TECHNICAL COMMUNICATION FOR ENGINEERS

Basics, Using Graphics, Expressing Risk

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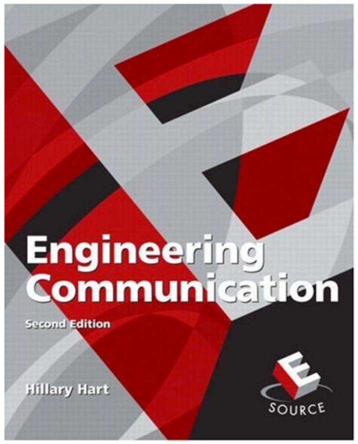
Agenda and Credits

- Topics:
  - The role of engineers as communicators.
  - Using graphics/visuals in presentations and reports.
  - Communicating risk to stakeholders.
- Most of the material here is inspired by and adapted from the lecture notes from Dr. Hillary Hart in the Department of Civil Engineering at The University of Texas at Austin.
  - Course CE 389C: Advanced Engineering Communication[1].
- More details are available in her book[2].



Resources at CMU

- **Global Communication Center (GCC)**
  - Tutoring resource supporting CMU students' efforts to improve their written, oral, and visual communication skills.

Written

- Essays
- Lab reports
- Proposals
- Apps for Grad School and Jobs

Visual

- PowerPoint design
- Scientific posters
- Data visualization

Oral

- Presentation rehearsal and feedback

  - Scheduled appointments and walk-ins.
  - First floor in Hunt Library.
  - URL: http://www.cmu.edu/gcc/.

BASICS OF TECHNICAL COMMUNICATION

Data, Information, Knowledge

Engineers are Communicators

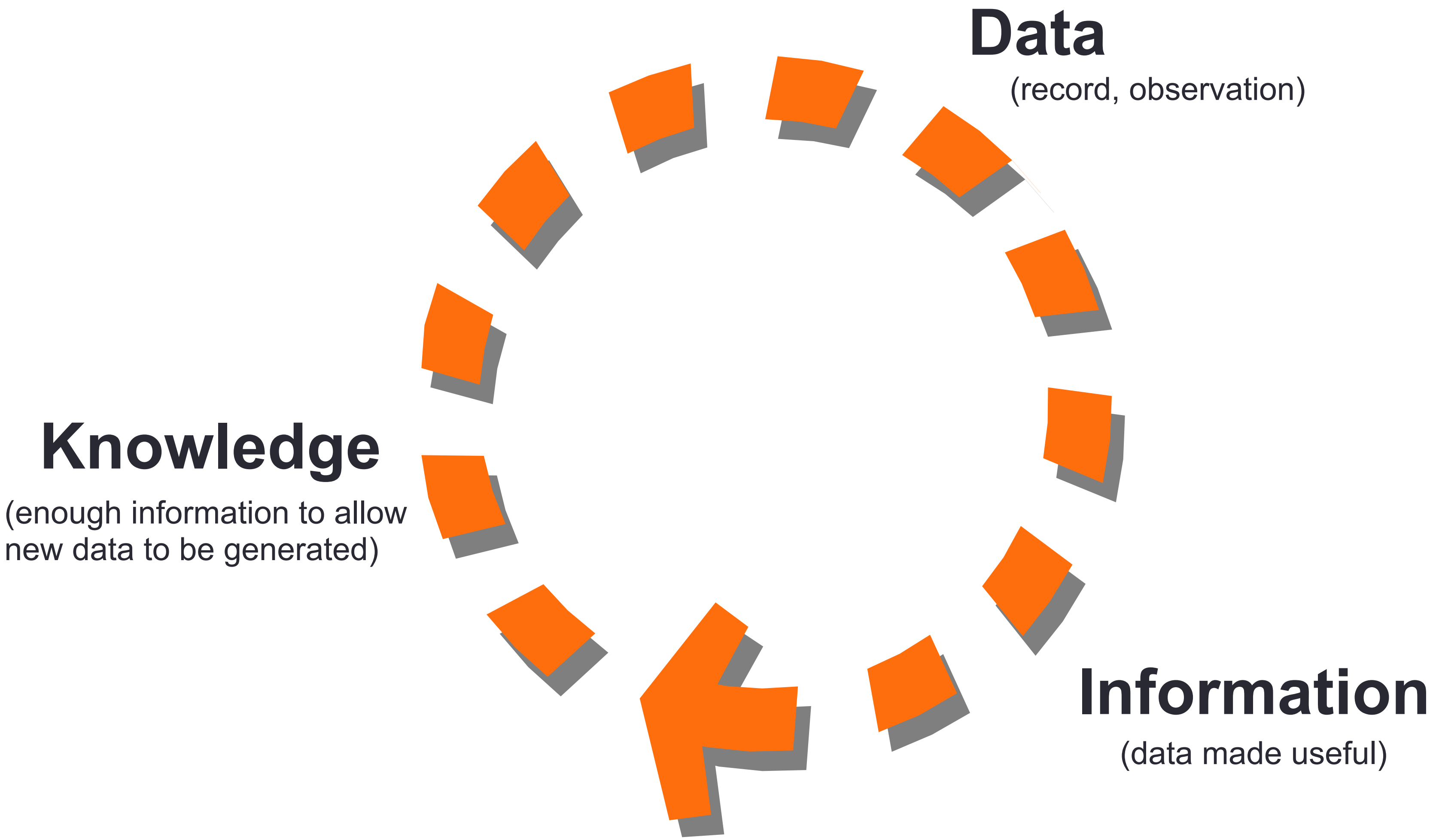
- By virtue of being an engineer, you are a Technical Communicator.
- Engineering is a people-oriented profession.
- Engineers not only develop technologies; they help people make use of technology.
- Engineers must communicate with *regulators*, *funding agencies*, *suppliers*, *clients*, *customers*, *the media*, and sometimes the *general public*.

