LABORATORY ANALYST TRAINING IN THE 1990'S AND BEYOND

Roy-Keith Smith, PhD, Analytical Methods Manager
Analytical Services, Inc., 110 Technology Parkway, Norcross, Georgia 30092

INTRODUCTION

Within our industry there has been a proliferation of instant chemistry test kits. I refer to them as "pseudo-chemistry"" It takes no skill to generate numbers using these kits, I have taught my 8 year-old to use several. He is quite proud of his success, but I would never describe him as an analyst. He completely lacks any understanding of what he is doing or why. Although my example may be extreme, I think that many persons who work in laboratories in the United States can also be characterized as having little to no idea of what they are doing or why. It takes a lot of time and effort to learn all the skills necessary to be an expert laboratory analyst. The immense popularity of the test kits is a symptom of the shortage of trained analysts in our industry. Many people have an expectation of instant gratification, and the test kits provide both instant and gratification without any great expenditure of effort or time. Thus there is a very low level of professionalism in our industry.

Aside from the desire to raise the overall level of professionalism among laboratory analysts, there is also a legal necessity to have trained analysts perform tests in treatment plants and commercial laboratories. As described in a recent book[1] an important part of the foundation evidence used to support scientific evidence in court cases is demonstration and documentation of the level of training of the analyst. Much scientific evidence has been refused admission or severely tainted due to a lack of documented training of the "expert". A recent example is the photographic analyst who testified in the O.J. Simpson civil trial that the pictures of the shoes presented by the plaintiffs were faked. It was subsequently brought out in cross-examination that the "expert" had absolutely no training in photographic analysis and was probably a fraud himself. The same can and has happened in court cases where laboratory results are submitted as evidence. Imwinkelried's standard reference[2] lists and discusses six known weaknesses in analyst training as tempting targets for legal challenge. They are:

I . The witness is unqualified to vouch for the theory's validity
    Lack of understanding of the theory
    Lack of theoretical background
    Insufficient theoretical background
2. The witness is unqualified to vouch for the instrument's reliability
    Unfamiliarity with the instrument or technique
3. The witness was unqualified to maintain the equipment
4. The witness was unqualified to operate the equipment and conduct the test
    Whether a credential is required
    Whether the witness possesses the credential
5. The witness did not use proper test procedures in conducting the test
6. The witness is unqualified to interpret the test result

It is important to remember that any result generated from a municipal or commercial laboratory in support of NPDES compliance monitoring requirements, hazardous waste characterization, industrial pre-treatment monitoring verification[3], or any of the other myriad regulatory programs, has the potential of ending up in court, sometimes in criminal court where the evidentiary requirements are much more stringent. This implies that all analysts need to be trained if legal defensibility of data is to be maintained.

This article is broken into three parts. The first is a discussion of the skill areas that analyst needs to know to be successful. The second part discusses a training program that addresses and meets these goals. The third part describes documentation of the analyst training.

TRAINING GOALS

Before we can address the issue of how to train an analyst, we need to examine what an analyst needs to know to function in a safe and responsible fashion. First and foremost is a knowledge of chemistry laboratory technique. I remember when I was in college there was only about 30 or so of my fellow chemistry undergraduates but in the biology department three buildings down the street there were over 100 students in the biology program. I often wondered what biology majors did for a living if they didn't go on to graduate school. Well now I know - many of them go to work in analytical chemistry labs. Which is strange because none of them ever take analytical chemistry as a course, most stop chemistry classes after general and organic. Which is also not to imply that chemistry majors learn any great amount of laboratory technique in analytical chemistry. Most persons graduating from college science majors have at best a smattering of proper laboratory technique that they picked up by accident during their studies. It's definitely not due to any systematic training program in lab technique.

Second, a detailed knowledge of chemistry laboratory safety is absolutely necessary. Colleges and universities are notorious for having a complete lack of awareness of safety in their laboratories. Sure they comply with the fire regulations and provide extinguishers, blankets, showers and eye-washes, but that's about it. Most college research laboratories are accidents on the verge of occurring. The cavalier attitude toward chemical toxicity and other health hazards, and especially toward responsible disposal (pour it down the sink) is prevalent. These attitudes and practices have to he changed to bring analysts into compliance with OSHA and other regulations dealing with work place safety, chemical exposure, and proper waste disposal practices. There is also a distinct need to develop common sense in the analyst with regards to chemicals and laboratory equipment.

