EVALUATION OF A SMALL SUBURBAN HIGH SCHOOL REGARDING ITS ABILITY TO IMPLEMENT THE PRINCIPLES OF GREEN CHEMISTRY IN THEIR SCIENCE CLASSES

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION

NEW YORK STATE OF OPPORTUNITY. | Department of Environmental Conservation

ACKNOWLEDGEMENTS:

United States Environmental Protection Agency (EPA), Region 2 -In appreciation to EPA Region 2 for the grant funding, supporting New York State DEC's green chemistry in schools program. A word of thanks to Walter Schoepf, Environmental Scientist for EPA Region 2's Pollution Prevention Team, to recognize of his support and guidance to DEC's green chemistry in NYS schools program, as well as his presentation and attendance at DEC's Capital District and NYC green chemistry workshops.

New York State Education Department (SED) -In appreciation to Will Jaacks, Associate in Science Education in the SED Office of Curriculum, Instruction and Instructional Technology, for all of his assistance and time in providing feedback at monthly meetings with DEC and hours devoted to reviewing documents related to the DEC green chemistry in NYS schools program and presenting at the Capital District DEC green chemistry workshop.

Beyond Benign -In appreciation to Dr. Amy Cannon, Co-Founder and Executive Director of Beyond Benign and Kate Anderson, Director of K-12 Education for Beyond Benign, for the excellence of their green chemistry presentations and labs at the four DEC green chemistry workshops in the Hudson Valley, Capital District, Long Island and NYC areas of New York State.

Capital Region BOCES - A word of thanks to Kristin Buccifero and Cynthia Holmes, Health, Safety, Risk Management Services coordinators for the Capital Region, for their assistance with the chemical inventory and cleanout at Schalmont High School, and for their outreach efforts to their component school districts to promote DEC's green chemistry workshop at Siena College.

Siena College -In appreciation to Siena College's Chemistry Department's Dr. Lucas Tucker and Ann Klotz for facilitating DEC access to the college's laboratory facilities and lecture rooms and their assistance at DEC's Capital District's green chemistry workshop.

A special word of thanks to all the teachers and administrators at Schalmont High School who agreed to take part in DEC's green chemistry for NYS schools program as their region's green chemistry candidate school and with their commitment to adopt the principles of green chemistry in their classroom labs.

Schalmont High School- Principal Terence Nash, and Chemistry teachers: Adam Labuda, Rose Hochmuth and Lynn Gemmiti.

Disclaimer:

Although the information in this document has been funded wholly or in part by the United States Environmental Protection Agency under grant #NP96296412 to the New York State Department of Environmental Conservation, it has not gone through the Agency's publication review process and, therefore, may not necessarily reflect the views of the Agency and no official endorsements should be inferred.

TABLE OF CONTENTS:

ABSTRACT.....3

INTRODUCTION.....3

STEP ONE-SITE INVESTIGATION AND ANALYSIS.....4

RESULTS OF THE CHEMICAL INVENTORY.....4

RESULTS OF CHEMICAL STORAGE REORGANIZATION.....5

STEP TWO-ACCEPTANCE AND COMMITMENT.....7

STEP THREE-TRAINING.....8

RESULTS OF GREEN CHEMISTRY WORKSHOP.....9

STEP FOUR-IMPLMENTATION OF GREEN CHEMISTRY IN THE CLASSROOM.....11

OVERALL SUMMARY AND CONCLUSION.....15

ADDITIONAL GREEN CHEMISTRY RESOURCES.....17

REFERENCES.....18

"Evaluation of a suburban school district regarding its ability to implement the principles of green chemistry in their science classes"

ABSTRACT

The primary goal of the grant program, "Pollution Prevention Practices at NYS Schools with a focus on Green Chemistry", is to promote green chemistry and proper chemical management in schools. A secondary goal is to provide insights to stakeholder groups of the benefits of green chemistry and to provide evidence of these benefits, in terms of toxicity reductions and cost savings, which can be achieved through chemical management and green chemistry. The objective of the individual case studies is to determine whether or not the chosen school has the capability and commitment to implement the principles of green chemistry in their school. It is evident that the overall objectives of the grant program as well as the objectives of the individual case studies have been met. As a result of this grant program, the principles of green chemistry have been advanced, stakeholder groups have been made aware of the benefits of green chemistry through toxicity reduction and cost savings and green chemistry principles have been implemented in high school chemistry classes.

