

# Oil & Natural Gas Technology

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## Quarterly Progress Report (01/01/08 – 03/31/08)

### Gas Storage Technology Consortium

Submitted by:  
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The Energy Institute  
University Park, PA 16802

Prepared for:  
United States Department of Energy  
National Energy Technology Laboratory

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Office of Fossil Energy

## **DISCLAIMER**

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## ABSTRACT

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Gas storage is a critical element in the natural gas industry. Producers, transmission and distribution companies, marketers, and end users all benefit directly from the load balancing function of storage. The unbundling process has fundamentally changed the way storage is used and valued. As an unbundled service, the value of storage is being recovered at rates that reflect its value. Moreover, the marketplace has differentiated between various types of storage services and has increasingly rewarded flexibility, safety, and reliability. The size of the natural gas market has increased and is projected to continue to increase towards 30 trillion cubic feet over the next 10 to 15 years. Much of this increase is projected to come from electric generation, particularly peaking units. Gas storage, particularly the flexible services that are most suited to electric loads, is crucial in meeting the needs of these new markets.

To address the gas storage needs of the natural gas industry, an industry-driven consortium was created – the Gas Storage Technology Consortium (GSTC). The objective of the GSTC is to provide a means to accomplish industry-driven research and development designed to enhance the operational flexibility and deliverability of the nation's gas storage system, and provide a cost-effective, safe, and reliable supply of natural gas to meet domestic demand.

This report addresses the activities for the quarterly period of January 1, 2008 through March 31, 2008. Key activities during this time period included:

- Drafting and releasing the 2008 Request for Proposals;
- Planning the 2008 GSTC Spring Meeting, Chicago, IL, on April 17-18, 2008;
- Scheduling and participating in four (4) project mentoring conference calls;
- Conducting elections for five (5) Executive Council seats;
- Releasing the *GSTC Insider* e-newsletter; and
- One 2006 project final report received.

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## **INTRODUCTION**

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Gas storage is a critical element in the natural gas industry. Producers, transmission and distribution companies, marketers, and end users all benefit directly from the load balancing function of storage. The unbundling process has fundamentally changed the way storage is used and valued. As an unbundled service, the value of storage is being recovered at rates that reflect its value. Moreover, the marketplace has differentiated between various types of storage services and has increasingly rewarded flexibility, safety, and reliability. The size of the natural gas market has increased and is projected to continue to increase toward 30 trillion cubic feet over the next 10 to 15 years. Much of this increase is projected to come from electric generation, particularly peaking units. Gas storage, particularly the flexible services that are most suited to electric loads, is crucial in meeting the needs of these new markets.

To address the gas storage needs of the natural gas industry, an industry-driven consortium was created – the Gas Storage Technology Consortium. The objective of the GSTC is to provide a means to accomplish industry-driven research and development designed to enhance the operational flexibility and deliverability of the nation's gas storage system, and provide a cost-effective, safe, and reliable supply of natural gas to meet domestic demand. Consortium technology development is conducted in the general areas of well-bore and reservoirs, operations, mechanical, and salt caverns. Consortium members elect an executive council that is charged with reviewing projects for consortium co-funding. Projects are submitted by GSTC members and are funded on an annual basis. Proposals must address improving the production performance of gas storage and provide significant cost sharing. The process of having industry members develop, review, and select projects for funding ensures that the GSTC conducts research that is relevant and timely to the industry.

The scope of Penn State's activities includes managing the process of attracting and maintaining consortium members, soliciting proposals, awarding and monitoring subcontracts to members to accomplish the selected technical works and disseminating the results of the technical work via meetings and final reports.

## EXECUTIVE SUMMARY

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This report summarizes the important accomplishments during the period of January 1, 2008 through March 31, 2008. The GSTC was established under contract to The Pennsylvania State University from the U.S. Department of Energy (DOE), National Energy Technology Laboratory (NETL), in June 2004. The agreement provides the Pennsylvania State University with the overarching management responsibilities for the GSTC. Key activities for this reporting period included the following:

### *2008 Request for Proposals*

The 2008 GSTC Request for Proposals was released in January 2008 with proposals due on April 2, 2008.

### *2008 GSTC Spring Meeting*

Plans for the 2008 GSTC Spring Meeting continues. The meeting will be held at the Embassy Suites Chicago Downtown Lakefront, Chicago, IL on April 17-18, 2008. All proposals received are required to give a presentation as well as technology updates from current projects.

### *Project Mentoring Conference Calls*

Four conference calls were scheduled and conducted, as follows:

- RGD X-ray Technology Well Bore Inspection and Assessment- A Feasibility Study, (Gas Technology Institute), January 24, 2008;
- Evaluation of Magnetic Pulse Welding (MPW) for Improved Casing Repair, (Edison Welding Institute), January 31, 2008;
- Gas Storage Facility Design Under Uncertainty, (University of Texas at Austin), January 31, 2008;
- Smart Gas: Using Chemicals to Improve Gas Deliverability – Phase II, (Correlations Company), January 31, 2008.

### *Executive Council Candidates*

The Technical Advisory Committee elected five (5) Executive Council representatives to serve for 2008-2009.

### *GSTC Insider E-newsletter*

The *GSTC Insider* e-newsletter was released in February 2008. This is the first newsletter in 2008 and offers an additional mechanism for keeping the industry informed.

