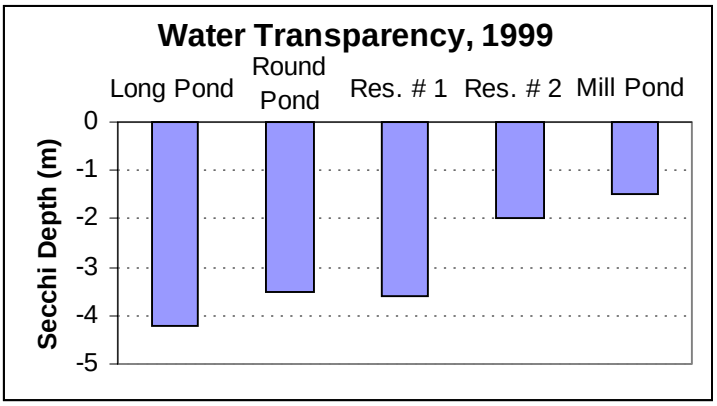
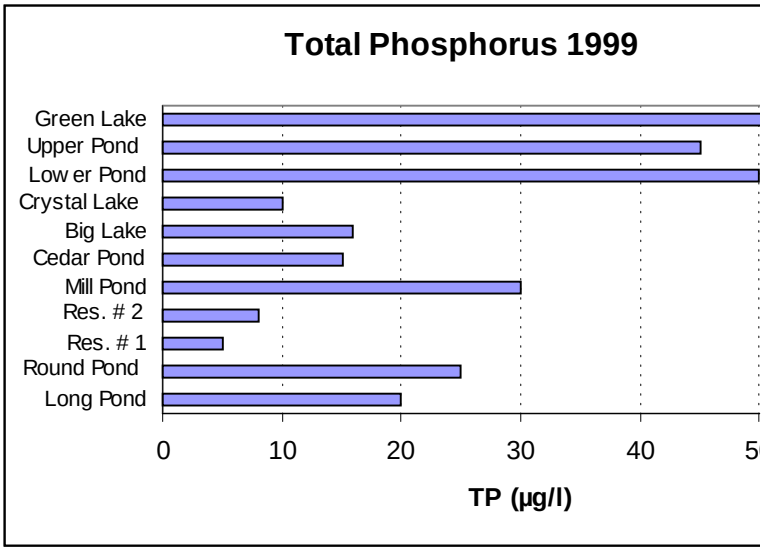
Tip
When the labels don't appear where you want them, use the "show labels" command for that axis to move them individually. (All graphs in this section were produced with Microsoft Excel.)



Example 3-7: In this bar graph, the y-axis scale shows negative values to depict depth under water.

If bar labels get cramped, the graph can be horizontally oriented, as shown in Example 3-8:



Example 3-8: The independent variable is traditionally placed on the x-axis, but if it has many points with long labels, it is better to place it on the y-axis as shown here, for better legibility.

Stacked bars allow you to show how composition of a whole changes over time (or from site to site). Stacked bars might be useful for comparing invertebrate percentages over a single season, from year to year, or from upstream to down. See the discussion below under pie charts.

Three-dimensional bar graphs
Three-dimensional graphs may make it hard to read exact values off of the axes. There are some instances, however, when it is necessary to show two relationships at once, such as bacteria over time as well as over space. The angle of the bars should not hide the data in the back row. In Example 3-9 it's easy to see that Site 5 is always low.

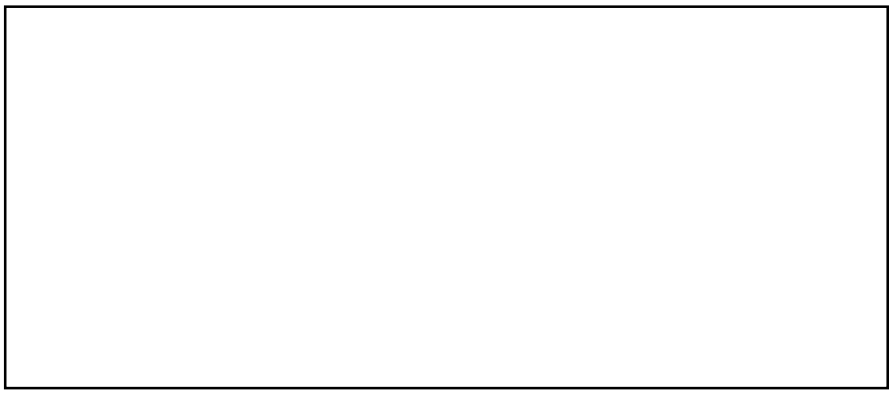
Example 3-9: A successful 3-D bar chart. (Kerr, 1995)

Pie Charts
This type of chart is effective to show the distribution of the parts of a whole: for example, the percentages of pollution contributed by different sources, or the composition of bug or plant species in a sample.

