FINAL REPORT

2001 Project Abstract
For the Period Ending June 30, 2003

TITLE:	**Improving Air Quality by Using Biodiesel in Generators**
PROJECT MANAGER:	Ken Bickel
ORGANIZATION:	University of Minnesota; Center for Diesel Research
ADDRESS:	1100 ME 111 Church St. SE Minneapolis, MN 55455-0111
WEB SITE ADDRESS:	http://www.me.umn.edu/centers/cdr/
FUND:	Oil Overcharge Money
LEGAL CITATION:	ML 2001, 1st Special Session, Ch. 2, Sec. 14, Subd. 9 (Energy)

APPROPRIATION AMOUNT: $90,000

Overall Project Outcome and Results

The objective of this project was to evaluate biodiesel fuel for producing electricity, Laboratory testing and a field demonstration were conducted to determine generator performance and the change in emissions when biodiesel blends were used.

Initially, screening tests using a NOx- reducing fuel additive and biodiesel blends were conducted to see if the fuel additive could offset the increase in NOx emissions that normally occurs using biodiesel. The fuel additive was not effective at reducing NOx in the biodiesel blends. Full emissions tests of the biodiesel blends with charge-air cooling demonstrated that significant particulate, CO and gaseous HC reductions can be achieved using B20 or B85 while lowering emissions of NOX. Particulate emissions were reduced by up to 30 %, while NOx reductions of up to 19% were observed. The use of a catalytic convertor increased particulate emissions using B20, but reduced particulate emissions when used with B85. No significant change in generator performance was observed.

Based on lab test results, a B20 biodiesel blend combined with supplemental charge air-cooling was demonstrated on a standby generator at the School of Environmental Studies at the Minnesota Zoo in Apple Valley. Comparable emissions reductions were measured.

Utilities, regulators, policy makers and others interested in producing power from renewable energy sources can use the results from this study, The use of biodiesel for generating electricity can benefit Minnesota by increasing the market for soybean oil and decreasing dependence on fossil fuels, reducing emissions from generators, and by helping utilities meet state goals for producing electricity form renewable energy sources. The project results are summarized in a separate report entitled "Using Biodiesel in Generators."

Project Results Use and Dissemination

As of this writing, the results from the laboratory evaluation have been supplied to project cooperators. In addition, the project has been discussed with at least eight different utilities interested in using biodiesel in diesel generators. The Minnesota Pollution Control Agency, National Biodiesel Board, and others have enquired about the project, and various aspects of the project have been discussed with them. The results of the laboratory tests were presented to over 200 attendees at the 2003 Biodiesel Brainstorming Meeting held January 28-29, 2003 in New Orleans, LA. An article describing the project was published in the March issue of AURI's Ag Innovation News, and the project was discussed in the July, 2003 issue of BioCycle magazine. The final report , which will include the results from the field testing, will be supplied to all cooperators and other interested parties.

In addition, a brief project description and pictures from the field demonstration are available at the Center for Diesel Research Center's web page (http://www.me.umn.edu/centers/cdr/zooschool/).

August 1, 2003

LCMR Final Work Program Report

I. PROJECT TITLE: **Improving Air Quality by Using Biodiesel in Generators**

Project Manager: Ken Bickel
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111 Church St. SE
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Total Biennial Project Budget:

LCMR:	**$90,000**	**Match:**	**$125,000**
-LCMR Amount Spent:	**$89,629**	**-Match Amount Spent:**	**$125,000**
= LCMR Balance:	**$ 371**	**=Match Balance**	**$ 0**

A. Legal Citation: Minn. Laws 2001, Special Session, Chapter 2, Section 14, subd. 9 (Energy).
$90,000 is from the oil overcharge money to the commissioner of administration for an agreement with the University of Minnesota to evaluate the use of biodiesel fuel in diesel-powered generators and associated impacts of emissions on air quality.

B. Status of Match Requirement:
The Minnesota Soybean Growers Association (MSGA), the Agricultural Utilization Research Institute (AURI), and the Minnesota Department of Commerce have agreed to provide $25,000 each for this project.