Third, a detailed knowledge of environmental regulations is needed. The analyst operates within a compliance monitoring framework and certain test methods are approved while others are not. The mere possession of the most recent copy of *Standard Methods for the Examination of Water and Wastewater,* will not satisfy regulatory needs. First, the most recent copy is probably not the approved edition for compliance monitoring methods, and second, not all the methods found in *Standard Methods* are approved for use. The analyst must be familiar with the *Code of Federal Regulations,* plus any State environmental regulations that govern the analyst's sphere of responsibility. The quickest way to have analytical results rejected as evidence in court cases is to use unapproved test methods to generate the data.

Fourth, an in-depth knowledge of the chemistry of the test is necessary. You can frequently recognize the untrained analyst when you hear the question, "is this step really necessary?" Persons writing test methods do not waste time and space by adding unnecessary steps to the procedure. Even though the chemist following the procedure may not know why each step is performed, they have enough trust and experience to recognize that each step is important to the successful generation of the result. On the other hand the analyst may find that the sample needing analysis is not completely amenable to the written test procedure and some modifications are necessary. Further, it is an advantage to know the chemistry of the test so that the analyst has an awareness of the limitations of the test. No test procedure works equally well for all samples and the analyst must know the symptoms that indicate when the test is not working. Learning to avoid or correct for test interferences is the hallmark of the expert chemist.

Fifth is a knowledge of the use and interpretation of quality control procedures. Without quality control there is no confidence in results. Quality controls are always part and parcel of every approved method. Knowledge of how to interpret the quality control results is needed to assist the analyst in making the determination of whether the test is working or not working for any particular sample. The knowledge of specific quality controls must also be accompanied by a knowledge of where they fit within the overall quality assurance program.

We can summarize these job knowledge goals as follows:

1. General laboratory technique
2. Safety and chemical hygiene
3. Regulatory requirements
4. Chemistry of specific test procedures
5. Quality control

TRAINING PROGRAM

When we consider training normally we have in mind a new employee, who we would have to make productive as soon as possible. It is not in our best interests to teach laboratory technique, then when that subject is finished move on to the next item on the list. We also can not sit the employee down in a class for one or two weeks, drill them with everything they need to even know, and then move them to the lab and expect them to remember or understand everything that was covered. Learning to be an analyst takes a long time and the most rewarding process occurs when the skills learned in the lab are supplemented with material discussed in the classroom.

Successful training can never be passive. The simple presentation of a block of information in a class is rarely sufficient by itself. It must be followed up with supervised practical application on the job and then the person receiving the training must be evaluated. Further, evaluation must be continued over the lifetime of the employee. This is especially true in the case of laboratory work, where overtime an analyst will introduce short-cuts in their work. Sometimes these short-cuts will introduce valuable savings in time and materials to the procedure, however the most common occurrence is that the quality of the work suffers. Periodic re-evaluation serves to identify when the product quality is deteriorating

We have taken the approach of tiered training. The levels can be characterized as introduction, development and maintenance. The introduction coexists of 8 hours of formal classroom lecture/demonstration that the new employee receives within the first 3 weeks of employment and on-the-job training by the immediate supervisor. The 8 hours of formal class contains 2 hours of chemical hygiene and safety training, 1 hour of radiation safety training, 3 hours of quality assurance training, 1 hour of LIMS orientation, and 1 hour of administration-personnel orientation.

The QA training is broken into three segments, one presented each of the first three weeks of employment. This allows the analyst to digest the information and integrate it into the on-the-job instruction they are receiving from their Section Supervisor. A lesson plan for the 3 hour QA training is presented in Table 1.

All employees are required to receive the complete introductory training regardless of job area. At the next level of training, the classes are more directed toward job function. Field service personnel take an OSHA and hazardous waste field sampling course, while all laboratory analysts participate in a 40 hour Analyst course. Georgia, as does a number of states, requires laboratory analyst licensing for persons performing drinking water or wastewater analysis. The licenses are obtained through written examination. The Analyst class is oriented toward helping employees pass the certification exams. A large number of references are used to develop and supplement the information presented. These are listed in Table 2. The topics of the Analyst class are chosen to present a wide variety of general chemistry knowledge (Table 3) that encompasses the subject range of the certification exams. The class is presented in one hour segments, with two classes a week during the lunch hour. The participants eat lunch and listen to the lecture. The whole course takes 20 weeks and at the end of the schedule, the class presentation cycles back to hour #1 and is repeated. The presentations are largely independent and analysts can join at any point of the schedule. Problem sets (homework) are frequently handed out and the answers discussed at the next meeting of the class.