### *Technical Feasibility Evaluation of Casing Cement Leaks Final Report*

The Technical Feasibility Evaluation of Non-Intrusive Optical Detection, Monitoring and Preliminary Characterization of Casing Cement Leaks for Gas Wells, (URS) has been received and posted to the GSTC member's only section of the website.

## **EXPERIMENTAL**

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A description of experimental methods is required by the DOE for all quarterly technical progress reports. In this program, Penn State is responsible for establishing and managing an industry-driven underground gas storage consortium. Technology development research awards are made on a competitive basis. Technical reports from the individual researchers are required to contain experimental discussion sections and are submitted to consortium members and the DOE for review. Therefore, this section is not applicable to the Penn State contracted activities.

## **RESULTS & DISCUSSION**

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This report addresses the activities for the reporting period from January 1, 2008 through March 31, 2008. Key activities during this time period included:

- Drafting and releasing the 2008 Request for Proposals;
- Preliminary planning for the 2008 Spring Meeting, Chicago, IL on April 17-18, 2008;
- Conducting four mentoring team conference calls;
- Identifying representatives to serve on the Executive Council for 2008-2009;
- *GSTC Insider* e-newsletter released; and
- One final report for a 2006 project received.

## **GSTC Administration**

The scope of the GSTC administration activities includes managing the process of attracting and maintaining consortium members, soliciting proposals, developing strategies for action on recommendations from the technical committee and executive council, keeping the industry informed on issues and events, and awarding and monitoring subcontracts to members to accomplish the selected technical works.

### **2008 GSTC Request for Proposals**

The 2008 GSTC Request for Proposals was drafted and released on January 30, 2008, with proposals due April 2, 2008. Proposals are sought in the following focus areas:

- Mechanical
- Well-bore and reservoir
- Operations
- Salt cavern

The Pipeline Research Council International (PRCI) is providing cost share to the GSTC and has a specific interest in the following topics:

- Deliverability maintenance and enhancement
- Base gas reduction
- Improved assessment of wellbore tubulars
- Reduced well workover costs

The RFP is attached as Appendix A.

### **2008 GSTC Spring Meeting**

The GSTC administration continues planning for the 2008 GSTC Spring Meeting at the Embassy Suites Chicago Downtown Lakefront, Chicago, IL on April 17-18, 2008. In addition to hearing funding requests, this meeting is an opportunity to hear the technology developments from current projects. At the close of the general meeting, the Executive Council will meet and recommend which proposals they desire to go forward.

### **Project Mentoring Conference Calls**

Four project-mentoring conference calls were conducted. The mentoring team was established in 2006 to better communicate between meetings, hence assuring the projects

are on track. The notes from the conference calls are posted in the member's only section of the GSTC website: <http://www.energy.psu.edu/gstc/>

The calls were:

- RGD X-ray Technology Well Bore Inspection and Assessment- A Feasibility Study, (Gas Technology Institute), January 24, 2008;
- Evaluation of Magnetic Pulse Welding (MPW) for Improved Casing Repair, (Edison Welding Institute), January 31, 2008;
- Gas Storage Facility Design Under Uncertainty, (University of Texas at Austin), January 31, 2008;
- Smart Gas: Using Chemicals to Improve Gas Deliverability – Phase II, (Correlations Company), January 31, 2008.

The RGD X-ray Technology Well Bore Inspection and Assessment- A Feasibility Study project proposes to study, develop, and demonstrate a real-time RGD tool for *in situ* compositional identification and quantification of scale in gas storage wells and pipelines. The RGD tool will also assess and quantify material defects, pitting, and penetrations in casings and associated piping. This innovative technology can provide real time data and analysis on both scale formation inside the well bore as well as assess the well bore casing integrity. The Executive Summary is attached as Appendix B. Due to the inability of GTI to begin work in a time frame that would allow the work to be completed in the allocated time period, this project was terminated during this quarter.

The objective of the Evaluation of Magnetic Pulse Welding (MPW) for Improved Casing Repair project is to determine the feasibility of MPW for improved casing repair. MPW is a single shot joining technology, which means the weld is made instantaneously by pressing a button. EWI has completed extensive work on externally welding tubular structures with MPW. Up to two internal coil systems will be built for testing. EWI is now doing welding trials to confirm the feasibility and durability of the internal coil system. Around 40 weld samples will be cut from casing material provided by Whipstock. The Executive Summary is attached as Appendix C.

The Gas Storage Facility Design Under Uncertainty project will examine the sensitivity of gas storage facility design decisions to uncertainty in the estimates used during concept comparison and selection. It will investigate how uncertainty in estimates

influence optimal facility sizing and other design decisions and assess the relative value of reducing uncertainty in these same estimates. There will be a spreadsheet of tools (or comparable format) that will convert the key findings of the research into tools and templates that decision-makers can use to inform decision-making. The Executive Summary is attached as Appendix D.

The Smart Gas: Using Chemicals to Improve Gas Deliverability – Phase II project proposes to develop new technology to improve gas deliverability from gas storage wells. The laboratory tests with oil demonstrated that intermediate wettability is optimum. Numerical simulation indicated the same. Phase I of the project showed that wettability alteration worked in sandstone cores, but not dolomite. Field-testing of the surfactant that reduced favorable laboratory results is proposed. The analytical approach developed during the original project will be used to evaluate the proposed field tests. Two operators of aquifer gas storage sites are interested in testing the wettability-altering concept. The Executive Summary is attached as Appendix E.