After the completion of Result 1 (Review Existing Technology), Dakota Electric and Great River Energy each agreed to donate $25,000 to conduct a more thorough laboratory evaluation (Result 2, Laboratory Evaluation).

II. AND III. FINAL PROJECT SUMMARY

The objective of this project was to evaluate biodiesel fuel for producing electricity, Laboratory testing and a field demonstration were conducted to determine generator performance and the change in emissions when biodiesel blends were used.

Initially, laboratory tests using a NOx- reducing fuel additive and biodiesel blends were conducted to see if the fuel additive could offset the increase in NOx emissions that

normally occurs using biodiesel. The fuel additive was not effective at reducing NOx in the biodiesel blends. Full emissions tests of the biodiesel blends with charge-air cooling demonstrated that significant particulate, CO and gaseous HC reductions can be achieved using B20 or B85 while lowering emissions of NOX. Particulate emissions were reduced by up to 30 %, while NOx reductions of up to 19% were observed. The use of a catalytic convertor increased particulate emissions using B20, but reduced particulate emissions when used with B85. No significant change in generator performance was observed.

Based on lab test results, a B20 biodiesel blend combined with supplemental charge air-cooling was demonstrated on a standby generator at the School of Environmental Studies at the Minnesota Zoo in Apple Valley. Comparable emissions reductions were measured.

Utilities, regulators, policy makers and others interested in producing power from renewable energy sources can use the results from this study, The use of biodiesel for generating electricity can benefit Minnesota by increasing the market for soybean oil and decreasing dependence on fossil fuels, reducing emissions from generators, and by helping utilities meet state goals for producing electricity form renewable energy sources. The project results are summarized in a separate report entitled "Using Biodiesel in Generators."

III. OUTLINE OF PROJECT RESULTS:

Result 1*) Review Existing Technology*: Engines used for generators will be evaluated for their compatibility with biodiesel fuels. Appropriate biodiesel blends will be chosen to obtain significant reductions in particulate, carbon monoxide, and hydrocarbon emissions at a reasonable cost. Methods of reducing NOx emissions will be surveyed, and a low cost method selected for evaluation in the laboratory.

LCMR Budget:	$ 12,581	Match:	$ 0
LCMR Balance:	$ (373)	Match Balance:	$ 125,000

Personnel: The following individuals worked on the project during this period:
1) Robert Waytulonis, Associate Director, University of Minnesota, Center for Diesel Research. ($1,542 LCMR dollars, 3 % of time on project.)
2) Kelly Strebig, Research Engineer, University of Minnesota, Center for Diesel Research. ($2,622 LCMR dollars, 8 % of time on project.)
3) Kenneth Bickel, Research Fellow, University of Minnesota, Center for Diesel Research ($8,787 LCMR dollars, 23 % of time on project).
Other: Miscellaneous publications and office costs ($0 LCMR dollars)

Completion date: Dec, 2001

Result Status (July, 2003):

The Center for Diesel Research (CDR) obtained data on generators used in MN from the following organizations:

Minnesota Pollution Control Agency: The PCA began permitting large facilities in the 1970's, and smaller facilities in the 1980's. Since 1993, PCA has required that anyone obtaining an air quality permit that has a generator that is 100 kW or larger include it in the application. They also want permits for any generator over 500 kW in size. They provided the CDR with a list of permitted facilities that reported burning diesel fuel in an engine on their permit application. CDR reviewed the permit application files for 156 facilities in the 11-county metro area. The 156 facilities had 311 engines listed in their permits. The generators ranged in age from 2-62 years old. The engine make could be identified on 169 generators, with 136 of those being Caterpillar or Cummins engines.
University of Minnesota: CDR obtained data on all of the 88 generators installed at the University of Minnesota's Minneapolis and St. Paul campuses. The data included information on generator make and model, generating capacity, installation date, fuel storage, and other data. Although the data is incomplete, the predominant gen-set manufacturers are Onan and Kohler and Cummins and Caterpillar are the predominant engines. The Cummins engines supply electrical power in the range of 75 to 775 kW, with an average power of 248 kW. The Caterpillar engines supply power in the range of 250 to 2000 kW with an average of 726 kW.
Great River Energy: Great River Energy is a Generation and Transmission Utility serving rural cooperatives throughout the state. They provided the number of commercial and interruptible customers for each of the cooperatives they service.
Minnesota Valley Electric Cooperative: MVEC is a rural cooperative, supplying power to customers in nine counties, including the metro counties of Dakota, Hennepin, and Scott counties. They provided engine make, model, generating capacity and age for generators in their service area.
Zeigler: Zeigler is one of the largest suppliers of engines and construction equipment in the world. They supplied CDR with engine make, model, generating capacity and age for 108 commercial generators in the metro area. All the generators used Caterpillar or Caterpillar-Perkins engines.