Obviously, one hour of semivolatile organics class is not going to make an analyst proficient in the analysis of organic target analyses using a gas chromatograph or any other instrument or involved technique. For these job positions, the analyst will receive specialized training by either the manufacturer of the instrument or other person certified to present the training. Although it is sometimes advantageous to hold the training in-house, for the most part these courses require the analyst to travel to the manufacturer's site, particularly when extensive instrument hands-on instruction is involved. Examples of these courses include, basic and advanced Gas Chromatograph Operation and Maintenance, Gas Chromatograph-Mass Spectrometer Operation and Maintenance, Mass Spectral Interpretation, ICP-AES Operation and Maintenance, Atomic Absorption Spectrometer Operation and Maintenance, Microbiological Species Identification, Laboratory Data Evaluation, *etc.*

During the development training, and continuing on through their career, formal evaluations of the analyst are performed. Two key evaluations in Georgia are the State Certification examinations for drinking water laboratory analyst and wastewater laboratory analyst. The exams are administered under the authority of the Georgia State Board of Examiners for Certification of Water & Wastewater Treatment Plant Operators and Laboratory Analysts by LGR Examinations (Pennsylvania). The examinations that are used are drawn from the test bank of questions prepared and maintained by the Associated Boards of Certification (ABC). We require that all analysts pass at least one of the certification exams by the end of their first year of employment, with the second examination passed not later than the end of the second year.

A number of other states (California, Connecticut, Idaho, Kansas, Kentucky, Louisiana, Nevada, Ohio, and Pennsylvania) have voluntary or mandatory analyst certification that is performed through testing, and most use the ABC exams. For states and areas that are subject to limited or no state-sponsored testing, ABC currently offers administration of analyst exams to individuals through designated proctors. Both drinking water and wastewater laboratory exams are available. The wastewater analyst exams have four levels of difficulty:

Class I - Plant operators who perform process control tests: alkalinity, BOD, CBOD, chlorine, coliforms, color, DO, odor, oxygen uptake, pH, SDI, solids, turbidity, *etc.*

Class II - Intermediate level treatment plant laboratory analysts who perform regulatory monitoring and process control: Class I plus COD, conductivity, nitrogen, oil & grease, phosphorus, *etc.*

Class III - Advanced laboratory analysts in larger municipal or commercial labs: Class II plus bioassay, cyanide, inorganics, metals, organics, phenols, *etc.*

Class IV - Expert laboratory analysts/laboratory managers Class III plus detailed instrumental analysis - AA, ICP, GC, GC-MS, etc., and management skills

The Georgia certification exams are drawn from the Class II question bank. These serve as an excellent starting point for analyst evaluation. The higher classification exams can be used to measure analyst progress through later stages in their career. More information about the ABC exams can be obtained from the Executive Director of ABC[4].

There are no written examinations available that measure analyst skills outside of the drinking water or wastewater arenas[5]. Our experience has been, however, that the wastewater exams are an accurate measure of the analyst's general success in other areas of environmental analysis, with the single exception of knowledge of specific regulations. Part of the reason, I believe, lies in the compliance monitoring analytical requirements under the water and wastewater permitting programs are much more stringent than the requirements under other regulatory programs. It's easier to move from a very strict regimen of testing to a less stringent protocol, rather than *vice versa.*

Evaluations of the analyst's hands-on technical capability are separate from evaluations of the analyst's general knowledge,. but no less important. Initial demonstrations of ability (IDA) are method-specific evaluations of the ability of the analyst to perform a particular test, prior to any analysis of real-word samples. Many EPA test methods contain a detailed description of a required IDA. Normally it consists of analysis of 4 to 7 repetitions of a spiked reagent water sample, with the accuracy and precision of the replicate analysis compared to performance standards. Successful completion of a Method Detection Limit Study as described in 40 CFR 136, Appendix B, is an evaluation that is performed at least once a year for each test analyte for which the analyst is responsible.