INTRODUCTION

The goal of this case study is to ascertain whether or not Schalmont High School can benefit from proper chemical management and the implementation of the principles of green chemistry. Additionally, a function of this study will be to provide evidence of the benefits, in terms of toxicity reduction and cost savings that can be achieved through chemical management. The results of the case study will also be used to illustrate the benefits of partnerships between tertiary level educators and their institutions, as well as teachers in the secondary school system. It is anticipated that the case studies can be used as educational tools to illustrate the benefits of proper chemical management and green chemistry to key stakeholder groups.

Schalmont High School is a suburban school district with an average needs to resource ratio, as categorized by the New York State Education Department (SED) school report card. It is located in the Town of Rotterdam in Schenectady County. The district has approximately 669 students in grades 9-12 with an average of 175 students per grade. The school offers a variety of science courses at the high school level (9-12) including Honors Chemistry.

The study was undertaken in steps: The first step was an evaluation of the need for assistance which includes a site investigation by New York State Department of Environmental Conservation (DEC), Toxic Reductions & Green Chemistry (TRGC)' staff, to determine if the school was a viable green chemistry candidate. The second step included a commitment by school administration and staff to take the necessary steps to implement the principles of green chemistry for one calendar school year in their chemistry classes. The third step included completing green chemistry training conducted by TRGC staff and Beyond Benign, a non-profit organization contracted by DEC. The fourth and final step was having the candidate school report back to TRGC on their teaching results after implementing the principles of green chemistry in their high school classes.

This project was funded by a grant from the United States Environmental Protection Agency, Region 2, (USEPA), administered by the Division of Materials Management's Toxic Reduction and Green Chemistry Section of the DEC.

STEP ONE – SITE INVESTIGATION AND ANALYSIS

On September 13, 2011, DEC staff conducted a preliminary visit at Schalmont High School to determine the scope of chemical usage, storage practices, and purchasing practices, and also to gauge interest by the school personnel in participating in this case study. There are two regulations, which impact science areas in schools. One regulation comes from the State Education Department (SED). SED law requirements specify locked and secure chemical storage rooms and cabinets. In addition, chemical inventories must be updated at least annually and kept in a secure location. The other is regulation is from the Occupational Safety & Health Administration (OSHA)'s "Laboratory Standard 29 CFR 1910.140", where the authority has been delegated to the New York State Department of Labor under a state plan. This is a more comprehensive regulation, which seeks to reduce significant risks associated with hazardous chemical exposure in a manner appropriate to laboratories. The goal of this project was not to try to enforce the OSHA laboratory standard or any regulation under the NYS Department of Labor.

Schalmont High School did not have an up-to-date chemical inventory in any format; the most current was dated 2007. They also lacked a current inventory that could be easily referenced. The school had one main chemical storage area and a significantly smaller chemical inventory, for use by the living environment class, in another storage area. The chemicals were segregated and kept in large double-door wooden cabinets, with appropriate storage for acids, bases and flammables. After a cursory review of the chemical storage area, TRGC staff concluded that the chemical inventory appeared to be disproportionately large for a school of this size.

The next step in the process required that a thorough analysis of the chemical inventory be performed by TRGC staff to identify those items considered to be highly toxic in accordance with the Material Safety Data Sheet (MSDS). In order to determine the chemicals that were required for green chemistry, TRGC staff matched the current Beyond Benign green chemistry experiments to SED Science Learning Standards and Core Curriculum. SED regulations require that students who wish to take a Regents examination in any of the sciences must complete the course study leading up to that particular Regents examination and complete 1,200 minutes of hands-on (not simulated) laboratory experiments with satisfactory documented laboratory reports. Beyond Benign's green chemistry curriculum can provide at least 1,000 of the required 1,200 minutes for a course designed to culminate in the Regent's examination in Physical Setting/Chemistry Core Curriculum.