### **Executive Council**

The GSTC conducted elections for five representatives to serve on the Executive Council for 2008-2009. The Council's responsibilities include attending a two-day proposal meeting to review and select proposals for GSTC funding, to participate, either in person or via teleconference, in other Council meetings at various locations throughout the year and are encouraged to serve on Ad hoc committees to steer the GSTC research projects. The Executive Council Election Form is attached as Appendix F. The new representatives are:

- Larry Kennedy, El Paso Corporation
- Brian Hall, Equitable Resources
- Ramon Harris, National Fuel
- Steve Bergin, ONEOK, Inc.
- John Jackson, Spectra Energy

The Executive Council members who will continue to serve until the end of 2008 are:

- Greg Theirl, Dominion Delivery
- Todd Thomas, NW Natural



- Jim Mansdorfer, Southern California Gas
- George Hodges, Southern Union

### **New Members**

The 2008 membership includes 43 members from 16 U.S. states and two members from Canada. Three new members have been added:

- Atmos Energy, Dallas, TX
- Enstor Operating Co., Houston, TX
- NITEC, Denver, CO

### ***GSTC Insider* E-newsletter**

The *GSTC Insider* electronic newsletter was released in February 2008. This was the first electronic newsletter for 2008. The newsletter is another method of keeping representatives informed on issues relevant to the industry. The newsletter was distributed to the GSTC list serve as well as being posted to the GSTC website.

### **Technology Transfer/Outreach**

There are several avenues for accelerating the commercialization and deployment of technology into industry. The GSTC strategy includes meetings to hear technology updates from co-funded projects, software training, and disseminating the final research results in a timely manner.

### **Technical Feasibility Evaluation of Casing Cement Leaks Final Report**

The final report for the 2006 project, Technical Feasibility Evaluation of Non-Intrusive Optical Detection, Monitoring and Preliminary Characterization of Casing Cement Leaks for Gas Wells, (URS) has been received and posted to the GSTC member's only section of the website. The report is attached as Appendix G.

**Planned Activities for Next Reporting Period**

During the next quarter the GSTC will:

- Host the 2008 GSTC Spring Meeting in Chicago, IL on April 17-18, 2008;
- Begin negotiations on subcontracts for projects identified at the 2008 Spring Meeting;
- Continue the mentoring team conference calls;
- Submit final reports for the 2004, 2005, and all 2006 reports received to DOE for posting on the public website;
- Release another online newsletter.

## **CONCLUSIONS**

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During this reporting period, the GSTC drafted and released a request for proposals. The GSTC continued planning for the GSTC 2008 Spring Meeting in Chicago, IL. Four project mentoring calls were conducted. Three new members were added this quarter. Elections were conducted for five new Executive Council members. The GSTC released an on-line newsletter. Through these efforts, the GSTC continues to improve and better serve the gas storage industry.

## **REFERENCES**

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A listing of referenced materials is required by the DOE for each quarterly technical progress report. However, this technical progress report for the GSTC did not utilize any reference materials during this reporting period.

## **APPENDICES**

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**Appendix A**  
**2008 GSTC Request for Proposals**

The  
Gas Storage Technology Consortium

**Request for Proposals  
For 2008**

**Submission Deadline:  
April 2, 2008 (4:00 pm EST)**

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## 2008 REQUEST FOR PROPOSALS FOR THE GAS STORAGE TECHNOLOGY CONSORTIUM

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### APPLICANT ELIGIBILITY

Competition is open to all current Full and University Members of the Gas Storage Technology Consortium (GSTC). The GSTC Executive Council will not review proposals without a fully executed membership agreement in place. New memberships are accepted throughout the year. Membership information and applications can be found on the GSTC website at <http://www.energy.psu.edu/gstc>. Proposals received from members whose dues are not current, or whose membership agreement is not fully executed will be returned without review.

University employees eligible to serve as principal investigators for proposals submitted to the consortium are:

- Full-time regular tenure-track or regular faculty, and;
- Persons with the title of Research Assistant, Associate, Scientist or Senior Scientist.

### INSTITUTION COMMITMENT

Each proposal must be signed by an official of the company or university who is authorized to commit the company/institutional resources to the project. The name of the Applicant's authorized official shall be entered in the appropriate space shown on the cover page (Attachment B).

### RESEARCH FOCUS AREAS

The mission of the GSTC is to assist in the development, demonstration and commercialization of technologies to improve the integrity, flexibility, deliverability, and cost-effectiveness of the nation's underground natural gas/hydrocarbon storage facilities. Projects selected for funding will be based on those that best accomplish the Consortium goals. Proposals in this funding cycle are being solicited from GSTC Full and University Members in the following focus areas:

#### ***Mechanical***

Examples include, but are not limited to, investigations that address pipe and well casing integrity, the improvement of downhole leak detection, the development of new casing evaluation tools, the development/ evaluation of advanced metallurgy/ materials for use in well casing and casing repairs, cement bonding, delta-temperature effects on casing, use of "smart pipe" concepts for well casing, corrosion mitigation and quantification, removal

*Visit the GSTC web site - <http://www.energy.psu.edu/gstc> to download this and other GSTC documents.  
Last modified on January 30, 2008.*

techniques for scales, fines, salts, asphalts, and techniques to remediate damage through stimulation/ recompletion/ workover of existing wells.

### ***Well-bore and Reservoir***

Examples include, but are not limited to, investigations that address reservoir characterization, consider new approaches to modeling of gas cycling and inventory verification, develop techniques to maintain and improve injectivity and deliverability, and expand existing aquifers and reservoirs.