Other important evaluations include performance audits of analyst success in following test procedures. A performance evaluation (PE) sample is a blind test of the analyst's ability to obtain an acceptable result on samples containing unknown concentrations of target analyses. The two most common PE Studies are the Water Supply (WS) and Water Pollution (WP) series administered by EPA. Both of these studies are conducted twice a year and cover metals, pesticide/PCB, volatile organics, and general chemistry parameters. Several commercial firms also provide PE samples that cover the entire range of environmental analyses and in a variety of matrices. PE samples serve as an excellent test of analyst capability and are frequently the first indicator that there are egregious problems in the way the analyst is following a test procedure.

Another form of performance audit is performed in conjunction with preparing and updating performance expectations (data quality objectives) for detection/reporting limits, accuracy, and precision. This evaluation reviews quality control results over a period of time and compares the results with either historical laboratory performance or with method specified performance.

Periodic system audits are valuable evaluations. System audits take many forms and may be conducted by either in-house Quality Assurance personnel or by visitors to the laboratory. Most state certification programs and many federal government programs require an on-site visit and audit as part of the certification or validation process. The visit may be conducted by a state or federal government employee, or the audit may be contracted out to a third-party accreditation organization. These audits from persons outside the laboratory are extremely valuable as an independent source of evaluation. Often we who work in the lab get so involved with day-to-day operations that we can't see the forest for the trees. Our objectiveness is further clouded by the personal relationships that exist in the lab, frequently leading to the decision that, "It's not really that big a deal and I don't want to hurt her feelings." Regardless of the feelings of the analyst, failure to follow prescribed procedures hurts the laboratory. Outside auditors are free from these personal relationships and can give a more objective evaluation.

System audits compare in detail what the analyst is doing on the bench with what is prescribed in the official approved method, the lab's Quality Assurance Manual and the appropriate standard operating procedure (SOP). An annual system review of the SOP by the analyst and the laboratory's most knowledgeable chemist is an excellent procedure. A system audit should always be triggered by an unacceptable result on a performance audit.

TRAINING DOCUMENTATION

As was discussed in the Introduction to this article, the training of an analyst is a necessary part of foundation evidence to support scientific evidence in court cases. Proof of the training is best supported through documentation to give credence to any testimony claiming proper training. This suggests that individual training records need to be maintained for each employee.

The file should contain a resume of the analyst that summarizes any technical formal training or experience that they had prior to being employed at your laboratory. A one page resume is often more than adequate and an example is illustrated in Figure I . If the analyst has attended or graduated from a university, a copy of the transcript is frequently useful.

It is necessary to document each class or course that the analyst attends while they are at your laboratory. If the course consists of more than one session, having a sign-in sheet is useful for keeping up with who has attended which session. Once a course of study is completed, the Training Manager issues a signed certificate. An example is illustrated in Figure 2. Necessary information on the certificate is the name, date and reference source for the course, the name of the student, and the name and dated signature of the instructor. For in-house courses, it is frequently beneficial to attach a copy of the lesson plan to the certificate in the file, especially if the record is to be admitted in a court case. For courses taken outside the laboratory, a copy of the training completion certificate should be placed in the file.

Evaluations also need to be documented. Passage of the certification exam is accompanied by issuance of a Certificate by the state certification board. A copy should be kept in the file. A copy of the license that goes along with the certification, and any subsequent renewals, should be kept in the training file.

Copies of completed IDA and MDL studies should be available in the training records. Acceptable results on PE samples should also be documented. We use the form illustrated in Figure 3 It has been suggested that a copy of the official report from the organization responsible for the PE sample be attached to the certificate in the training record file. This may or may not be useful.

Written reports of audits, regardless of whether internal or external, should be included in the training file. They should indicate by whom and when the audit was conducted, the findings of the audit, and recommendations to correct deficiencies. Most audits require a written response, and a copy of the response should be attached to the audit report. Any documentation that is produced as a corrective action to deficiencies should be copied and included.