RESULTS OF THE CHEMICAL INVENTORY

TRGC' staff began the process by creating a working inventory with the assistance of the chemistry teachers from the school. Working alongside the teachers in a one-on-one setting, each chemical container was analyzed for integrity, proper storage and safety, usefulness to the current chemistry curricula, and

usefulness to a green chemistry curriculum. The containers that were deemed to be in poor condition or not useful to the current or future needs of the chemistry curriculum were set aside for future disposal.

As TRGC' staff progressed through the inventory, chemicals were segregated based upon their disposal requirements. The individual bottles of chemicals and solutions were inventoried but there were a number of chemicals in kit form, some of them in less than stable conditions. One was obviously polymerized possibly due to the heat and lack of air circulation in the storage area. Because the kits were shrink –kits-wrapped and kept on a shelf near the ceiling, it was impossible to tell what the kits contained. Some dated back to 1995. While chemistry activities provided in kit form provide an easy way for teachers to conduct lesson plans, they often have chemicals of mixed storage requirements within each shrink-wrapped packet. It is not uncommon for solvents and reagents to be stored side-by-side. For optimum safety and security, it was recommended that these kits should be opened up and the individual chemicals stored properly.

The results of the inventory indicated that a large supply of chemicals were on hand due to years of chemical acquisitions without maintaining an annual chemical inventory.

RESULTS OF CHEMICAL STORAGE REORGANIZATION

Of the original 958.2 lbs of chemicals inventoried, 833.2 lbs were classified as toxic, meaning that 87% of the initial inventory was toxic. The results can be seen in **Table 1. - Chemicals by Hazard Type**. Toxicity information is found on chemical MSDS sheets and formed the basis of this analysis.

Table 1

Chemicals by Hazard Type			
	Nov-11	Dec-11	**% change**
Storage class	**lbs**	**lbs**	
Blue (Health Hazard)	19.9	4.1	**79.6**
Red (Flammable)	374.0	85.1	**77.2**
Green (General Storage)	325.2	229.4	**29.4**
Yellow (Oxidizers)	52.2	21.2	**59.4**
White (Corrosives)	186.9	126.5	**32.3**
Totals	**958.2**	**466.3**	**51.3**

The chemical inventory and reorganization effort resulted in a reduction of 51% in chemicals bu hazard type, a decrease from 958.2 lbs to 466.3 lbs. In addition, the quantity of highly toxic chemicals was reduced by 61%. The results can be seen in **Table 2- Chemical Inventory by Toxicity and Table 3- Hazardous/Highly-Toxic Chemicals**.

Table 2

Chemical Inventory by Toxicity					
Category	# Inventory items Nov-2011	lbs	# Inventory items Dec-2011	lbs	**% reduction**
Known Carcinogen	5	1.9	2	1.3	**31.6**
Possible Carcinogen (2B)	14	4.6	5	0.7	**84.8**
Very Hazardous to Health	22	55.4	19	50.8	**8.3**
Hazardous to Health	123	670.4	96	207.1	**69.1**
Severe Irritant	7	7.9	7	7.9	**0.0**
Irritant	42	93.0	32	53.5	**42.5**
total	213	**833.2**	161	**321.3**	**61.4**
total highly-toxic chemical reduction				**511.9 lbs**	

Throughout the chemical inventory and reorganization effort, the chemistry teachers were given the opportunity to keep chemicals based on a "one year plan." Chemicals that are used throughout the following school year are marked by affixing a colored dot to the bottle. If, at the end of the school year, the bottle does not have a colored dot, then it should be tagged for disposal.