### ***Operations***

Examples include, but are not limited to, investigations that address handling of produced water, techniques to minimize/mitigate water encroachment, cost effective multiphase wellhead measurement systems, design criteria for facility sizing to meet variable demand, and best practices associated with product quality shipped/delivered. In addition, applied research into the development/ evaluation of low-cost salt inhibitors to mitigate salt precipitation within the reservoir, well, and pipeline systems are being sought.

### ***Salt Cavern***

Examples include, but are not limited to, investigations that address salt cavern stability and growth rates, interconnectivity and best practices techniques for management of caverns.

The four focus areas and their corresponding examples are to be used as general guidelines for applicants. The Pipeline Research Council International (PRCI) is providing cost share to GSTC. In addition to the above, PRCI has a specific interest in the following topics:

**Deliverability maintenance and enhancement** – reduce time and cost to deliver improved storage performance (applicable to existing well maintenance/enhancement or new wells). Examples include:

- Lower cost, long lasting damage remediation, precipitate removal
- Enhanced coiled tubing delivery technology
- Improved downhole sensing devices for determining reservoir parameters and performance
- Improved reservoir characterization for quick, low-cost optimization analysis
- Develop protocol for identification and remediation of damage mechanisms impacting brine disposal wells

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Last modified on January 30, 2008.*

- Improved technology for eliminating gas hydrates in wells and pipeline systems. Must be non-damaging to reservoir and pipe
- Improved wellhead separation/filtration methods for removing produced brines and eliminating undesirables from being injected into storage. Need low maintenance cost solutions.

#### **Base gas reduction**

- Conversion to top gas capacity
- Replacement with inert gas

#### **Improved assessment of wellbore tubulars**

- Improved MFL (magnetic flux leakage) defect characterization
- Other technology (non-MFL) for defect detection
- Improved understanding of the remaining strength in wellbore casings with defects of various character (geometry, depth, general versus isolated pit, well bonded cement, no cement, poorly bonded cement, tension, etc)
- Follow-up to threaded coupling work
- Assessment of non-metallic wellbore tubulars
- Develop an operational tool to determine the maximum velocity in brine strings to avoid damage to tubulars in caverns. Examine applicability to velocity strings in reservoir storage.
- Review casing vintage/manufacturer relationship to corrosion/defects

#### **Reduced well workover costs**

- Improved casing repair methods – follow-up to assessment of casing repair alternatives
- Examine methods of recycling workover fluids for use in multiple wells
- Improved technology for removing defective casings from wellbores – present brute force methods can be time consuming and uneconomic (ripping, pulling, cutting, milling)

## AWARDS

Awards will be made on an annual basis. Subcontracts will be issued from The Pennsylvania State University to the successful applicant. The period of performance for the 2008 funding cycle will be from July 1, 2008 to June 30, 2009. Members will be permitted to submit future proposals to extend the proposed work; however, this must be performed on a year-to-year basis.

If additional documentation is required prior to issuance of a subcontract, a delay in submission of the July 1 start date may occur.

## SUBMISSION

The deadline for receipt of GSTC proposals is **April 2, 2008 by 4 PM (Eastern Standard Time)**. Proposals received after the deadline will be returned to the applicant. Applicants are to submit one original, twelve copies of the proposal, and one electronic copy in PDF format. The full proposal and a separate copy of the public abstract should be saved in PDF format on a CD or ZIP disk and submitted with the paper copies.

In addition to the proposal, each applicant is required to provide the GSTC Membership a nominal 20-minute presentation at the GSTC Spring Meeting which will be held in Chicago, Illinois on April 17-18, 2008. The 20-minute presentation will consist of a 15-minute presentation focused on the technical and budget aspects of the proposed project and 5-minute question and answer session. **The presentation is due at the time of the proposal submission.** The presentation format should be either in the form of an electronic PowerPoint presentation or in the form of overhead transparencies. The proposal packet should be submitted to the following address:

Mr. Joel L. Morrison  
Director, Gas Storage Technology Consortium  
The Pennsylvania State University  
C-211 Coal Utilization Laboratory  
University Park, PA 16802-2323

If funded, the applicant will be required to provide the GSTC membership with an annual presentation in 2008 and 2009 at the GSTC fall technology transfer meetings in addition to the required reporting requirements.

*Visit the GSTC web site - <http://www.energy.psu.edu/gstc> to download this and other GSTC documents.  
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## **PROPOSAL FORMAT**

Proposals should be formatted to fit standard 8 x 11" letter size paper with 1" margins, single-spaced, using 12 point font and be consecutively numbered at the bottom on each page.

## **SECTIONS OF THE PROPOSAL**

The proposal shall consist of the following sections in order.

### ***Proposal Checklist*** See Attachment A

The proposal checklist is required to ensure the proposal submittal is complete and that the applicant is eligible for Consortium funding consideration.

### ***Public Cover Page*** See Attachment B

The cover sheet along with the public Executive Summary will be distributed to the GSTC membership as part of the proposal evaluation process.

### ***Table of Contents*** One (1) page maximum

### ***Public Executive Summary*** One (1) page maximum

Provide a one-page summary of the proposed research. The executive summary should not contain any propriety or business sensitive data because the summary will be distributed to the GSTC membership along with the proposal cover sheet. An electronic copy of the executive summary is required. The summary will be posted to the GSTC and/or program sponsor websites if the Consortium funds the proposal. The summary should be written in the third person and include a statement of objectives and methods to be employed. It should be informative to other persons working in related fields and understandable to a scientifically or technically literate lay reader.