Tip for Pie Charts
If you have many small percentages, your pie chart may get cluttered. Try grouping the small values together as an "other" slice. Be sure to identify the composition of the "other" slice elsewhere if you are presenting to a technical audience.

Example 3-10: A pie chart is an effective way to show percentages. (From River Watch Network)

Pie charts are easier to read than stacked bars, but to compare how percentage compositions change among samples, stacked bars can be linked as in Example 3-11.



Example 3-11: Linked stacked bars highlight the change in bug composition between sites.

Combination

Sometimes a combination of charts is useful, such as when one parameter is highly dependent on another, but is emphasized more than the other. For example, use bar charts of dissolved oxygen levels with a background line of temperature, or bars of rainfall against a line for flow. Example 3-5 is a combination graph of pH and Acid Neutralizing Capacity (ANC).

What makes a good graphic?

"When a graph is constructed, quantitative and categorical information is *coded*, chiefly through position, size, symbols, and color. When a person looks at a graph, the information is visually *decoded* by the person's visual system. A graphical method is successful only if the decoding process is effective. No matter how clever and how technologically impressive the encoding, it is a failure if the decoding process is a failure." (*The Elements of Graphing Data*, Cleveland, 1985.) The following characteristics are all important in coding and decoding information:

Graphic Tips

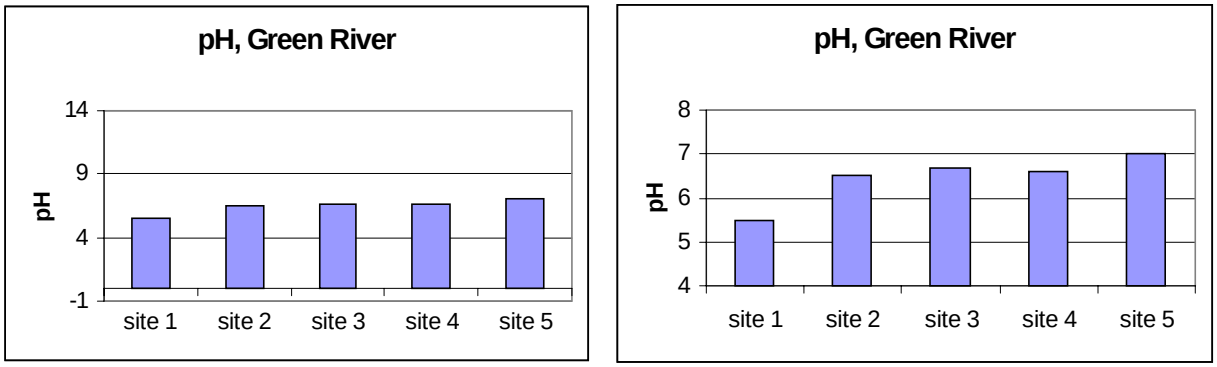
- Lettering: Simple, legible "sans serif" fonts (without strokes) such as Arial work better than busy fonts like DESDEMONA or Minstrel.
- Use fonts at least 18pt in size for slides and overheads.
- Amount: in general, less is better than more: use as few words as possible. In tables, more than three columns and rows is usually too much for a projected graphic.
- Orientation: keep the writing horizontal if possible.

- Simplicity: keep graphics simple, especially in slides and overheads, or the audience will be distracted. Display one concept per graphic, but don't oversimplify and mask the results.
- Clarity: label axes, use a title, and use a legend in reports (see Example 3-5).
- Color: use clearly different colors or patterns for your variables, but don't overstimulate your audience with a rainbow of colors. This will only distract their attention away from your message.

Scale considerations

Although it's OK to exaggerate scales to show differences (for example elevation vs. distance), it is dishonest to distort the scale to make your results look more significant than they are.