Table 3

Hazardous/Highly-Toxic Chemicals					
School	# Inventory items pre assesment	lbs	# inventory items post assessment	lbs	% reduction
Schalmont	213	833.2	161	321.3	61.4
total hazardous/highly toxic chemical reduction				**511.9 lbs.**	

In addition to the reduction in toxic chemicals, 50.6 lbs. of relative less-toxic chemicals were recommended for disposal. The results can be seen in **Table 4- Schalmont High School Relative Less -Toxic Chemicals and Table 5-Relative Less -Toxic Chemicals Recommended for Disposal.**

Table-4

Schalmont High School Relative Less-Toxic Chemicals				
#Inventory Items November 2011	lbs	# Inventory Items December 2011	lbs	% reduction
218	160.5	167	109.9	31.5
Total Relative Less-Toxic Chemicals Reduced			**50.6 lbs**	

Table-5

Relative Less-Toxic Chemicals Recommended for Disposal						
School	# Inventory items pre assessment	lbs	# Inventory items post assessment	lbs	lbs of chemicals recommended for disposal	**% reduction**
Schalmont HS	218	160.5	167	109.9	50.6	31.5
lbs of relative less-toxic chemicals recommended for disposal				**50.6 lbs**		

TRGC staff was able to recommend significant improvements to the existing chemical management system by reducing the number and quantity of toxic chemicals. The chemical inventory and reorganization effort resulted in a 57% decrease of total chemicals in stock, a decrease from 993.7 lbs. to 431.2 lbs. In addition, acutely toxic chemicals in storage were reduced by almost 20%. The quantity of possible carcinogens was reduced by 70%. The known carcinogens and possible carcinogens that remain are comprised of lead compounds, lead strips, and potassium dichromate; all compounds that the teachers still use in some of their experiments. TRGC staff explained to the teachers the toxicity associated with using these materials, but the teachers wanted to keep them.

As the teachers adapt to a changing science curriculum which will include more green chemistry and fewer toxics, they will see further reductions in their chemical inventory.

STEP TWO-ACCEPTANCE AND COMMITMENT

Upon hearing and reviewing the results of the initial assessment by TRGC staff, with a thorough explanation of the benefits of the program, Schalmont High School administrative staff and faculty expressed their commitment, for one calendar school year, to take the steps necessary to implement the principles of green chemistry in their chemistry experiments.

STEP THREE-TRAINING

Chemical Hygiene Training

On April 25, 2012, DEC staff traveled to Schalmont High School to offer a 40 minute presentation on the general guidelines of the Occupational Safety and Health Administration (OSHA) laboratory standards and their applicability to the three chemistry teachers, four additional science teachers and the school principal.

The presentation highlighted the importance of a chemical hygiene officer, who that person must be (an employee of the school district), and what the chemical hygiene plan must include. The school has a current chemical hygiene plan, which was not provided to DEC staff before the presentation, but was provided to TRGC for review at a later date. TRGC concluded that Schalmont High School had a good chemical hygiene plan.

As a result of the chemical inventory, reorganization and chemical hygiene training, the chemistry teachers at Schalmont High School now have the tools to move forward with the implementation of green chemistry in the classroom.

Teachers from the Capital District working at green chemistry lab "stations" during the DEC Green Chemistry Workshop

Green Chemistry Training

The purpose of the green chemistry workshop was to offer training to high school teachers on how to infuse the principles of green chemistry into a traditional high school level curriculum.

For this workshop, a green chemistry laboratory booklet was created by Beyond Benign staff, replacing traditional laboratory activities that use and teach techniques and materials that are hazardous to human health and the environment with more benign chemicals and procedures.

Green Chemistry Labs provided by Beyond Benign for workshop:

- **Essential Oil Extraction Using Liquid CO2**
- **Le Chatelier's Principle/ Equilibrium**
- **Solubility**
- **Sublimation**
- **SeaNine 211 (Toxicity & Serial Dilution Lab)**
- **Exothermic & Endothermic**
- **Reactions Lab**

Schalmont High School chemistry teachers took part in the DEC green chemistry workshop offered to high school science teachers in the Capital District on January 20, 2012, at Siena College, in Loudonville, New York.

Siena College was chosen as the site for DEC's second green chemistry workshop as it is one of the few institutions of higher learning in the state that offers green chemistry coursework. Siena's chemistry department has been successfully replacing conventional chemistry experiments with equivalent green chemistry experiments,

to increase student safety and decrease environmental hazards. In addition, given DEC's difficulty in coordinating logistics, time and securing adequate lab space to conduct the workshop in a high school setting, it was decided that future workshops should be held at institutions of higher education.