There are a number of ways to keep these records. In some laboratories the personnel, technical training and safety training records may be kept together in a single folder. In other labs, where the personnel/finance, training, and chemical hygiene/safety functions are managed by different people at different locations, the three sets of records may be maintained separately. Regardless of where the records are stored, it is important to give the employee a copy of the record and to keep at least one copy for filing. When the training records are required to be produced in court, frequently it is a period of 3-6 years or more after the event of the analysis and often the employee is now working elsewhere. The necessity to prove that the analyst was trained and capable of doing the text procedure at the time the test was done still exists. Training record files are invaluable in this situation.

It is beneficial to the Training Manager to maintain tabular training summaries. These allow one to tell at a glance who has had what training. There are computer programs available that will accomplish this function. An example is "PC Compliance Training Tracker" available from J.J. Keller & Assoc. Other companies who produce comparable software include Achieve Technology, Eclipse, Envirowin Software, and Software Resources & Marketing. Hardcopy printouts of these training summaries are also useful in marketing efforts by the laboratory. Project proposals can be enhanced through inclusion of lists of employees who hold particular certifications such as OSHA field sampling or drinking water licensed analyst.

CONCLUSION

No one is born an expert analyst. Training is absolutely necessary to produce a knowledgeable, competent laboratory worker. I have described the program we have been using at Analytical Services for a number of years with some degree of success. Hopefully, with some situation specific modifications, this program will work equally well in your facility.

1. Berger, W., H. McCarty, and R.-K. Smith. Environmental Laboratory Data Evaluation. Genium Publishing, Schenectady, NY, 1996.
2. Imwinkelried, E.J. The Methods of Attacking Scientific Evidence, Second Edition. The Michie Company, Charlottesville, VA, 1992.
3. Industrial user inspection and sampling mutual for POTW's, EPA 831-B-94-001, 1994.
4 Dr. Stephen Ballou, ABC, 208 5th Street, Ames, Iowa 50010-6259, telephone number 515-232-3623.
5 ABC used to offer an Environmental Laboratory Analyst exam but it is no longer available.

Table 1. Introduction to Quality Assurance lesson plan

Subject	Informational Objective and Method
Definitions of QA & QC	Quality assurance and quality control are defined.
Analytical validity and legal defensibility	Definitions and how ASI accomplishes the two requirements of environmental regulatory analysis are described. The legal accountability of each analyst for their work is described. Personal responsibility is stressed.
ASI QA Manual	The purpose, use and frequency of updates of the QA Manual are described.
SOPs	How SOPs are written and updated are described. The format and authority of the QP is described. The frequency of update is described.
Approved methods	The 4 types of regulatory analysis performed at ASI (Drinking water, wastewater, RCRA and USACE) and location of the approved methods are discussed along with role of CFR and other regulatory documents.
Holding times	Definition of holding time, how to calculate and location of holding time lists in the ASI QA Manual and other regulatory sources.
Preservatives	Definition of preservatives and location of preservative lists in the ASI QA Manual and other regulatory sources.
Containers	Location of container lists in the ASI QA Manual and other regulatory sources.
Accuracy and Precision	Terms are defined, target analogy and mathematical methods of quantitation are presented.
Batch QC	The idea behind batch QC is described and the requirements for it's implementation is illustrated.
Control charts	The company policy and daily up-dating of control charts is described. How limits are established and the frequency of adjustment is described.
MDL	Mean and standard deviation are defined and illustrated along with normal distribution. MDL is defined and EPA method of determination is presented.
Significant figures	Dlscussion of implied ±1 error in last place, ASI standard of no more than 3 significant figure reporting, how measurement with least significant figures affects final reporting significant figures quantitation limit effect.
Error correction	Demonstration of approved method for correcting errors in analytical records such as benchsheets by drawing a single line through the error, annotation with initials and date and addition of corrected data.
Unit conversions	ppt, ppb, ppm and % defined and related to µg/L, mg/L, µg/kg and mg/kg. Interconversions are presented. Air reporting units.
Volumetric glassware	Definition of Class A volumetric glassware and recognition of what is not volumetric glassware such as Erlenmeyer flasks and beakers.
Volumetric pipets	Definition and demonstration of correct use of TD and TC volumetric pipets.
Volumetric calibration	Discussion of method of calibration of non-Class A volumetric devices with water and inclusion of temperature correction for water density. Required documentation and frequency of procedure is discussed.
Representative samples	Discussion and demonstration of methods for obtaining a representative sample from a container. Separation of layers and mathematical combination of results is described.
Dilution factors	Discussion of dilution equation, C1xV1 = C2xV2.
Percent moisture	Percent moisture and percent solids are defined, method of determination explained and example of dry weight reporting worked through.
PE samples	Importance of PE sample success is discussed along with internal records and reports.
Analyst Certification	Reasons, requirements and forms are discussed.