Sometimes, however, it is a good idea to alter the scale of the vertical axis. Since natural waters' pH values usually stay within the 3-8 unit range, it is better to start the y-axis at 4 and end at 8, rather than depict the whole pH range of 0-14 because that range will mask (compress) significant differences in results.

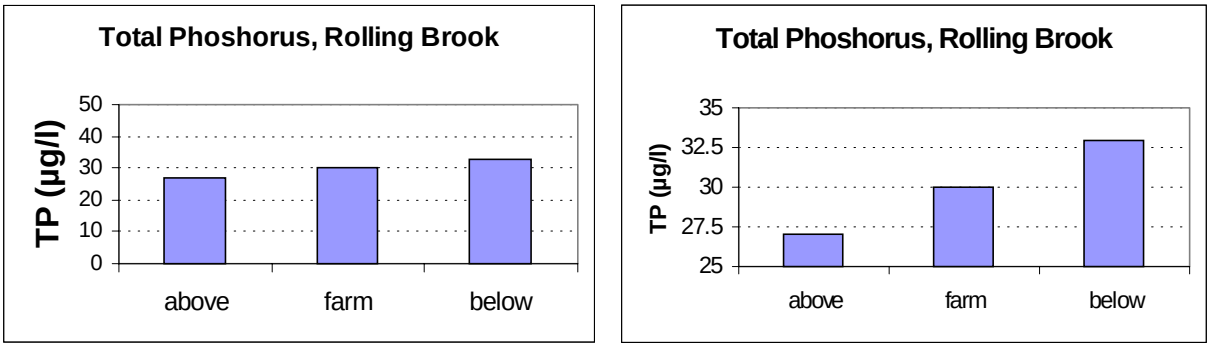


Example 3-12: The graph at left gives the mistaken impression that the results are similar among sites. The chart on the right, displaying a narrower y-axis scale, more accurately conveys a significant difference between sites.

There are other times when altering the scale can mislead the audience on the significance of difference between results. Take this case, which measures total phosphorus levels in a stream above, at, and below a farm. The values recorded are (in μg/l or parts per billion):

above	27
farm	30
below	33

For an impact study of this nature, it is highly unlikely that these are significant differences. A reasonable conclusion would be that the farm does *not* have a meaningful impact on stream phosphorus levels. The example below shows two ways of graphing these results. The left chart, with a scale from 0 to 50, shows three bars of about the same height, indicating little change as we move downstream past the farm. On the right chart, the scale has been enlarged so that the same data now look dramatically different, misleading the audience into thinking the farm is a real problem.



Example 3-13: Changing the scale to dramatize insignificant differences is not recommended.

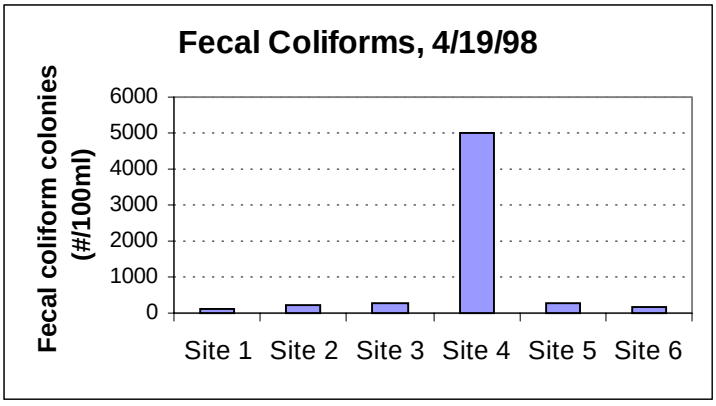
Another common scale problem occurs when trying to display widely varying values, as is often the case with fecal coliform and other bacteria. Consider this case, where the following results were obtained (in fecal coliform units / 100 ml of sample):