Colleges/Universities generally have larger laboratory facilities and there is greater flexibility of finding a time and date when a laboratory is available. TRGC staff also felt that a tertiary educational institutional setting could serve to illustrate to the teachers the importance for their students to learn green chemistry at the high school level as they move on to higher education, especially if that institution has a green chemistry program.

Workshop Attendance:

A total of 50 people attended the workshop, with 32 high school science teachers representing eight counties located in the Capital District and the Hudson Valley regions of the state as illustrated in Table-6. (See page 8)

RESULTS FROM THE GREEN CHEMISTRY WORKSHOP

An overwhelming consensus expressed by workshop participants about what they liked most was the "hands on" green chemistry laboratory stations that were set up around the classroom. Many of the teachers said that they will be using the green chemistry experiments in their classes after the workshop.

The workshop participants indicated that they liked the ability to network and discuss the experiments as they worked the stations. They were highly satisfied with the green chemistry replacement experiments and handouts and their practical applications. Participants appreciated the enthusiasm and knowledge of the presenters and the quality of the handouts. They felt that there was a good balance between the video, lecture and hands on components in the workshop agenda. They indicated that they wanted more "hands-on: lab work, especially green chemistry experiments. They expressed a desire for presenters to elaborate on how to modify existing, traditional chemistry experiments to better use green chemistry techniques. Participants also indicated that they would have been better prepared if they had access to more green chemistry information before the workshop.

Many participants indicated that certain topics were missing from the workshop. Those topics included: information on chemical waste disposal and inventorying; more inquiry based green chemistry labs and purchasing/budget comparisons, and a discussion of subsequent cost saving of using green chemistry versus traditional chemistry experiments.

Table -6

Workshop Attendance

Schools Represented	Counties	Number of Teachers	Professional Titles
Guilderland HS	Albany	1	H.S. Chemistry
Ravena-Coeymans-Selkirk HS	Albany	2	H.S. Chemistry
Shaker HS	Albany	3	H.S. Chemistry
Watervliet JR/ HS	Albany	1	H.S. Chemistry
Andes CSD	Delaware	1	H.S. Science/STANY 2012 Chair
Millbrook HS	Dutchess	2	H.S. General Science/Earth Science
Poughkeepsie HS	Dutchess	2	H.S. Chemistry/Science
Worcester CSD	Otsego	1	H.S. Science
Berlin CSD	Rensselaer	1	Science Academic Chair
Columbia HS	Rensselaer	2	H.S. Science/Chemistry
Goff MS	Rensselaer	1	8th Grade Physical Science
Tech Valley HS	Rensselaer	1	H.S. Science
Oliver W. Winch MS	Saratoga	1	M.S. Science
Saratoga Springs HS	Saratoga	2	H.S. Chemistry
Schuylerville HS	Saratoga	1	H.S. Science
South Glens Falls HS	Saratoga	2	H.S. Chemistry & AP Biology/Forensic
Schenectady HS	Schenectady	1	H.S. Chemistry
Schalmont HS	Schenectady	3	H.S. Science
Scotia-Glenville CSD	Schenectady	2	H.S. Science
Salem CSD	Washington	1	H.S. Chemistry
Granville HS	Washington	1	H.S. Chemistry

STEP FOUR-IMPLEMENTATION OF GREEN CHEMISTRY IN THE CLASSROOM

Since the workshop, Schalmont High School chemistry teachers have implemented the following green chemistry experiments and techniques:

- A video entitled, "*Intellectual Ecology*", a video that provides an introduction to green chemistry and the importance of green chemistry for society.
- An exercise entitled, "*Writing the 12 Principles*", an exercise that serves as an introduction to green chemistry which gets the students thinking about how to apply the "*12 Principles of Green Chemistry*" and can also be used to talk about lab safety.
- An exercise that introduces the concept of E-factor and how it can be used to evaluate matter.
- An exercise entitled, "*Chemical or Physical Reaction*", an exercise that replaces traditional reactions involving chemicals such as cupric chloride, 6M hydrochloric acid, potassium hydroxide and copper sulfate. Students learn to understand the difference in chemical reactions vs. physical reactions using all green materials. The goal is to observe different types of reactions in order to discover common threads, ultimately leading to conclusion regarding evidence of chemical reactions. Students will learn the difference between chemical and physical reactions. The goal of the experiment is to dispel common misconceptions, i.e., boiling water is not a chemical reaction.
- An experiment on stoichiometry, chemical reactions and limiting reagents.
- An experiment entitled, "*Reaction Lab- 1, 2 Replacement, Synthesis, Decomposition*", a lab where students must decide which procedures to follow based on the "*12 Principles of Green Chemistry*".
- An experiment entitled, "*Stoichiometry Challenge*", a lab that replaces a traditional use of Aluminum to Alum stoichiometry lab with a greener precipitation reaction of sodium carbonate and calcium chloride. It is used to demonstrate how stoichiometry works, showing that if concentrations and amounts of the starting materials are known then the theoretical yield can be calculated from a balanced chemical equation.

The students liked the videos, and for the most part, the experiments went well. Some experiments did not involve all the students at all times, so, sometimes focus was lost. Rewriting the experiment procedures to match each of the 12 green chemistry principles proved time consuming and teacher intensive to be successful. It was suggested that students be given a copy of the "*12 Principles of Green Chemistry*" to be used as a reference document. The experiment on Chemical or Physical Reaction worked well. It offered a lot of easy observations of chemical versus physical reactions and students reacted positively to it.

The teachers indicated that most experiments required extra time to complete. This is because it always takes class time for students to read the procedures, direct students to where the materials for use are located, and clean up procedures. There is rarely enough time to properly conduct the experiment, answer the questions that students pose and have time, as a teacher, to wrap up. The teachers plan on refining some of the existing green experiments and trying some additional experiments and demonstrations before the year is over. However, the experiments were successful overall.

Table-7 describes the lab exercises in detail and summarizes the results**:**

Table -7

Green Chemistry Lab	Conclusions
Topic: "Intellectual Ecology" video clip provided by Beyond Benign This video clips is a good introduction to green chemistry and the importance of green chemistry for society.	Students liked watching this video. They said it had good information and was interesting. It would have been better if there was follow along question sheet or prepared discussion questions to wrap up and summarize after viewing to hold students accountable during viewing
Topic: "Writing the 12 Principles" provided by Beyond Benign This activity serves as an introduction to green chemistry gets the students thinking about how to apply the *12 Principles of Green Chemistry* and can also be used to talk about lab safety at the beginning of the school year.	This was a good demonstration in theory, but difficult to administer with large groups of students. Many students were not actively participating, so it is hard to hold their attention. There is lots of down time in this demo for students. We think it would be better if each student group did this experiment on their own The procedure given on-line didn't work making glue as an end product. Not sure why? The procedure conducted at DEC Green Chemistry workshop at Siena College worked great. Is on-line procedure correct? We did not have time to do "Properties of Material Created". The glue created (even after sitting 1-2 days) was not testable. It was a very gross. The student's said that since the experiment didn't work, it was so not fun to do and was awkward. Rewriting theexperiment procedures to match each of the *12 Green Chemistry Principles* was too daunting. It was too time consuming and teacher intensive to be realistically successful. To improve this experiment, we suggest that the students be given a copy of *12 Principles of Green Chemistry* to refer to. A strong understanding of the *12 Principles* along with vocabulary included is needed. Teachers can also review the *12 Principles* with students and have them write four ways to improve/modify this experiment.