Purpose of Engineering Communication

- Engineers communicate their methods, results, conclusions, and recommendations so that information can be understood and *used* by a variety of people.
- Engineers generate raw *data* and then turn them into *information* to help people solve problems.
- Data alone are usually not useful.

Information is data made useful for other people.

Information Life Cycle



Required Skills for Engineers

- Manage information
- Write technical information for many audiences – often with conflicting needs
- Design graphics for technical information
- Elicit expert information – interview others
- Present information verbally
- Work collaboratively – write collaboratively

Multiple Audiences

- Academic audiences
  - **Other researchers**
  - **Faculty**
  - **Students**
  - **Supervisor**
- Research audiences
  - **Experts**
  - **Executives/Managers**
  - **Technicians**
  - **Regulators**
  - **Funding agencies**
  - **General public**

Business audiences

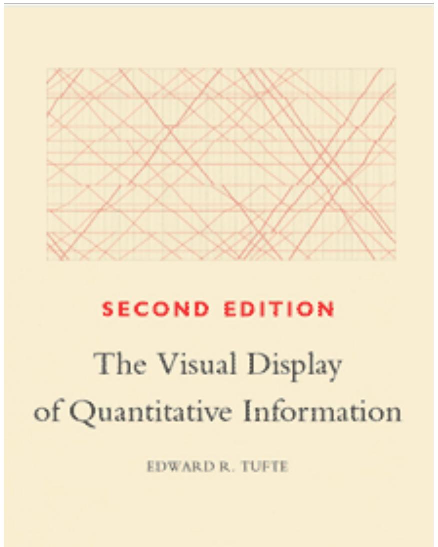
- Inside the organization
  - **Management**
  - **Colleagues**
  - **Support staff**
  - **Salespeople**
  - **Technicians**
- Outside the organization
  - **Customers**
  - **Regulatory agencies**
  - **Financial institutions**
  - **Suppliers/vendors**
  - **News media**