### ***Technology Overview*** One (1) page maximum

The technology overview section of the proposal enables the applicant to discuss how their proposed technology is different from existing technology that may be available within the industry. At a minimum the following should be discussed:

- Is the technology covered by existing patents, and if so, what are they; and
- How does the proposed technology differ from existing technology?

### ***Project Description*** Five (5) page maximum

The main body of the proposal should outline the plan of work, including the broad design of activities to be undertaken. At a minimum, the following should be discussed:

- Statement of the problem;
- Has the proposed work, or a portion of the proposed work, been funded elsewhere;
- Objectives and expected significance of the research;
- Statement of the work plan;

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Last modified on January 30, 2008.

- Relation of the proposed work to comparable work in progress;
- Description of available facilities and major items of equipment available for the work; and reference citations.

***Project Schedule*** One (1) page maximum

A plan which establishes the time schedule for accomplishing the work. The plan should include major milestones of the project in bar chart format and should cover the complete period of performance.

***Anticipated Results*** Two (2) page maximum

Discuss how the project will improve the integrity, flexibility, deliverability, and cost-effectiveness of the nation's underground natural gas/hydrocarbon storage facilities. Discuss the commercial viability of the proposed project. Identify specific groups in the commercial sector that may use the project results.

***Previous GSTC-Funded Projects*** One (1) page maximum/ project

If the applicant has been awarded GSTC-funding in previous years, the applicant is required to provide a brief summary of those projects for review. The summary for each project should not exceed one page and should contain the following:

- Project title
- Total level of funding (GSTC funding and applicant cost share)
- Description of how it has benefited the U.S. underground natural gas storage industry.
- List of companies and key contact information for those using the previously funded project results.

***Budget*** See Attachment C

The submission of a reasonable budget is an important part of the proposal. Your budget may request funds under any of the categories listed on Attachment C, as long as the item and amount are considered necessary to perform the work. Proposed equipment expenditures are permitted; but their purchase must be justified. Ownership of the equipment vests with the Pennsylvania State University and is reported to DOE on an annual basis. It is expected that the participants will already have most of the necessary permanent equipment to conduct the research. The majority of the funding is intended to support research activities. Permanent equipment purchases are discouraged and will be considered during the proposal evaluation. After approval by the Executive Council, but prior to purchase, written approval must be obtained by the Department of Energy for purchase of equipment items that have a life of 2-years or more and a cost of \$5,000 or more.

***Cost-Share Commitments***

A minimum of 40% cost-share is required for each project that is selected by the GSTC for funding. The 40% cost-share is calculated as 40% of the proposed project (i.e. the sum of the recipient's allowable cost-share and the GSTC share equals the total allowable

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costs of the project). Cost-share, which may be in the form of cash and third party in-kind, is acceptable as part of the match provided it meets the following criteria:

- Are verifiable, necessary and reasonable for proper and efficient accomplishment of the project;
- Are incurred within the project performance period. Previously expended research development, or exploration costs are unallowable.
- Are not included as contributions for any other federal project, are not paid by the Federal Government under another award, and otherwise allowable in accordance with Federal cost principles and DOE regulations governing cost sharing.
- The value of patents and data contributed to the project is unallowable as cost sharing.
- The value of salaries or wages of 1<sup>st</sup> party personnel directly involved in the project are allowed as cost share.

All cost-share commitments must be supported by appropriate documentation. Third parties proposing to provide all or part of the required cost share must include a letter from the third party stating its commitment to provide a specific minimum dollar amount of cost-share. The letter should also identify the type of proposed cost share (e.g., cash, services) to be contributed. Letters must be signed by the person authorized to commit the expenditure of funds and be provided in PDF format. Failure to provide appropriate documentation can result in the proposal being returned without review.

### ***Biographical Sketches***

One (1) page per person maximum

Vitae of key personnel involved in the project must be included and should include educational background, professional experience, research interest, honors, professional activities and relevant publications.

### ***Letters of Support***

Letters of support from outside sources are encouraged, but not mandatory.

## **PROPOSAL EVALUATION PROCESS**

The GSTC Executive Council will review and recommend projects for GSTC funding. The GSTC Director will notify all applicants within thirty (30) days of the GSTC Executive Council meeting, by letter, of the final decision regarding their proposals. The decision of the GSTC is final and not subject to reconsideration or appeal.

## **ADDITIONAL INFORMATION**

Additional questions should be forwarded to the GSTC Director. Questions should be submitted via e-mail to [gstc@ems.psu.edu](mailto:gstc@ems.psu.edu) or contact Mr. Joel Morrison at (814) 865-4802.

*Visit the GSTC web site - <http://www.energy.psu.edu/gstc> to download this and other GSTC documents.  
Last modified on January 30, 2008.*

## **ATTACHMENT A – PROPOSAL PACKET CHECKLIST**

I certify that:

- ☐ I am a current Full member of the GSTC  
☐ I am a current University member of the GSTC

Project Title: \_\_\_\_\_

Principal Investigator (PI): \_\_\_\_\_

To assure that your application is complete, please complete and paper clip (one copy only) the proposal packet checklist to the cover sheet of the original (signed) copy of the proposal. Be sure the following items are included in the following order.