Topic: Environmental Impact Factor "E-Factor" provided by Beyond Benign This lesson introduces the concept of the E-factor and how it can be used to evaluate matter.	Potato Chip section of this lab activity worked well. In the M&M section, the second E-Factor equation didn't make sense. (i.e. E-Factor=(mass input – mass output)/ mass product) What is the input, output & product? This was the final bullet/piece of the lab procedure. We, as teachers needed a better understanding of how each example bag was produced. The concept made sense. But I could not explain, for example, why "solvents & detergents" have an E-factor of .1 (little waste) & pharmaceuticals have an E-factor of 250 (much waste) This experiment was very teacher intensive, lots of explaining for what seems like a very basic concept.
Topic: "Chemical or Physical Reaction" provided by Beyond Benign This lab replaces traditional reactions involving chemicals such as cupric chloride, 6M hydrochloric acid, potassium hydroxide and copper sulfate. Students will understand the difference in chemical reactions versus physical reactions using all green materials. The goal is to sue observations of different types of reactions to discover common threads, ultimately leading to conclusions regarding evidence of chemical reactions. Students will ultimately learn the difference between chemical and physical changes. The goal of the lab is to dispel common misconceptions; i.e. boiling water is not a chemical reaction.	This is a good experiment. It offered lots of easy to ID observations of chemical versus physical reactions, and the students reacted very positively to it. The Kool-Aid reaction worked, but the students need to be advised to observe the dissolving nature (solubility) of the Kool-Aid. The instructional steps are not explicit to observe solubility. The Kool-Aid experiment needed two lab periods to finish. Students needed more time and some thought it was not interesting. A general observation was that the lab is set-up intensive with all the various stations Two reactions did not work too well: • **Heating the Extract:** Ideally, extract should evaporate=physical change, but this was not observed. • **Steel Wool & Vinegar:** Did not observe a temperature change (1-2 groups total observed a 1 C increase). We replaced parafilm with Al foil. There needs to be a very tight seal over the beaker; Al foil didn't seal that well. Also the thermometer needs to be placed in the middle of the steel wool and temperature taken immediately. In Steel Wool & Vinegar experiment, students need to be advised to take note of steel wool color change (This is not in the instructional steps)

Topic: "S'mores Stoichiometry" provided by Beyond Benign	This is a good experiment on stoichiometry, chemical reactions and limiting reagents.
Topic: "Reaction Lab – 1,2 Replacement, Synthesis, Decomposition" provided by Beyond Benign In this lesson, students observe reactions and identify the type and products produced in those reactions and compare the reactions for their toxicity using the *12 Principles of Green Chemistry*.	This is a very goodexperiment. The introduction is good, where students must decide which procedure to follow based on *12 Principles of Green Chemistry*. Most students arrived at conducting same experiment! Also, good pre-labs questions on types of reactions. Experiment itself went very smooth. All reactions worked well, with minimal set up. Good, relevant post experiment questions. Student reaction was that burning is always good (combustion of Cu), cool flames! The experiments worked. This experiment works best as a 3-day (40 minute each) lab.
Topic: "Stoichiometry Challenge" provided by Beyond Benign This lesson replaces a traditional use of Aluminum to Alum stoichiometry lab with a greener precipitation reaction of sodium carbonate and calcium chloride. It is used to demonstrate how stoichiometry works, showing that if concentrations and amounts of the starting materials are known that the theoretical yield can be calculated from a balanced chemical equation.	This is a very good experiment which worked well with minimal set up. However, this experiment was not overt in its green chemistry applications. The students were not sure how it related to green chemistry. They had to think about it, arriving at the conclusion that most of these experiments are using non-toxic chemicals in relatively small amounts=part of green chemistry

OVERALL SUMMARY AND CONCLUSION

The goals of this case study were accomplished. The overall methodologies used for this case study indicates that the format works. The inventory, training and actual implementation of the green chemistry principles has allowed us to evaluate the program and make the necessary changes to improve it for the next phase. The school showed that they were capable of working in a cooperative manner with the DEC and made the commitment to implement green chemistry practices. The study showed that the school benefitted from proper chemical management practices and were made aware of the benefits as the chemical inventory and reorganization efforts resulted in a 24% decrease in line item highly toxic chemicals. Of the original 993.7 pounds of chemicals inventoried, 833 pounds were classified as toxic, meaning that 84% of the initial inventory was toxic to some degree. DEC staff was able to recommend significant improvements to the existing chemical management system by reducing the number and quantity of highly toxic chemicals. As the teachers adopt a curriculum that consists of more green chemistry, they will see further reductions in their chemical inventory which will result in costs savings. A significant amount of money will be saved as a result of less purchasing in the future and lower disposal costs.