The gen-set data was used to help select the engine, type of emission controls, the engine test cycle, and the biodiesel blend levels to evaluate in the laboratory. The engine selected was a University-owned 386 horsepower, turbocharged, aftercooled engine used in generators manufactured by Cummins, Inc.

Methods for reducing particulate matter (PM) and nitrogen oxide (NOx) emissions were compiled from technical literature and personal communications. The methods included cooling of the charge air (air drawn into the engine for combustion), fuel additives, exhaust aftertreatment, and others such as exhaust gas recirculation. Data was obtained on cost, potential emissions reductions, the maturity of the method, applicability to gen-sets, and other information. Based on this review, practical, low cost methods of reducing emissions were selected for evaluation during the laboratory testing. The methods selected were a NOx -reducing fuel additive, charge-air cooling, and a DOC.

While work was being conducted on Result 1, Dakota Electric and Great River Energy agreed to provide additions funds to conduct a more extensive laboratory evaluation. With the additional funding, the laboratory evaluation was expanded to include an evaluation of two biodiesel blends. The blends selected were B20 (20 % biodiesel, 80%

diesel) and B85 (85% biodiesel, 15% petrodiesel). They were selected because B20 and B85 were the two blend levels specified in legislation proposed during the state of Minnesota's 82nd Legislative Session (Senate File 2421). This Bill provided incentives for "qualified biodiesel generation facilities." To qualify, facilities in operation before May 30, 2002, must use a B20 or higher blend. Any facility using B85 would also qualify (facilities coming online after May 30, 2002 must use B85). Note that the 2002 Legislative Session did not act on Senate File 2421.

Work on Result 1 began in September 2001 and Result 1 was completed in April 2002.

Result 2*) Laboratory Evaluation*: The fuels and emission control system selected during the first portion of the project will be evaluated at the University of Minnesota's Center for Diesel Research (UM-CDR). Different blends of biodiesel and petrodiesel will be tested in a smaller version of an engine that is typically used for standby generators. Based on the results, a biodiesel blend and emission control system will be selected that gives the largest emissions reduction at a reasonable cost.

LCMR Budget:	$ 32,039	Match:	$ 81,938
LCMR Balance:	$ 739	Match Balance:	$ -549

Personnel: The following individuals worked on the project during this period:
1) Robert Waytulonis, Associate Director, University of Minnesota, Center for Diesel Research. ($12,307 LCMR dollars, 23 % of time on project.)
2) Kelly Strebig, Research Engineer, University of Minnesota, Center for Diesel Research. ($568 LCMR dollars, 2 % of time on project.)
3) Kenneth Bickel, Research Fellow, University of Minnesota, Center for Diesel Research ($6,028 LCMR dollars, 16 % of time on project).
4) Darrick Zarling, Scientist, University of Minnesota, Center for Diesel Research ($3,969 LCMR dollars, 12 % of time on project).
5) John Gage, Senior Electronics Technician, University of Minnesota, Center for Diesel Research ($8,096 LCMR dollars, 27 % of time on project)

Equipment: Lab supplies - parts, fittings, sample filters, etc. ($331 LCMR dollars)
Other: Laboratory maintenance, office costs ($0 LCMR dollars)

Completion date: June 2002

Result Status (July, 2003):

B20, B85, and two diesel baseline fuels were tested in a Cummins engine that is commonly used in standby generators. The emissions resulting from the selected fuels and three emission control techniques were compared to baseline emissions. The baseline engine setup consisted of a regular diesel and a premium diesel fuel with no emission control devices installed on the engine.