Organizational Chart	Chain of command and laboratory management structure.
Client Contracts	Role of Project Managers.
Flow of work	How samples are received, logged-in and processed. How data is entered into LIMS and turned into a final report.
Record Keeping	Retaining and storage of records. Need for authentication of records.
Bar-code system	Need and use of internal chain-of-custody, recording supplyroom withdraws.
Building security	Custody and security of samples and building, wearing name badges, escorting visitors.

Table 2. References and Study Materials used in the Analyst Class

1	Laboratory Procedures and Chemistry, Chapter 16, *Operation of Wastewater Treatment Plants,* Volume 2, 1991. California State University, Office of Water Programs.
2	*Standard Methods for the Examination Water and Wastewater,* current edition, WEF, AWWA, and APHA.
3	Smith, R.-K., 1997. *Handbook of Environmental Analysis,* 3rd Edition, Genium Publishing, Schenectady, NY.
4	*Methods for Chemical Analysis of Water and Wastes,* USEPA 1983.
5	Title 40, *Code of Federal Regulations,* Parts 100-149, US Government Printing Office, current year's edition.
6	Smith, R.-K., 1995. *Water and Wastewater Laboratory Techniques,* WEF, Alexandria VA.
7	*Handbook for Analytical Quality Control in Water and Wastewater Laboratories,* USEPA 1979.
8	*Manual for the Certification of Laboratories Analyzing Drinking Water,* USEPA, current edition.
9	Laboratory Procedures, Chapter 11, and Advanced Laboratory Procedures, Chapter 21, *Water Treatment Plant Operation,* California State University, Office of Water Programs, 1993.
10	Berger, W., H. McCarty, and R.-K. Smith, 1996. *Environmental Laboratoy Data Evaluation,* Genium Publishing, Schenectady, NY.
11	Any first year college general chemistry textbook.

Table 3. Analyst Class Schedule

Hour	Topic
1	Molecular formulas and names of chemicals, Part 1
2	Molecular formulas and names of chemicals, Part 2
3	Molarity, solutions and dilutions
4	Stoichiometry and calculations, Part 1
5	Stoichiometry and calculations, Part 2
6	Chlorine chemistry and analysis, Part 1
7	Chlorine chemistry and analysis, Part 2
8	Chloride and Fluoride analysis
9	Nitrate, nitrite, TKN and ammonia analysis, Part 1
10	Nitrate, nitrite, TKN and ammonia analysis, Part 2
11	DO, BOD and COD, Part 1
12	DO, BOD and COD, Part 2
13	Fecal and total Coliform, Part 1
14	Fecal and total Coliform, Part 2
15	Regulatory programs
16	Sample receipt, Chain-of-Custody and LIMS
17	Sampling, holding times, containers and preservatives
18	Accuracy, precision and MDLs (DQO)
19	Regulatory reporting levels (NPDES and SDWA)
20	Reagents standards and lab water (Specific gravity)
21	Calibrations
22	Glassware and volumetric ware
23	Temperature measurement and conductivity
24	Solids, Part 1
25	Solids, Part 2
26	Phosphorus
27	Sulfate, sulfite and sulfide
28	Metals
29	Volatile organics
30	Semivolatile organics
31	Turbidity and colorimetric measurement
32	Color
33	Odor and taste
34	Oil and grease and TPH
35	Surfactants
36	Cyanide
37	pH, alkalinity and hardness, Part 1
38	pH, alkalinity and hardness, Part 2
39	pH, alkalinity and hardness, Part 3
40	Jar test