- \_\_\_\_\_ Public Cover page completed and signed by PI and authorized representative
- \_\_\_\_\_ Public Executive Summary (one page maximum)
- \_\_\_\_\_ Technology Overview (one page maximum)
- \_\_\_\_\_ Project Description (five page maximum)
- \_\_\_\_\_ Project Schedule (one page maximum)
- \_\_\_\_\_ Anticipated Results (two page maximum)
- \_\_\_\_\_ Previous GSTC-Funded Work (one page maximum/ project)
- \_\_\_\_\_ Budget (Using Attachment C budget template)
- \_\_\_\_\_ Cost-Share Commitment Letters
- \_\_\_\_\_ Biographical Sketches (one page/ person maximum)
- \_\_\_\_\_ Letters of Support
- \_\_\_\_\_ One signed original copy, twelve copies, and one electronic copy of the proposal in PDF Format are due to the GSTC Consortium no later than 4:00 PM (EST) on April 2, 2008.
- \_\_\_\_\_ One electronic copy of the Public Executive Summary in PDF Format
- \_\_\_\_\_ Proposal presentation (15 minute presentation, PowerPoint encouraged)

*Visit the GSTC web site - <http://www.energy.psu.edu/gstc> to download this and other GSTC documents.  
 Last modified on January 30, 2008.*



## **ATTACHMENT B – PROPOSAL COVER SHEET**

Proposal Submitted to: Mr. Joel Morrison  
 Director, Gas Storage Technology Consortium  
 The Pennsylvania State University  
 C-211 Coal Utilization Laboratory  
 University Park, PA 16802-2308

Proposal Deadline: April 2, 2008 (4:00 PM EST)

Date of Submission \_\_\_\_\_

Title of Proposal: \_\_\_\_\_  
 \_\_\_\_\_

Company Name: \_\_\_\_\_

Principal Investigator: \_\_\_\_\_

Phone: \_\_\_\_\_ Fax: \_\_\_\_\_ Email \_\_\_\_\_

Address: \_\_\_\_\_  
 \_\_\_\_\_

Other Participants: \_\_\_\_\_

Amount Requested from GSTC \$ \_\_\_\_\_

Cost Share Commitments Cash \$ \_\_\_\_\_  
 (Minimum 40% Required)

In-Kind \$ \_\_\_\_\_

Total Project Costs \$ \_\_\_\_\_

Submitted by: \_\_\_\_\_ Approved by: \_\_\_\_\_

\_\_\_\_\_  
 Signature of PI

\_\_\_\_\_  
 Authorized Representative

*Visit the GSTC web site - <http://www.energy.psu.edu/gstc> to download this and other GSTC documents.  
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## **ATTACHMENT C – BUDGET**

Name of PI: \_\_\_\_\_

### Salaries and Wages

List individually all personnel identified in the proposal.  
Include title and percent of effort

NOTE: The use of undergraduate and graduate students is encouraged, and appropriate.

The basis for proposed percent of effort or labor hours should be identified (historical hours, engineering estimates).

REQUESTED GSTC

COST-SHARE

\$ \_\_\_\_\_

\$ \_\_\_\_\_

### Fringe Benefits

\$ \_\_\_\_\_

\$ \_\_\_\_\_

### Materials and Supplies

List types required and estimated costs.

NOTE: State whether amounts proposed are based on catalog prices or other cost estimating.

\$ \_\_\_\_\_

\$ \_\_\_\_\_

### Equipment

Items exceeding \$5,000 and a 1-year useful life are defined as permanent equipment. List item and dollar amount for each amount. Justify and/or provide quotation.

\$ \_\_\_\_\_

\$ \_\_\_\_\_

### Travel (see Note 4)

State the type and extent of travel and its relation to the project. Itemize by destination and estimated costs.

\$ \_\_\_\_\_

\$ \_\_\_\_\_

### Publication/Information Dissemination

Estimate costs of documenting, preparing, publishing and sharing research findings. Show estimates.

\$ \_\_\_\_\_

\$ \_\_\_\_\_

### Other Direct Costs

Itemize and justify. (\*See note below)

\$ \_\_\_\_\_

\$ \_\_\_\_\_

\$ \_\_\_\_\_

\$ \_\_\_\_\_

### Facilities and Administration (F&A)

Specify current rate(s) and base.

Note: A copy of the negotiated agreement should be included with the proposal. If none exists, a disclosure of the contents of the rate should be made.

\$ \_\_\_\_\_

\$ \_\_\_\_\_

TOTALS

\$ \_\_\_\_\_

\$ \_\_\_\_\_

**\*Applicants can attach up to two additional pages of justification covering items.**

**\*NOTES:**

- 1) If more than 5% of project funding is provided by the Gas Storage Technology Consortium the contracting organization must be a Full or University Member of the Consortium.
- 2) Projects that include subcontracts to current consortium members must insure the subcontract is less than 50% of the total requested Consortium funding. Budgets and work statements from each subcontractor, in the format above, should be included with the initial proposal.
- 3) Fees or profits cannot be recovered from any award resulting from this solicitation. Nor can fee or profit be considered as part of the applicant total cost-share.
- 4) The GSTC is planning to host two technology transfer workshops in 2008 and 2009. Recipients of GSTC funding are required to provide a presentation on the status of their project at these meetings if requested. The costs of attending these GSTC technology transfer meeting are to be included in the travel budget.