Charge-air cooling was the primary NOx control technique tested. Charge air-cooling improves the specific power output of an engine by increasing charge air density.

Benefits derived from this improved specific power output are better fuel economy and reduced exhaust emissions

Three charge air temperatures (nominally 45, 65, 90°C) were selected to represent a jacket-water aftercooled engine, an engine with intermediate charge air temperature, and an air-to-air aftercooled engine, respectively.

Fuel additives, known as cetane number improvers or ignition improvers, are used to raise a fuels cetane number. By increasing the cetane number of diesel fuel, the ignition delay time (the time between injection and ignition when fuel is sprayed into the combustion chamber) is reduced and results in reduced NOx emissions. 2-Ethyl-hexyl-nitrate (EHN) is a cetane number improving fuel additive that in tests by others, made B20 NOx-neutral. Several treat rates of EHN in D2 and biodiesel blends were evaluated for their effects on NOx emissions.

The test engine was a Cummins M11 that was programmed to a 1999 ISM 370 model. The engine was an electronically controlled, 6-cylinder, 10.8-liter, direct (unit)-injection; turbocharged and intercooled diesel rated 370 at hp (276 kW) at 1800 rpm.

For some tests, a DOC was used. The catalyst was supplied by DCL International, Concord, Ontario, Canada. One common application of this catalyst is on diesel-powered electric generators. Prior to emissions tests, the DOC was "degreened" by running hot exhaust (>325 degrees C) through it for 12 hours to stabilize its performance.

Flint Hills Resources in Inver Grove Heights, MN supplied the base diesel fuels, Performance Gold and Performance Gold Plus. The biodiesel fuel, a soy methyl ester, was produced by Agricultural Environmental Products in Iowa. The B20 and B85 fuels were blended by Cannon Valley Co-Op, Northfield,

The following is a list of conclusions from the laboratory testing:
Ethyl-Hexyl Nitrate (EHN) fuel additive: The screening tests demonstrated that the EHN was not effective at reducing NO_x emissions with either the Performance Gold or Performance Gold Plus diesel fuels. It also did not reduce NO_x when used in the biodiesel blends.
Brake specific fuel consumption (BSFC): Due to the lower energy content of biodiesel, the BSFC increased when using biodiesel blends. The increase was proportional to blend level. B20 increased BSFC by 2-4 %, depending on engine mode and charge air temperature, while an increase of 7–11 % was observed using B85.
Charge-air Temperature: Reducing charge-air temperature was very effective at reducing brake specific NO_x emissions. When evaluated with the baseline diesel fuel, reducing charge-air temperature from 90° to 40° C lowered NO_x emissions by 22-25 %. There was no clear trend regarding particulate emissions, with the emissions decreasing with charge-air temperature at mode 1, and increasing at mode 3.
B20: Brake specific NO_x increased by about 6% using B20, but were reduced 19 % when the charge air temperature was lowered from 90° to 40°C. Total particulate matter was reduced by 11-18%, depending on charge-air temperature.

B85: The use of B85 increased brake specific NO_x emissions by 13 %. That increase was essentially offset by cooling the charge air from 90° to 65° C. A NOx decrease of 11 % was measured when using B85 and cooling the charge air to 40° C. Total particulate emissions dropped 24-29%, depending on charge-air temperature.
DOC: The DOC reduced emissions of CO, gaseous HC, and the hydrocarbon portion of volatile particulate at both modes and all charge-air temperatures. However, due to the heavy-duty cycle and high exhaust temperatures, the DOC oxidized SO_2 present in the exhaust gas to sulfate, which is measured as volatile particulate. This was especially significant using B20, with increases of up to 50% in total particulate observed. This effect was much less pronounced using B85 because of the lower sulfur content of the fuel. However, using fuels that are currently available, the use of a DOC is not a good application on generators with heavy-duty cycles that result in the oxidation of fuel sulfur to sulfate.