GRAPHICS IN DOCUMENTS

Guidelines, ACCENT Principle

Graphics *Reveal* Data

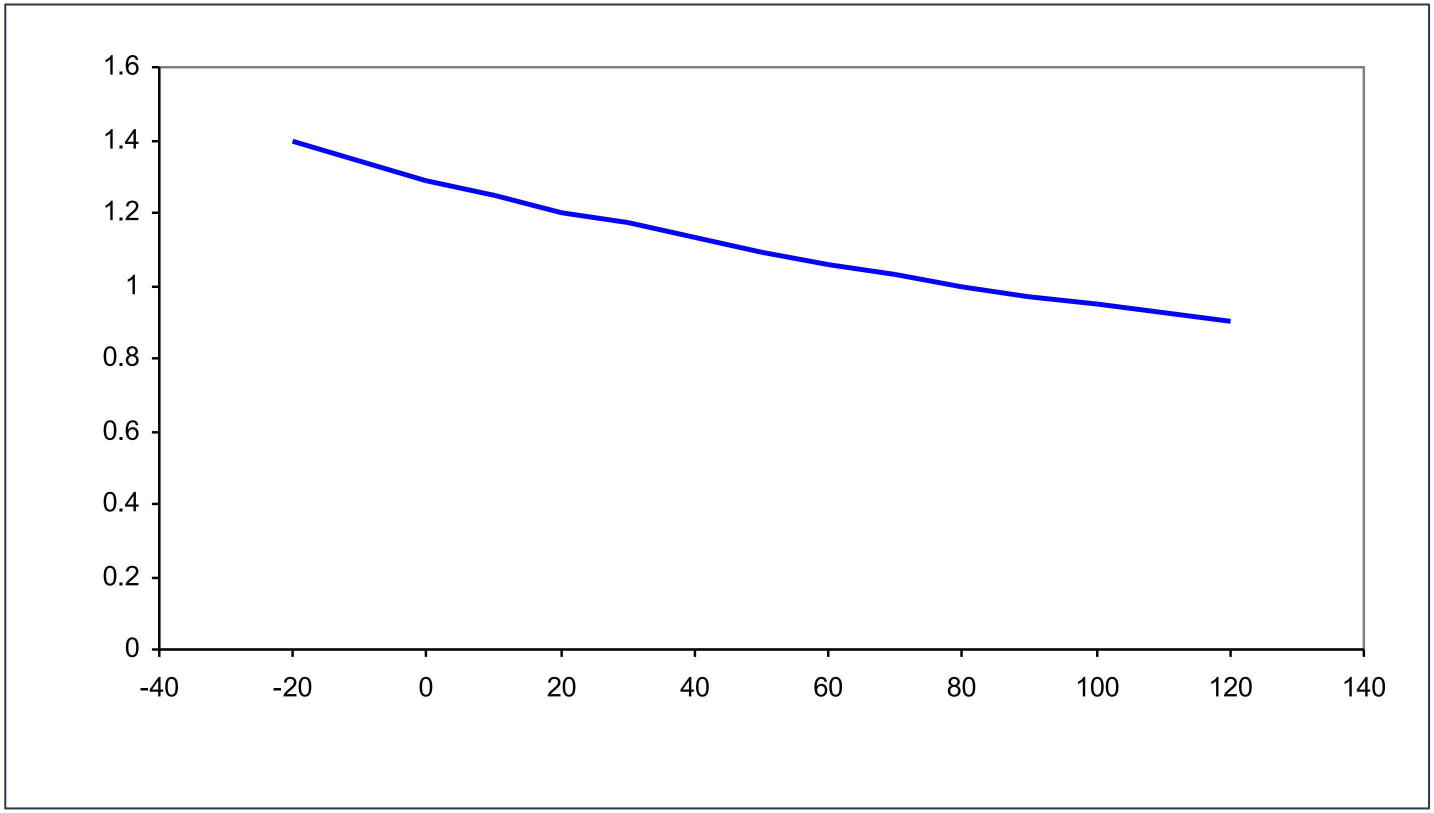
- Graphics can be used to communicate complex ideas with clarity, precision, and efficiency.
- Graphical displays should[3]
  - Show the data;
  - Avoid distorting what the data have to say;
  - Serve a clear purpose: description, exploration, tabulation, or decoration.
- Principles of information display
  - Dr. Edward R. Tufte books[3-5]
  - Tufte analyzes visuals displays of data to see which ones help the reader/viewer think through the problem or understand the results.