*Visit the GSTC web site - <http://www.energy.psu.edu/gstc> to download this and other GSTC documents.  
Last modified on January 30, 2008.*

**Appendix B**  
**RGD X-ray Technology Well Bore Inspection and Assessment -**  
**A Feasibility Study Executive Summary**

## PUBLIC EXECUTIVE SUMMARY

# RGD X-ray Technology Well Bore Inspection and Assessment - A Feasibility Study

## Research Focus Area: Mechanical

Scaling, Corrosion, Precipitates, and Casing defects are all issues storage operators face on a continual basis in managing the integrity of their gas storage assets. These issues often lead to diminished deliverability (5 to 20%), as well as casing integrity issues requiring costly remediation. The mineral scale formation and material defect assessment process in well bores is complicated, time consuming, and costly due to the range of storage conditions and existing technologies.

GTI proposes to study, develop, and demonstrate a real-time RGD tool for in-situ compositional identification and quantification of scale in gas storage wells and pipelines. The RGD tool will also assess and quantify material defects, pitting, and penetrations in casings and associated piping. The system consists of a RGX Source tube to produce and scan the object with X-rays with single exposure (with minimum dosage). An array of crystal detectors simultaneously acquires RGX-ray images from several different positions. The separate images are combined to produce individual “slices” through the object. By shifting the images with respect to one another, different planes within the object volume come into focus. This technology determines the gray value of every point in the three-dimensional space of an object that makes it possible to reconstruct any layer.

The gas storage industry will benefit from this innovative technology as it can provide real time data and analysis on both scale formation inside the well bore as well as assess the well bore casing integrity itself. The proposed technology can provide this information in a single scan, creating an ideal application of for determining pre and post remedial treatment effectiveness. The assessment process will be significantly streamlined, eliminating the delay for lab analysis and reducing rig time considerably. Cost savings will be in the tens of thousands on an annual basis for a typical integrity management program. The project goals include improved well bore integrity assessment, flow deliverability, and reduced O&M costs.

The following table summarizes the team members involved in the proposed project.

**Table 1 – Team Member Roles and Qualifications for the Proposed Project**

Team Member	Role	Qualification
Gas Technology Institute	Project Manager/Lab Analysis	<ul style="list-style-type: none"><li>• The leading natural gas R&amp;D organization</li><li>• 60 years of developed technology-based solutions for consumers, industry, and government</li></ul>
CMOSXRAY	X-Ray tool manufacturer	<ul style="list-style-type: none"><li>• 10+ years of portable X-ray tool manufacturing experience</li><li>• Equipped with large test facilities, safety and field experience</li></ul>

**Appendix C**  
**Evaluation of Magnetic Pulse Welding (MPW) for**  
**Improved Casing Repair Executive Summary**

## **PUBLIC EXECUTIVE SUMMARY**

### **Evaluation of Magnetic Pulse Welding (MPW) for Improved Casing Repair**

Principal Investigator: Mr. Matt Boring, P.E.

Edison Welding Institute, Inc. (EWI)

1250 Arthur E. Adams Drive, Columbus, Ohio 43221

Phone: (614) 688-5257, Fax: (614) 688-5001, Email: [matt\\_boring@ewi.org](mailto:matt_boring@ewi.org)

#### **Background**

Natural gas storage well casings occasionally require repair as the result of deterioration over time. Currently-used repair methods are costly and often create flow restrictions and subsequent operational limitations. Alternative repair methods for natural gas storage well casings are required to lower the costs of casing repairs and to reduce operational constraints. Magnetic Pulse Welding (MPW) was identified as one of the most promising candidate repair technologies identified by GSTC Project No. 3138-EWI-DOE-1779, State-of-the-Art Assessment of Alternative Casing Repair Methods.

#### **Objective**

The objective of this project is to determine the feasibility of using Magnetic Pulse Welding for improved casing repair.

#### **Statement of Work**

The statement of work is summarized as follows:

- Development of a Robust Coil System Design for Repetitive Use
- Numerical Modeling to Determine Initial Welding Parameters
- Coil Fabrication
- Welding Evaluation Trials
- Reporting

#### **Budget and Duration**

The project is estimated as a 12 month, \$150,750 effort. The portion of the estimated cost that is being cost shared by PRCI and Whipstock Natural Gas is \$60,750.

#### **Anticipated Results**

If Magnetic Pulse Welding is determined to be feasible for casing repair, use of this process will potentially reduce the costs of repair and reduce operational constraints following repair.

#### **Contractor Information**

Based in Columbus, Ohio, EWI is North America's leading engineering and technology organization dedicated to welding and materials joining. EWI's staff provides materials joining assistance, contract research, consulting services, and training to over 3,300 member company locations representing world-class leaders in the aerospace, automotive, defense, energy, government, heavy manufacturing, medical, and electronics industries. Cost sharing contribution is being provided by Pipeline Research Council International Inc. (PRCI).

**Appendix D**  
**Gas Storage Facility Design Under Uncertainty Executive Summary**



## **Gas Storage Facility Design Under Uncertainty**

### **Public Executive Summary**

During the concept comparison phase of gas storage projects, many estimates are required to value the development scenarios under consideration. These estimates determine which concept proceeds into front end engineering and design. Estimates are required for reservoir attributes, surface facility costs, construction schedule, facility performance attributes, and market demand and price. The importance of these estimates cannot be overstated, they determine which concept is selected for development, the configuration and sizing of facilities, project timing, maximum injection and delivery rates, and ultimately, the value derived from the project.