Laboratory testing was completed in September 2002. The data was analyzed and the results presented to representatives from Dakota Electric, Great River Energy, and Energy Alternatives in November of last year. This information was used in the selection of a site for field demonstration.

Electrical utilities, government agencies, policy makers and others who have an interest in producing power from renewable fuels can use the results from the laboratory testing.

Result 3*) Demonstration on a Peak Shaving Generator*: Dakota Electric has agreed to provide a site and a standby generator used for peak shaving. Fuel storage and transfer issues will be addressed. If necessary, the generator's engine and fuel system will be cleaned and modified for use with biodiesel. The emission control system evaluated during the lab study that is sized for the generator used for the demonstration will be installed, and emissions measurement equipment will be used to determine the reduction in emissions.

LCMR Budget:	$ 45,379	Match:	$ 43,007
LCMR Balance:	$ 4	Match Balance:	$ 0

Personnel: The following individuals worked on the project during this period:
1) Robert Waytulonis, Associate Director, University of Minnesota, Center for Diesel Research. ($8,581 LCMR dollars, 11 % of time on project.)
2) Kelly Strebig, Research Engineer, University of Minnesota, Center for Diesel Research. ($1,397 LCMR dollars, 13 % of time on project.)
3) Kenneth Bickel, Research Fellow, University of Minnesota, Center for Diesel Research ($16,793 LCMR dollars, 30 % of time on project).
4) Darrick Zarling, Scientist, University of Minnesota, Center for Diesel Research ($12,596 LCMR dollars, 24 % of time on project).
5) John Gage, Senior Electronics Technician, University of Minnesota, Center for Diesel Research ($5,366 LCMR dollars, 12 % of time on project)

Equipment: Exhaust and fuel system parts, fittings, sample filters, calibration gases, etc. ($240 LCMR dollars)
Other: Travel and transportation of equipment, office costs ($395 LCMR dollars)

Completion date: January 2003

Result Status (July, 2003):
The laboratory testing of biodiesel showed that the use of B20 and B85 resulted in significant reductions in PM, CO, and HC, but increased NOx. When compared to regular D2 fuel, for example, NOx increased about 6% using B20, but dropped about 20% when the charge-air temperature was lowered from 90 to 40 degrees C via supplemental charge-air cooling. Based on these test results, it was determined that a demonstration of the effects of charge-air cooling and B20 fuel on exhaust emissions at a field site was warranted.

The demonstration of biodiesel fuel took place at the School of Environmental Studies at the Minnesota Zoo in Apple Valley. The "Zoo School" is an optional high school developed by Independent School District #196, the Minnesota Zoological Gardens, and the City of Apple Valley with support from Dakota County and the State of Minnesota.

The Dakota Electric Association, Energy Alternatives, and Great River Energy cooperated to provide the diesel-powered electric generator (Gen Set). The demonstration gen-set diesel was a Caterpillar model 3406 B, turbocharged and aftercooled engine rated 400 kW standby and 365 kW prime at 60 Hz, 1800 rpm. This gen-set is used for standby emergency power and off-grid peak shaving. The "standby rating" is the electric power that can be supplied for emergencies for the duration of normal power interruption. The "prime rating" rating is the maximum power available at a variable load for an unlimited number of hours.

Prior to the field demonstration, it was not known how much the charge-air temperature could be reduced from the stock inlet air temperature owing to the availability of city water and other factors. However, the objective of the field demonstration was to demonstrate that a renewable fuel, such as B20, could be effectively used in gen-sets with accompanying reductions in PM and no increase, or possibly a decrease, in NOx when compared to emissions from D2.