Guidelines for Using Graphics

- Keep every graphic as simple and uncluttered as the complexity of your data allows.
- Labels are a frame of reference, of orientation.
- Label each graphic clearly with a figure or table number and a title.
- Unless otherwise specified by the publication venue's guidelines,
  - place the figure number *below* the figure (graph, chart, etc.);
  - place the table number *above* the table.

What is missing?



Correct Example of Figure

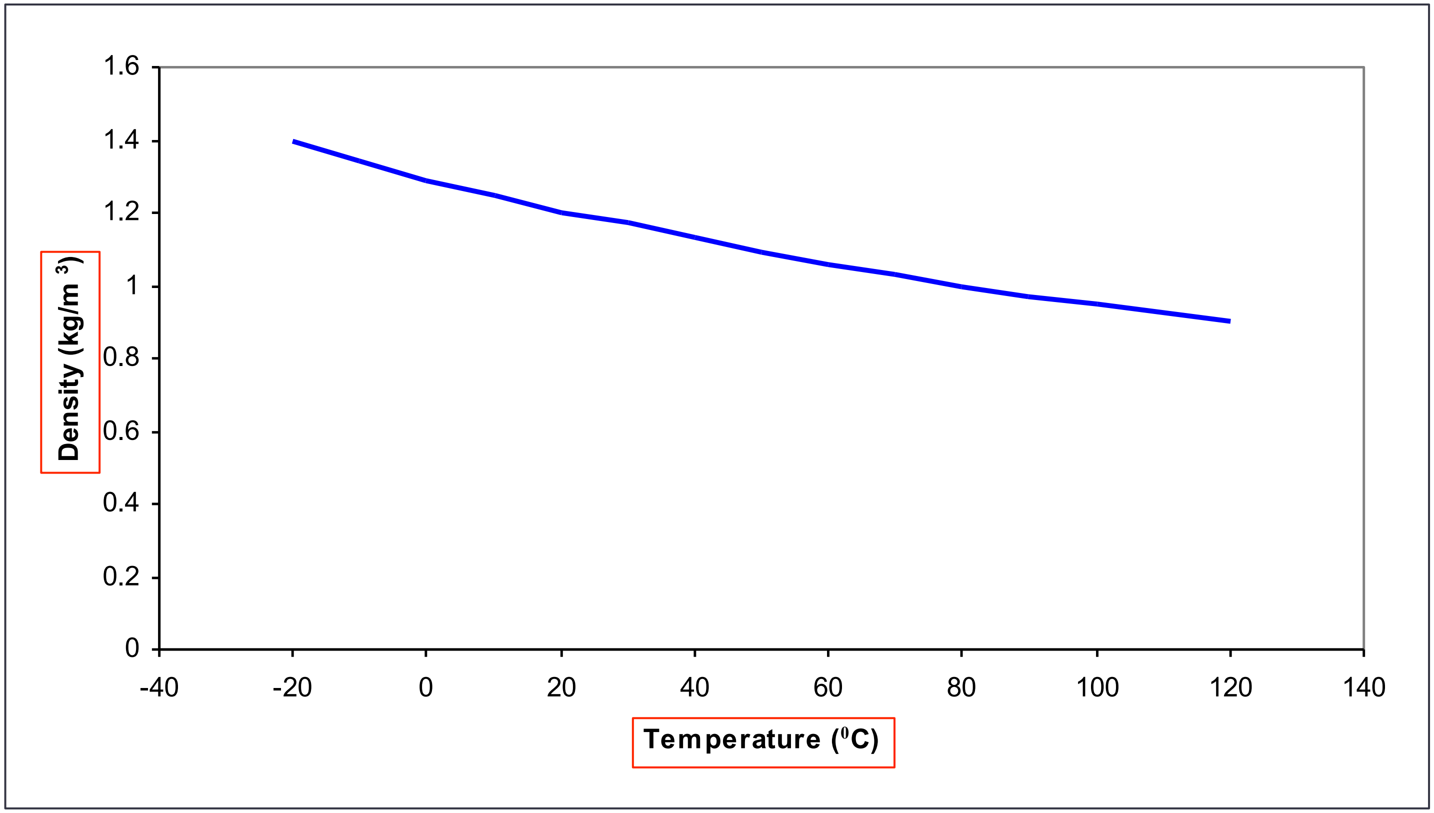


Figure 3. Relationship between density and temperature of air at standard atmospheric pressure. Source of data: Elger et al. (2001). *Engineering Fluid Mechanics*.

What is missing?

The table below shows examples of thermal expansion/shrinking coefficients.

Patching Material	**Thermal Coefficient**
(Target Property Values)	**(14)**
High Density Low Slump Concrete	7-20
Fiberglass jackets	Not Available
Latex Modified Concrete	13-23
Epoxy Resin-Concrete Composite	27-54
FRP Overlay	5.5

Correct Example of Table and Body Text

A low coefficient of thermal expansion indicates that the material will have minimal change in length given temperature fluctuations. Thermal coefficients for the patching materials are summarized in Table 4; as can be seen, FRP overlay has the lowest.

Table 4. Coefficients of Thermal Expansion/Shrinkage for Patching Materials

Patching Material	**Thermal Coefficient ($x10^{6}$ /°C)**
(Target Property Values)	**(14)**
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A Few More Guidelines

- Label both axes. These labels are NOT optional.