Site#	1	2	3	4	5	6
Fec.	103	210	300	5000	262	189

How do you display this information? It depends on what your objectives are. If you want to show that Site 4 vastly exceeded all others, Chart 1 makes the case dramatically. However, this style depresses the other values, making them all seem insignificant. People might think that the water at these sites is exceptionally clean. You might want to use a logarithmic scale, which visually exaggerates low numbers and diminishes high numbers by giving each order of magnitude (e.g. 1-10, 10 -100, 100 - 1000, etc.) equal height. In other words, the bar segment from 1-10 is just as long as the bar segment from 1000 to 10,000. The result, seen in Chart 2, suggests that there are notable pollution levels

at *all* sites. However, they all look fairly close together, and you've lost the visual punch of the 5000 colonies found at Site 4. Another way to tackle this might be to set a low y-axis range (as in Chart 3), which will cut off the high value. Note that the high value is listed atop the bar, and that the bar has no top line on it. This suggests that the pollution levels are literally "off the charts," and restores some of the shock value of the first chart. With this method, you are still free to point out the differences between the other sites. You might, for instance, draw a line across the 200 value, which is sometimes used as a swimming standard, and discuss how three of the sites exceeded it, one approached it, and one site stayed well below it.

Chart 1



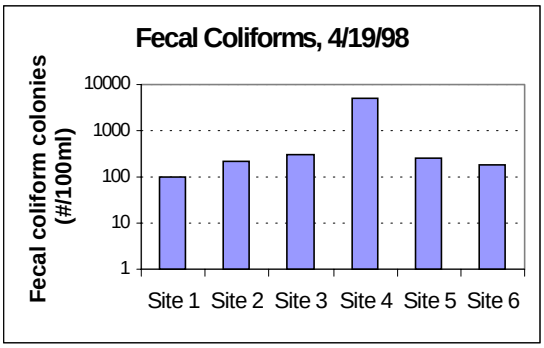


Chart 2

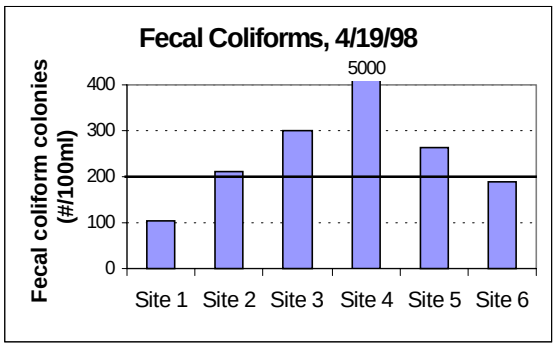
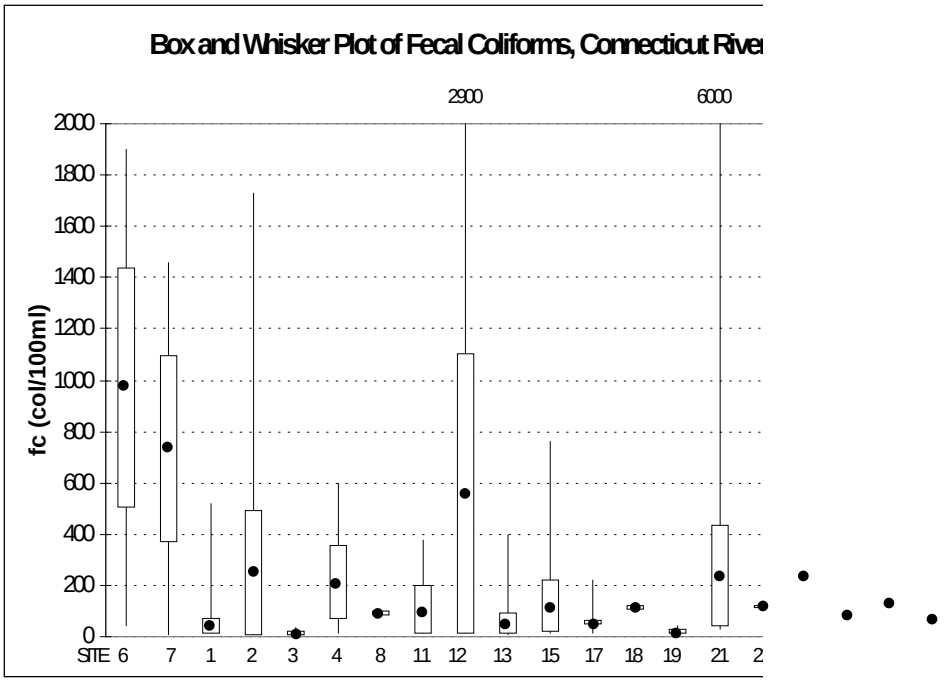


Chart 3

Example 3-14: Chart 1 uses a normal scale, which dwarfs all values but the high one. Chart 2 uses a logarithmic scale, which amplifies lower values, but visually diminishes the high value. Chart 3 compromises by allowing the high value to exceed the chart's limits.