The stock thermostat controls both the engine coolant and charge air cooler temperatures. The beginning opening temperature of the thermostat is 81-83 degrees C and it is fully open at 92 deg. C. The charge air cooler plumbing arrangement on the engine allowed this cooling circuit to be isolated from the engine coolant. With the assistance of Ziegler Power Systems of Shakopee, Minnesota, a separate, supplemental cooling circuit was installed that consisted of a separate shell & tube heat exchange r cooled with city water. This enabled a 41 degree C reduction in intake air temperature at 85% load, and a 40 degree C reduction at 50% load.

In addition to modifying the intake air cooling system, provisions for storage and transfer of the base diesel fuel and B20 were made. Two 500 gallon fuel tanks were placed onsite for fuel storage. A load bank was installed so that a constant load could be placed on the generator, allowing consistent engine conditions for sampling. The exhaust system was modified so exhaust samples could be drawn from the exhaust stack. Gaseous and particulate sampling instrumentation was installed on the roof of the generator enclosure.

Once all gen-set modifications, fuel tanks, load bank, and field instrumentation was set up on site, testing was conducted over a 5-day period. Two days of testing were conducted with the baseline diesel fuel, two days with the B20, and one day where both the baseline fuel and B20 were tested. No significant change in engine performance was observed, and the change in emissions was similar to those observed during the laboratory testing of B20 with charge aircooling. As of this writing, the final report summarizing all aspects of the project is being written and will be delivered to the LCMR by September 30, 2003.

The field testing was completed by June 30, 2003. This is about 5 months later than originally planned. The delay is due primarily to two factors: 1) the initiation of the project in September, 2001 (rather than July), and 2) concerns with conducting the field demonstration in the cold weather months of January and February.

IV. TOTAL PROJECT BUDGET

All Results: Personnel: $87,280
All Results: Equipment: $1050
All Results: Other: $ 1670

Total Budget: $90,000

A.) See Attachment A for more information on the budget. (Note: When the work program was first written, Todd Taubert was scheduled to work on Results 2 and 3. Taubert left CDR before Result 2 or 3 began. The work he would have done has been done by others).

VI: PAST, PRESENT AND FUTURE SPENDING

A. Past Spending: $89,629 of LCMR funds have been expended through January 31, 2003 on this project.

B. Current and Future Spending: The total cost for this project is $215,000. We entered into contracts with cooperators for $125,000 in funding that were spent during the funding period. No additional money is required.

C. Project Partners:

Minnesota Soygrowers Association: $25,000 cash

Agricultural Utilization Research Institute: Provide fuel analyses, technical support and $25,000 cash. The estimated value of the fuel analyses and technical support is $5,000, at no cost to the project.
MN Department of Commerce: $25,000 cash
Dakota Electric: Provide $25,000 cash and a site and generator for field demonstration
Great River Energy: $25,000 cash

D. Time: The project was completed by June 30, 2003.

VII: DISSEMINATION:

As of this writing, the results from the laboratory evaluation have been supplied to the Minnesota Soygrowers Association, the Agricultural Utilization Research Institute, the University of Minnesota, the Minnesota Dept. of Commerce, Dakota Electric, Great River Energy, and Energy Alternatives. In addition, the project has been discussed with at least five other utilities interested in using biodiesel in diesel generators. The Minnesota Pollution Control Agency, National Biodiesel Board, and others have enquired about the project, and various aspects of the project have been discussed with them. The results of the laboratory tests were presented to over 200 attendees at the 2003 Biodiesel Brainstorming Meeting held January 28-29, 2003 in New Orleans, LA. An article describing the project was published in the March issue of AURI's Ag Innovation News, and the project was discussed in the July, 2003 issue of BioCycle magazine. The final report, which will include the results from the field testing, will be supplied to all cooperators and other interested parties.

In addition, a brief project description and pictures from the field demonstration are available at the Center for Diesel Research Center's web page (http://www.me.umn.edu/centers/cdr/zooschool/).

VIII. LOCATION: The technology review and laboratory testing took place at the University of Minnesota in Minneapolis. The field demonstration of biodiesel fuel took place at the School of Environmental Studies at the Minnesota Zoo in Apple Valley.