- Create a title (or a title and a caption) that draws attention to significant aspects of the graphic.
  - Give significant details either on the figure itself or in parentheses (or smaller type) after the title/caption.
- In the body of the document, make sure you do the following:
  - Describe everything graphed. For tables, explain column headings, at least.
  - Draw attention to important features of data. Try to include them in title too.
  - Describe conclusions drawn from the data. What's significant about those data or findings?
- Place graphic close to its discussion.

ACCENT Principles for Effective Graphical Display[6]

Apprehension:

Ability to correctly perceive relations among variables.
Does the graph maximize apprehension of the relations among variables?

Clarity:

Ability to visually distinguish all the elements of a graph.
Are the most important elements or relations visually most prominent?

Consistency:

Ability to interpret a graph based on similarity to previous graphs.
Are the elements, symbol shapes and colors consistent with their use in previous graphs?

Efficiency:

Ability to portray a possibly complex relation in as simple a way as possible.
Are the elements of the graph economically used?
Is the graph easy to interpret?

Necessity:

The need for the graph, and the graphical elements.
Is the graph a more useful way to represent the data than alternatives (table, text)?
Are all the graph elements necessary to convey the relations?

Truthfulness:

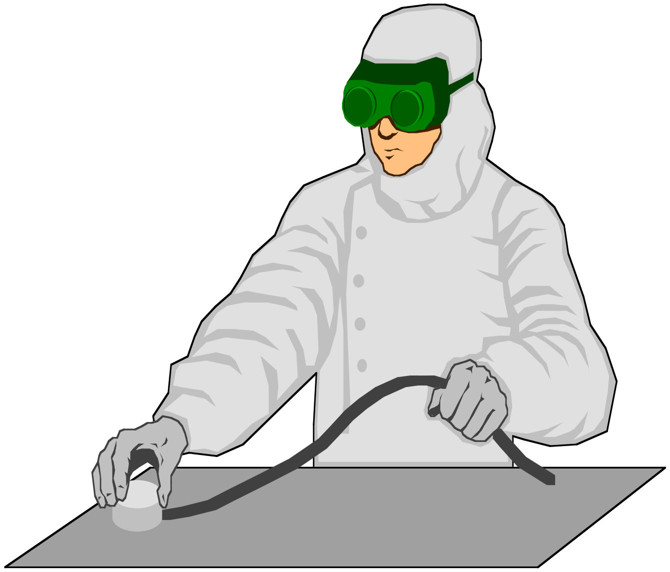
Ability to determine the true value represented by any graphical element by its magnitude relative to the implicit or explicit scale.