Tailor graphics to audience and venue

Charts and graphs–*in moderation*–are useful for most audiences (leave them behind when you give a talk to the elementary school). But design them to match the audience's technical knowledge. A scientific audience can understand more complex line graphs, while a general audience probably understands simplified bar charts or pie charts more readily. This doesn't mean you shouldn't use a bar chart for a technical audience–sometimes that's just the thing. Rather, think of how you can best get your message across. For example, the chart below, called a "Box and Whisker Plot" presents a lot of information: the top of the box represents the 75th percentile–meaning that 75% of the data for that date fall below that line. The bottom of the box represents the 25% percentile. The dot is the median (half the samples on that date were greater than this value, half were lower). The top of the vertical line is the maximum value recorded and the bottom of the lower line or whisker is the minimum value. Scientists love Box and Whisker Plots because they convey a lot of info quickly. But if you have to spend a lot of time explaining the chart to the audience, you've lost their attention. Better to sacrifice some detail for clarity, and stick with a simpler chart style.

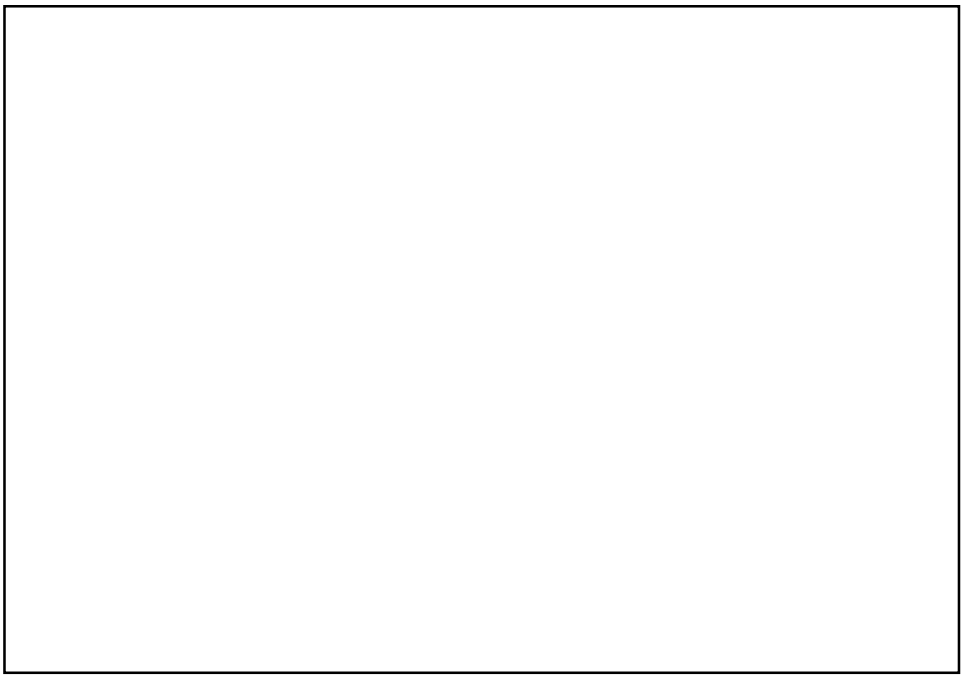


Example 3-15:
For a scientific audience, you can use a Whisker and Box Plot such as the one above, which was produced with an Excel spreadsheet. (Select the "stock" chart type and pick the "open-high-low-close" sub-type.)

Whenever possible, use graphics prepared specifically for the presentation at hand. Borrowing visuals you made for another purpose may backfire: for instance, a chart prepared for a written report may appear too detailed or complicated in a slide show. While report readers go through your information at their own pace, you don't want to spend a lot of time in your oral presentation verbally dissecting a slide for the audience. Therefore, pare down the report graphic to a simpler slide, or spread the information over several slides.

Graphics with visual appeal will attract exhibit audiences. Instead of points on a line or rectangular histograms, jazz up the graphic with symbols and colors. The Secchi disk example below is one idea of modifying a histogram to enliven a graphic.