IX. REPORTING REQUIREMENTS:

Workprogram updates will be submitted not later and December 2002. A final workprogram report and associated products will be submitted by January 30, 2003, or by the completion date as set in the appropriation.

ATTACHMENT A (include the attachment in all future update reports.) Use as many results as necessary. Landscaping on legal size paper to fit in all the columns may be helpful.

The commission will not allow office space rental fees or salary payments to officers or directors, this applies to ALL PROJECTS. See page 9 for Eligible and Ineligible expenses.
GENERAL OTHER WILL NOT BE ACCEPTED. BE SPECIFIC AND USE AS MANY LINES AS NECESSARY.

Project Title: Using Biodiesel in Generators

Project Number: IR 07

LCMR Recommended Funding: $90,000

Attachment A Deliverable Products and Related Budget

2001 LCMR Project Biennial Budget — Objective/ Result

	Result 1 Budget:	Result 1 Current invoice:	Result 1 Balance:	Result 2 Budget:	Result 2 Current Invoice:	Result 2 Balance:	Result 3:	Result 3 Current Invoice:	Result 3 Balance:	PROJECT TOTAL:		
Budget Item (Title of Result)	Review Existing Technology			Laboratory Evaluation			Demonstration on a Generator			BUDGET TOTAL:	CURRENT INVOICE TOTAL:	BALANCE TOTAL:
Wages, salaries & benefits												
David Kittelson	$ 389	$ -	$ 389	$ 970	$ -	$ 970	$ 1,547	$ -	$ 1,547	$ 2,905	$ -	$ 2,905
Robert Waytulonis	$ 1,228	$ 1,545	$ (317)	$ 5,105	$ 12,307	$ (7,202)	$ 4,751	$ 8,588	$ (3,837)	$ 11,084	$ 22,440	$ (11,356)
Kenneth L Bickel	$ 8,170	$ 8,787	$ (617)	$ 9,302	$ 6,028	$ 3,274	$ 14,131	$ 16,793	$ (2,662)	$ 31,603	$ 31,608	$ (5)
Kelly Strebig	$ 2,294	$ 2,622	$ (328)	$ 1,159	$ 568	$ 591	$ 2,114	$ 1,397	$ 717	$ 5,567	$ 4,587	$ 980
Todd Taubert				$ 4,871	$ -	$ 4,871	$ 6,734	$ -	$ 6,734	$ 11,605	$ -	$ 11,605
John Gage				$ 4,934	$ 8,096	$ (3,162)	$ 6,995	$ 5,366	$ 1,629	$ 11,929	$ 13,462	$ (1,533)
Darrick Zarling				$ 5,049	$ 3,969	$ 1,080	$ 7,537	$ 12,596	$ (5,059)	$ 12,586	$ 16,565	$ (3,979)
Total wages, salaries and benefits	$ 12,081	$ 12,954	$ (873)	$ 31,389	$ 30,968	$ 421	$ 43,809	$ 44,740	$ (931)	$ 87,280	$ 88,662	$ (1,382)
Maintenance				$ 200	$ -	$ 200				$ 200	0	200
Printing	$ 50	$ -	$ 50	$ 50	$ -	$ 50	$ 220	$ -		$ 320	0	320
Communications, telephone, mail, etc.	$ 300	$ -	$ 300	$ 200	$ -	$ 200				$ 500	0	500
Other Supplies (list specific categories)												
Publications	$ 150	$ -	$ 150							$ 150	0	150
Local automobile mileage paid							$ 500	$ 395		$ 500	395	105
Tools and equipment (list categories)												
Misc supplies (parts, fittings, sample filters, calibration gases, etc.)				$ 200	$ 332	$ (132)	$ 850	$ 240		$ 1,050	572	478
COLUMN TOTAL	$ 12,581	$ 12,954	$ (373)	$ 32,039	$ 31,300	$ 739	$ 45,379	$ 45,375	$ 4	$ 90,000	$ 89,629	371