Are the graph elements accurately positioned and scaled?

COMMUNICATING RISK

Communicating Risk Information to Stakeholders

- Much technical information is about assessing and controlling risks.
- Public and other stakeholders are part of process of making decisions based on risk information.
- It is *no longer one-way* messages from experts to non-experts



Some Typical Stakeholders

- Government
  - federal, state, municipal regulators
- Scientists/engineers and subject-matter experts
- Environmental or worker-safety groups
- Geographical neighbors
- Community and civic organizations
- Educational organizations
- Business and professional associations

Seven Cardinal Rules of Risk Communication[7]

1. Accept and involve the public as a partner.
Your goal is to produce an informed public, not to defuse public concerns or replace actions.

2. Plan carefully and evaluate your efforts.
Different goals, audiences, and media require different actions.

3. Listen to the public's specific concerns.
People often care more about trust, credibility, competence, fairness, and empathy than about statistics and details.

4. Be honest, frank, and open.
Trust and credibility are difficult to obtain; once lost, they are almost impossible to regain.

5. Work with other credible sources.
Conflicts and disagreements among organizations make communication with the public much more difficult.

6. Meet the needs of the media.
The media are usually more interested in politics than risk, simplicity than complexity, danger than safety.

7. Speak clearly and with compassion.
Never let your efforts prevent your acknowledging the tragedy of an illness, injury, or death. People can understand risk information, but they may still not agree with you; some people will not be satisfied.