Name: Roy-Keith Smith, PhD	
Position: Anlalytical Methods Manager Quality Assurance Manager	Date Began: 1 March, 1992
Education:	
High School: East Greenwich HS, East Greenwich RI	
College. Georgia Institute of Technology Degree: BS Chemistry, 1976	
College: Colorado State University Degree. Ph. D. Chemistry, 1981	
College: California Institute of Technology Research Faculty in Chemistry 1981-1982	
Technical Schools:	
Year: 1987	Course: Finnegan OWA 1020 GC-MS Operation, MS Interpretation
Year: 1990	Course: GA Right to Know Hazardous Chemical Supervisor
Year: 1992	Course: H-P MS-DOS GC/MS, UNIX, and Target analysis
Year: 1992	Course: all H-P GC and Cap. Column courses
Year: 1992	Course: TJA ICP-AES Operation
Seminars Attended: EPA Annual Technical Conference 1992, 1993, 1994, 1995, 1996; EPA WTQA 1992, 1993, 1994, 1995, 1996; PittCon 1991, 1995, 1997; and many others	
Work Experience:	
Last Position: Assistant Professor of Environmental Chemistry	Company: Southern College of Technology Dates: Jan 1990 - Jun 1992
Position: Laboratory Manager	Company: Southeast Laboratories Dates: Oct 1989 - Dec 1989
Position: Senior Scientist	Company: GA Dept. Agriculture Dates: Mar, 1985 to Oct 1989
Current Job Skills: Thorough knowledge of QA/QC and EPA, NIOSH and misc. analytical methods for analysis of pollutants in air, water, and solids by LC, GC, GC-MS, AA, Furnace AA, ICP, spectroscopic methods and wet chemistry. Responsible for laboratory certifications, regulatory agency contact, QA program development and management, and Analyst Training	
Certifications: State of Georgia Licensed Water Laboratory Analyst and State of Georgia Licensed Wastewater Laboratory Analyst	
Courses Presented: Environmental Analysis (Southern Institute of Technology), 5890 GC Operation and Maintenance (H-P), Environmental Laboratory Data Evaluation (ASI), and many others	
Publications. 43 articles and books in peer-reviewed and trade publications including: *Handbook Environmental Analysis,* ISBN 0-931690-55-2, Genium Publishing, Schenectady NY, 1993: *Handbook of Environmental Analysis,* Second Edition, ISBN 0-931690-77-3, Genium Publishing, Schenectady NY, 1995: *Water and Wastewater Laboratory Techniques,* ISBN 1-57278-014-2, Water Environment Federation, Alexandria VA, 1995: *Environmental Laboratory Data Evaluation,* ISBN 0-931690-91-9, Genium Publishing, Schenectady, NY 1996	
Other lnformation: Listed in *Who's Who Environmental Registry.* Consultant for chemistry and GC courses to the Analytical Education Center, Hewlett-Packard, Inc., Part Coordinator for Part 4000, *Standard Methods for the Examination of Water and Wastewater;* educational consultant and instructor for Georgia Water and Wastewater Institute; recipient of WEF/GWPCA Laboratory Analyst Excellence Award 1994; Chair, Education and Training Subcommittee, Lab Practices Committee, WEF	

Figure 1. Example of a Technical Training/Experience resume.

ASI

ANALYTICAL SERVICES, INC.

ENVIRONMENTAL MONITORING & LABORATORY ANALYSIS
110 TECHNOLOGY PARKWAY • NORCROSS, GA 30092
(770) 734-4200 • FAX (770) 734-4201

RECORD OF TRAINING

Name:	Homer Simpson
Date(s):	8 July, 1996
Training Subject:	Introduction to Quality Assurance Procedures, Part I
Reference:	*Handbook of Environmental Analysis*, 2nd Edition
Number of Hours:	1.0
Instructor(s):	Roy-Keith Smith, Ph.D.
Instructor's Signature:	
Date:	15 July 1996

Figure 2. Example of an in-house certificate of training.

ASI

ANALYTICAL SERVICES, INC.

ENVIRONMENTAL MONITORING & LABORATORY ANALYSIS
110 TECHNOLOGY • NORCROSS, GA 30092
(770) 734-4200 • FAX (770) 734-4201

RECORD OF PE SAMPLE SUCCESS

Name:	Jean Zheng
Date(s):	December, 1996
PE Sample:	USACE validation check sample
Analytes:	Explosives in soil and water (8330m)
QA Manager:	Dr. Roy-Keith Smith
Signature:	
Date:	22 January, 1997
Comment:	

Figure 3. Record of Acceptable Results on PE samples.