Don't rely entirely on graphs or charts. Add photos and drawings (e.g. a color diagram showing functions of riparian corridors) to the poster for greater visual impact.



Example 3-16: A water transparency bar chart modified for visual appeal.

Production and Cost
Most database and word processing programs now include graphics tools that allow you to make graphs and charts from your data. Lotus 1-2-3 and Excel are two popular spreadsheets with this capability. They all work in similar fashion. After you've entered a set of data in columns and rows, you specify which rows and columns represent a *data series.* The computer translates the numerical values into lines, bars, or pie wedges. It can even add a chart title, legends, and data labels if you arrange your data cleverly. But some customization will be necessary. If you are already using computers for data storage, your major cost may be the time you spend learning to use them to make charts.

Data Strategy:
Unless you are a clone of the person who developed the software package, you will probably encounter frustrations while trying to make charts. Labels are a particular problem; it's often hard to place them the way you'd like. It may be better to use old-fashioned technology, like pasting text on a printout of your computer graph, and then photocopying it, than to settle for unreadable computer-generated labels.

If you're working without a computer, don't despair. People have been making great graphs long before computers were used, and the technology survives. It is still possible to make good charts by hand. Use graph paper with non-photo blue lines, to aid in lining images up straight. Then draw your graph with dark ink and colors, so they will photocopy on paper or transparency sheets while the blue lines will not. Special transparency markers allow you to color in bars or pie chart slices. Cost is probably less than $20 for materials (pens, graph paper, transparencies for 5-10 graphs), and time involved is probably no more than the time you'd spend using a computerized graphing tool.

Consult the Reference section in the Appendix for guides on producing graphics, including an issue of *the Volunteer Monitor* newsletter devoted to "Managing and Presenting your Data" (Spring 1995).

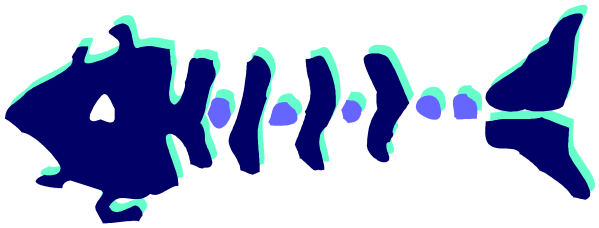
Photographs

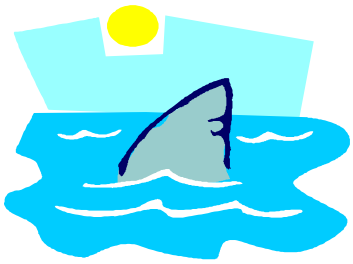
Data doesn't only mean numbers, graphs, and maps. Algal growth on a lake surface over the course of a couple of months, captured in photographs, is also data. So is a photographic record, taken from the same vantage point each time, of the "wetted perimeter": what part of a streambed is or is not exposed at different river stages. Pictures of different monitoring sites, your lake at different times of the year, anglers with their catch–these are all qualitative records of your watershed health or your monitoring project. Additionally, they can add interest as well as information to your presentation. Remember that one purpose of a presentation is to persuade or inspire. If you want people to get a feel for what's happening in the watershed, photos are the next best thing to "being there." They make the situation tangible, while numbers alone remain vague abstractions.

When to Use and What Kind to Use

If you are using photographs to document conditions or events, use them whenever possible. If you are using photographs to demonstrate ecological concepts, to suggest a hypothetical cause and effect, or as an emotional catalyst, then be a bit more circumspect. For instance, if a chemical spill caused a fish kill, then your photos of the resulting dead fish are an important part of the record, along with your pH, oxygen, or other chemical results. They are appropriate at every venue. But consider a different situation: you have recorded low dissolved oxygen values and you want to warn people that prolonged exposure to these conditions can kill trout. In this case, a stock photo of dead fish would work well in a talk to Trout Unlimited. Press the point even further with a couple of preceding photos of lunkers, alive and well, waiting to be courted with a well-cast fly. But this trick isn't necessary in your report to the Department of Environmental Protection. Professionals in the field know, without your lurid reminders, that fish die when certain water parameters cross known thresholds.

Tip
For around 20 dollars, you can buy no-frills cameras that take reasonably decent pictures. Keep one in your car at all times, loaded with slide film (or print, depending on whether you do more slide talks or newsletters). When you see a photo op (cows in stream, a pollution plume or eroding gully), you're all set.