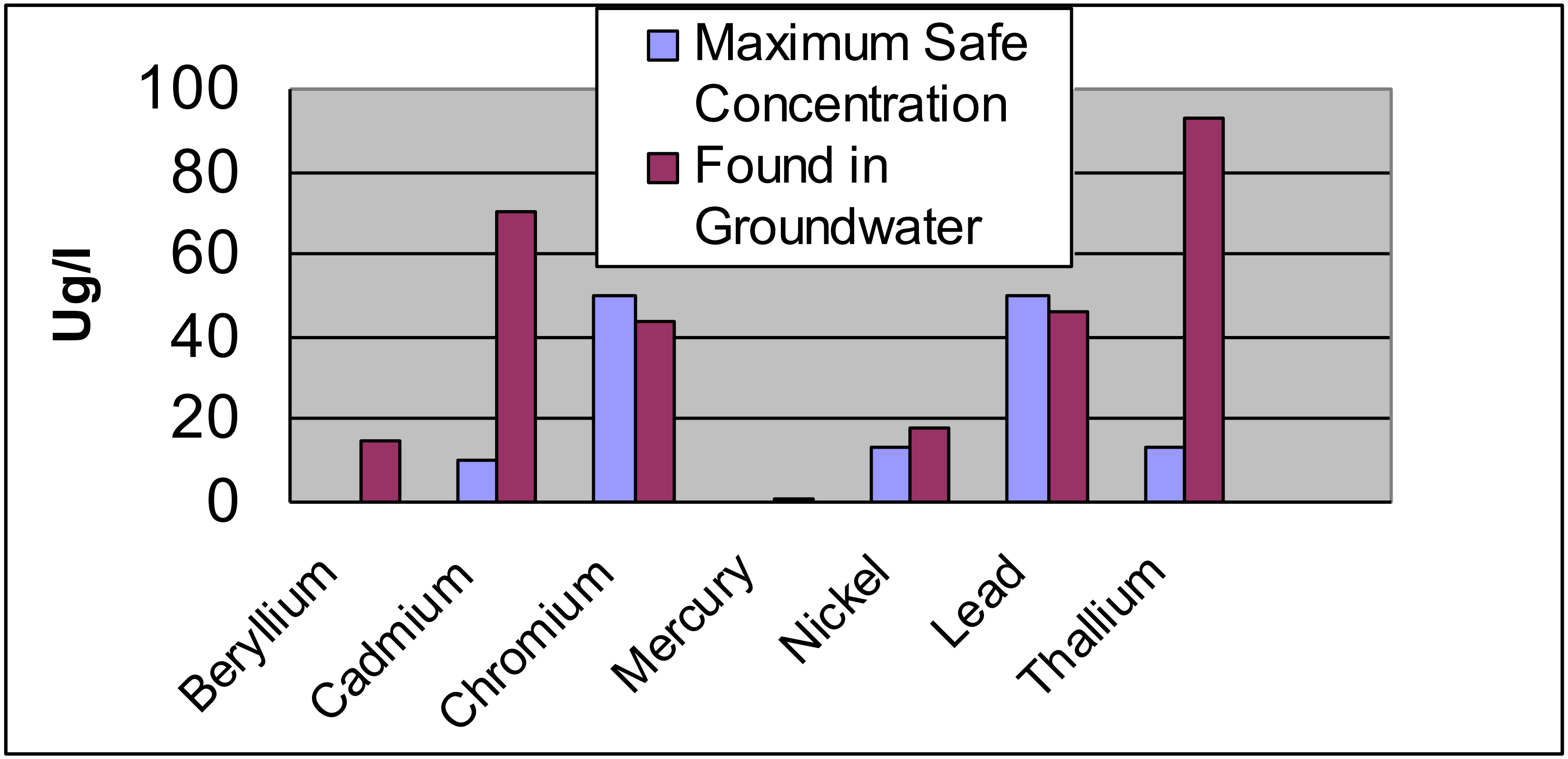
Presenting Numbers

Phenols and Metals:
Summary of Maximum Contaminant Concentrations and Human Health Criteria (all Units in Ug/l)

Chemical	Maximum Safe Concentration	Found in Ground Water
Phenols, Total	3,500	15,000
Metals		
Beryllium	0.037	15.0
Cadmium	10.000	70.0
Chromium	50.000	44.0
Mercury	0.144	0.4
Nickel	13.400	18.0
Lead	50.000	46.0
Thallium	13.000	93.0

- Even relatively simple tables are difficult to read and interpret.
- Bar charts are generally easier and faster to absorb.

Easier to Read Quickly



- See also references [8-9].

References

[1] Hart, H. (2006). *CE 389C: Advanced Engineering Communication*. **Lecture Notes**. Retrieved on April 26th, 2014, from: http://www.caee.utexas.edu/prof/hart/389c/gettingstarted.cfm

[2] Hart, H. (2008). *Engineering Communication*. Prentice Hall. Second Edition. New Jersey, USA.

[3] Tufte, E. R. (2001). *The Visual Display of Quantitative Information*. Graphics Press, LLC. Second Edition. Connecticut, USA.

[4] Tufte, E. R. (1990). *Envisioning Information*. Graphics Press, LLC. Connecticut, USA.

[5] Tufte, E. R. (1997). *Visual Explanations: Images and Quantities, Evidence and Narrative*. Graphics Press, LLC. Connecticut, USA.

[6] Burn, D. A. (1993). *Designing Effective Statistical Graphs*. In C. R. Rao, ed., **Handbook of Statistics**, Volume 9, Chapter 22.

[7] Covello, V. T.; & Allen, F. H. (1988). *Seven Cardinal Rules of Risk Communication*. U.S. **Environmental Protection Agency**. OPA-87-020. Washington, DC, USA.

[8] Chess, C.; Hance, B. J.; & Sandman, P. M. (1989). *Improving Dialogue with Communities: A Risk Communication Manual for Government*. Rutgers University. **Technical Report**. Retrieved on April 26th, 2014, from: http://hdl.rutgers.edu/1782.1/rucore00000002110.Document.000058820.

[9] Hance, B. J.; Chess, C.; & Sandman, P. M. (1990). *Industry Risk Communication Manual: Improving Dialogue with Communities*. CRC Press. Florida, USA.