Significant cost savings were realized with regard to disposal of chemicals identified during the chemical inventory and re-organization process. If, the school had to hire a private contractor to do the inventory, transportation and disposal of chemicals, the cost would have been over $20,000 as illustrated in Table-8. By having TRGC staff do the actual work and BOCES cover the expenses with transportation and disposal, the cost or savings to the school was $8,583 as illustrated in the Measurable Results Reporting Form of the final report.

Table-8

New York State Division of Remediation Vendor-Estimated Amount Breakdown for Lab Packs

Disposal (hazardous)	512 lb x $463/50 lb	$4,741
Lab Packing	$2,692/day x 5 day	$13,460
Disposal (non-hazardous)	51 lb x $235/50 lb	$240
Drum Loading Area	$1,806/day x 1 day	$1,806
Other Transport	$555/event	$555
PPe[i] Upgrades level C	$88 per person/ per day x 3 people x 5 days	$1,320
Total		$22,122

[i] Personal Protective Equipment

The workshop and training held as part of this case study enabled 32 science teachers, representing eight counties in the capital district region, and eight observers from interested stakeholder groups to become aware of the benefits of proper chemical management and green chemistry. This ensures that interested stakeholders have been made aware of the benefits of green chemistry with regard to toxicity reduction and cost savings. Green chemistry techniques and experiments have been implemented at the school and are under evaluation.

The greater volume of feedback and implementation of green chemistry lab experiments by the three Schalmont High School teachers highlighted the strength of having a team of teachers working together on a new concept rather than having one teacher trained, as was the case with Case Study - Liberty High School. The Schalmont High School chemistry teachers traded information, “bounced ideas” off each other and generally provided support to each other as they tried out these new concepts of green chemistry. These three teachers went beyond the given chemistry experiment, modifying and adapting the workshop green chemistry experiments to fit the conditions in their classrooms for the best effect. Overall, they were committed and enthusiastic in their efforts to implement green chemistry practices into their chemistry classes.

ADDITIONAL GREEN CHEMISTRY RESOURCES:

Organization	Internet Address
Siena College • Green Chemistry Summer Institute	http://www.sienagreenchemistry.org
Beyond Benign • Green Chemistry Curriculum (free)	http://www.beyondbenign.org
American Chemical Society's Green Chemistry Institute for educators and students • Experiments and Curriculum for download • List of ACS books on Green Chemistry	http://www.acs.org/greenchemistry
Greener Educational Materials (GEMS) Database thru the University of Oregon for educators and students • Searchable database with Green Chemistry education materials uploaded by faculty members and educators worldwide • Most curriculum is available for download (free) or with primary literature information	http://greenchem.uoregon.edu/gems.html
GCEdNet-Green Chemistry Education Network	http://cmetim.ning.com/
University of Scranton Greening Across the Chemistry Curriculum • Green Chemistry Modules for download	http://www.scranton.edu/faculty/cannm/green-chemistry/english/drefusmodules.shtml
Carnegie Mellon University Institute for Green Science • Green Chemistry Modules for download	http://igs.chem.cmu.edu/

References:

United States Environmental Protection Agency (USEPA) – www.epa.gov/region2

New York State Education Department (SED) – www.nysed.gov

Beyond Benign – www.beyondbenign.org

Capital Region BOCES – www.capregboces.org

Siena College – www.siena.edu

Schalmont High School – www.schalmont.org/HS

OSHA Laboratory Standard (29 CFR 1910.1450) – www.osha.gov

New York State Plan for Public Employee Safety and Health (PESH)
– www.osha.gov/dcsp/osp/stateprogs/new_york.html

NYSED C& I (Curriculum and Instruction) – www.p12.nysed.gov/ciai/mst/scirg.html