Compiling a good photo library is a year-round job. Whenever you find something noteworthy in your watershed, snap a shot. Build a portfolio to use in your talks and exhibits. We've seen a number of creative and effective uses of photographs in data presentations. Here's a list of some of our favorites:

- Start a slide talk with scenic shots of different parts of your watershed, to give people a sense of the value of what you are trying to protect. After you've drawn them through the horrors of pollution problems you are monitoring, end with another nice shot or two to remind them it's all worth the fight.
- In brochures and newsletters, nature photos and action shots of volunteers at work always attract people and keep them reading.
- Cows in the stream! For bonus points, wait around for the cows to make a direct deposit. Always a crowd pleaser on the dinner circuit.
- Shots of turbid streams entering clear ones. These aren't hard to find. Wait for the next day of heavy rain, when the river gets really roily. Drive upstream to the first major tributary. Snap a shot of the junction, and then follow the dirtiest branch. Keep doing this, until you find a specific source or two–or run out of gas or road. You may end up with a great photographic record of how your river muddies up–and locate a few restoration projects in the bargain. It may be difficult to capture the color difference between a clear and a turbid stream. Try taking the photos from as directly overhead as possible; for instance, from a bridge.
- Low water conditions.
- Erosion slumps.
- Storm drains.
- Rainbow-colored oil sheens on pavement.
- Lawns, row crops, pavement, or other human activity that encroaches on a wetland or riparian zone.
- Comparison photos; above and below a pollution source, before and after a development, etc.
- Fishing, swimming, walking; any recreation in or near the water.
- Sample sites and volunteer sampling action.
- Acres of aquatic plants.

Exhibits are another medium where you should consider including photographs. Enlarged color prints that are mounted on a rigid backing are a draw to passersby.

Photos are great for your Web site, if you have one. Net surfers will linger at sites with good photos. Sprinkle pictures in liberally among your text and graphs to keep people reading. One trick to using photos with Web sites: they take a little longer to download, so position the photos in a way that gives the viewer some text to read while the download occurs.

Slide shows are a natural for photographs, of course. Your graphs and charts can be made into slides and interspersed strategically with human interest and nature photos to help make your point.

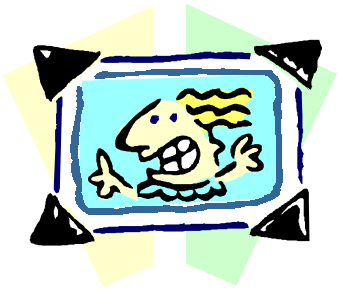


Photo production

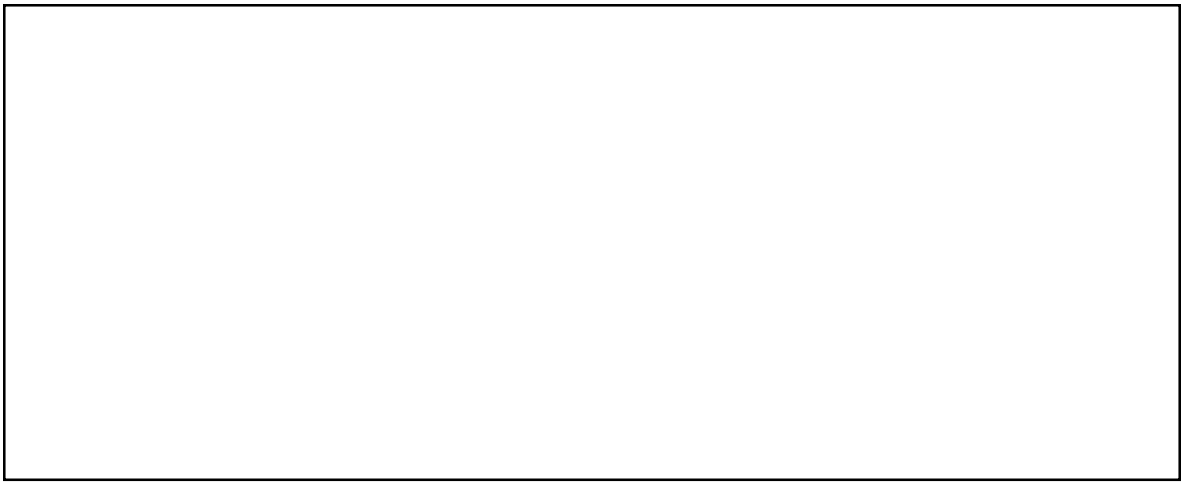
The basic ingredients–the photos themselves–are easily and inexpensively obtained. If someone in your group can take a variety of pictures, the outlay is limited to film and developing. Transferring photos into different formats can increase both cost and effort required.

