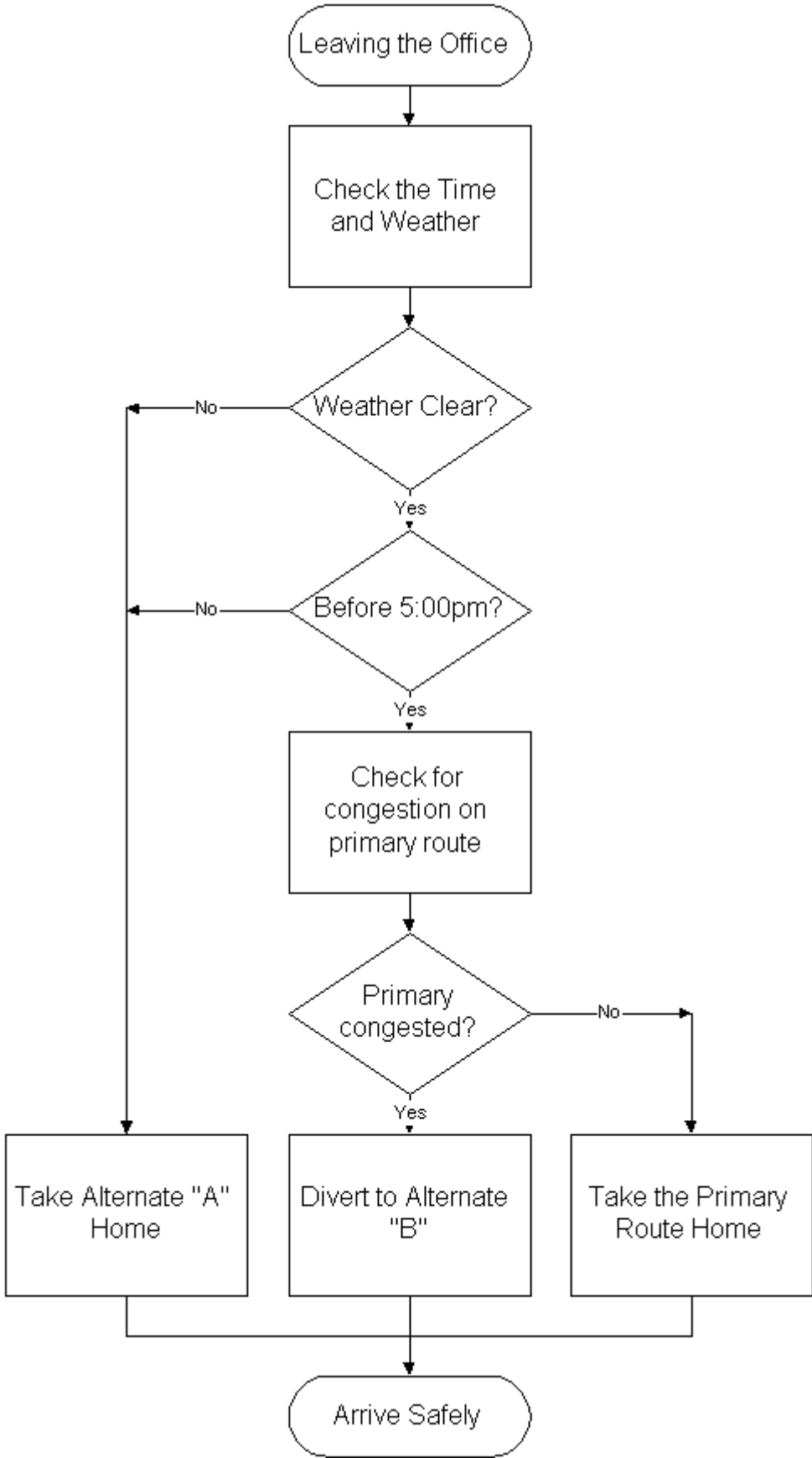


Tip There are many different flowchart symbols that can be used-see <http://www.nos.org/htm/basic2.htm> for more. However, remember that an important use of flow charts is in communication. If you use obscure symbols that only part of your audience understands, there's a good chance that your communication will fail. As ever, keep things simple!

Resources

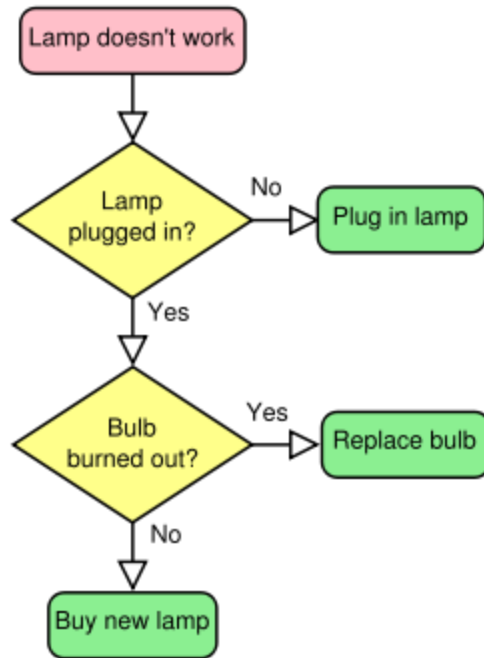
Creating Flowcharts in Canvas <http://www.deneba.com/community/howto/flowcharts/default.html>
Flowcharting <http://www.hci.com.au/hcisite2/toolkit/flowchar.htm>
Flowchart <http://en.wikipedia.org/wiki/Flowchart>

Process Flowchart for Finding the Best Way Home



This is a simple case of processes and decisions in finding the best route home at the end of the working day.

A simple flowchart for what to do if a [lamp](#) doesn't work



A Flowchart