If you have a scanner, you can scan photographs yourself for use in printed materials. Slides require a more advanced scanner, one that isn't usually part of a small office. But for a small fee, anywhere from $15 to $50, you can rent time on equipment at a local print shop or computer center. Alternatively, you can pay to have scans made for you if you're unfamiliar with scanning equipment.

Scans of images can be saved in many different graphic formats with names such as TIFF, EPS, PICT, and so on. For use on the World Wide Web, JPEG and GIF are common formats. The format you'll want to use depends on what software your material is being printed from and on what quality of image you want. Check the manual that came with your software for format compatibility with the final product you want. Microsoft Publisher has a useful guide on various graphic formats, or consult Web help sites such as webmonkey.com.

Photos can also be half-toned by your scanner for use in printing by offset or other methods (a halftone turns a photo into a field of dots that print with better quality).

Be sure to print out samples beforehand. Sometimes photos in PICT format, for example, look good on the computer screen but don't print well.



Example 3-17: Scanned photo as halftone.

Slides and Overheads

You can turn charts, graphs, and maps into overheads with a laser printer or photocopier and sheets of transparency film. You can also turn them into slides for a slide show talk. To make slides of paper materials, simply photograph them. A tripod helps to hold the camera steady; hand-held exposures usually lead to blurry slides. It's a good idea to mount the graphic on a black background so any border appearing on the slide will not be obtrusive.

Tips on making overheads and slides

Overheads: This is the cheapest and easiest way to project visuals on a screen. The advantage of using overheads rather than slides is that it allows for better contact with your audience: lights don't have to be turned off and you can look at the visual while facing the audience. Another advantage is that you can modify the visual as you are using it, by adding things with a marker. You can also make them in a hurry: all that is needed is access to a printer or photocopier. The transparencies can be bought in any office supply store. Either print directly on a transparency or photocopy a paper print onto a transparency. Make sure you have the right transparency film for the job, though: transparencies made for copiers will smudge with a laser printer. You can also add color with special transparency pens, available at art supply or office supply stores.

Tips for legibility
Hold your artwork 6 times its width from you. If you can read it, it will be readable on projection.
Maximum number of words: 10 lines of 24 characters per line. Ideal is 6 lines with a total of 20 words.
Overheads
Prepare artwork full size: 7.5"x 9.5".
Minimum line width: 1.5 mm.
Major lines: 3 mm wide
Minimum letter height: 3/16".
Slides
In text slides, use both upper and lower case letters.
Minimum lower case letter height: 1/50 graphic height.

Overhead transparencies work best for graphs and charts. Photographs can be transferred onto transparencies, but often look grainy and don't stand out well in a lit room.

Slides: If you take your own photos for slides, use Ektachrome film to emphasize blue or green colors, Kodachrome to emphasize reds and yellows. To take a slide of a graphic off of your computer screen without specialized equipment, take the slides at night, turning off all room lights. Set the exposure to 1/4 second, and f-stops to 5.6. To be sure to have a good slide, you can bracket the f-stop setting and try settings of 8 and 4 as well: one of the three will be perfect!

Since the dimensions of a slide frame do not exactly match the computer monitor, you can make a black frame out of construction paper to mask the monitor's plastic frame.

Another possibility is to give your computer disk to a developing lab that can make slides directly from them. The cost is about $6 per slide.

In conclusion

Graphics and other visual tools are the key to getting information across in our highly visual and media-rich culture. Whether you use them in a report, an oral presentation, or an exhibit, graphics help your audience grasp and retain the information you are sharing. It is a good strategy to prepare some basic graphics of your monitoring results in different formats, e.g., an overhead, a slide, and a photo print of the same graph comparing pollution levels at different sites. This will give you material to quickly adapt to a variety of presentations when opportunities arise.