This research project examines the sensitivity of gas storage facility design decisions to uncertainty in the estimates used during concept comparison and selection. There are two research objectives. (1) To investigate how uncertainty in estimates influences optimal facility sizing and other design decisions. (2) To assess the relative value of reducing uncertainty in these same estimates.

The first objective is accomplished using a stochastic simulation approach (Monte Carlo). The second objective employs the same approach but integrates it within a value-of-information framework. That is, reducing uncertainty increases project value—the question to be asked is “by how much?” The researchers will specify a dynamic optimization model of a greenfield and/or brownfield gas storage project assuming a risk-neutral, profit-maximizing decision-maker. Real options to expand will be fully accounted for in the model.

The project will yield practical and valuable deliverables that provide insight into which estimates “matter most” to project value:

1. A quantitative and qualitative assessment of the sensitivity of gas storage design decisions to uncertainties in estimates used during concept comparison;
2. A detailed value-of-information analysis that provides information on the relative value of reducing the uncertainty of estimates;
3. A workflow that incorporates the learning from the above assessment and analysis, including (a) a toolbox of specific planning aids for engineering teams to use in facility design given a particular project’s attributes and uncertainties, and (b) guidelines for decisions to collect, or not to collect, additional information to reduce uncertainty.

**Appendix E**  
**Smart Gas: Using Chemicals to Improve Gas Deliverability –**  
**Phase II Executive Summary**

***Public Executive Summary***

Each year, more than 17,000 gas storage wells in the United States lose from 3–5% of their storage capacity and deliverability. The gas storage industry spends \$80–100 million annually to revitalize existing wells with methods such as mechanically removing debris, washing, injecting acids, and creating new perforations in the well pipe. Only limited and temporary improvements have been achieved. There is a need to cost effectively increase the deliverability and hence the flexibility of the Nation's underground gas storage facilities.

It is known that water-wet porous media imbibe water in a fashion similar to water rising in a glass capillary tube. In the reservoir of a gas storage well, the imbibition force promotes the retention of water in the pore space, which curtails the deliverability of gas to the wellbore during periods of high demand. Similarly, the injection of gas during the fill cycle is restricted. In addition, the pore space occupied by irreducible water is not available to hold gas.

The overall objective of the proposed project is to develop new technology to improve gas deliverability from gas storage wells. During the first year of the original project, two cost-effective surfactants were selected from 11 candidates through screening tests prior to reservoir core tests. Reservoir cores from three gas storage facilities including sandstone and dolomite reservoirs were used to evaluate the two surfactants. The imbibition and core flood tests showed that gas deliverability and storage capacity were improved in surfactant-treated sandstone cores. However, the surfactants had a very limited effect on dolomite cores. An engineering analysis was conducted to develop an analytical method to evaluate future field tests of the new technology. It was concluded that the aquifer storage facilities are candidates for field testing. Results from the first year provided the foundation for this continuation project.

During Phase II, we propose to field test the surfactant that produced favorable laboratory results. Two operators of aquifer gas storage sites are interested in testing the wettability-altering concept. The analytical approach developed during the original project will be used to evaluate the proposed field tests. Many variables are expected to affect the field results. New smart technology based on fuzzy logic and neural networks will be used to analyze the results of the field tests and generate correlations that will optimize future commercial applications.

Although storage facility costs where gas is bought and sold remain relatively constant, the economic benefits of increasing gas deliverability by 50%, while difficult to quantify, should be considerable. Operating economics are frequently proprietary in this competitive industry making a detailed economic analysis difficult, but the improved flexibility in the form of greater deliverability could significantly increase profitability.

Laboratory results consisting of screening additional surfactants, crude oil, and crude oil plus surfactant will be compared to the two surfactants known to be effective. An additional laboratory screening technique based on contact angle observations will be examined. The use of a centrifuge technique for evaluating changes in core wettability induced by surfactants will be investigated.

Correlations Company staff has experience directing both university research programs and the application of laboratory results to commercial oilfield projects. The company has considerable experience with reporting requirements and has successfully completed several Department of Energy-funded projects.

**Appendix F**  
**2008 GSTC Executive Council Ballot**



# GAS STORAGE TECHNOLOGY CONSORTIUM

**Company Name:** \_\_\_\_\_

**Your Name:** \_\_\_\_\_

**Indicate your selection of five (5).**

## **GSTC Executive Council Election Form**

*See the following pages for a brief description of each nominee's experience and/or credentials.*

- ☐ Thomas Stemmer, *Basic Systems, Inc.*
- ☐ Larry Kennedy, *El Paso Corporation*
- ☐ Brian Hall, *Equitable Resources*
- ☐ Andrew Hammerschmidt, *Gas Technology Institute*
- ☐ Ramon Harris, *National Fuel*
- ☐ Steve Bergin, *Oneok, Inc.*
- ☐ Ken Brown, *Schlumberger Data and Consulting Services*
- ☐ John Jackson, *Spectra Energy*

**Return Deadline:** January 24, 2008 (5 PM EST)

**Fax completed form to:** GSTC Director, (814) 863-7432

### **Thomas Stemmer** (*Basic Systems, Inc.*)

Basic Systems provides engineering services to the natural gas industry. Our primary focus is in the design of facilities such as compressor stations – both transmission and storage, gas treatment and dehydration, metering and regulation. Basic has experience in the design of many storage facilities for members of the Consortium. 75 employees, Nationwide Service Area.

Tom has 26 years of natural gas engineering experience in the design of compressor stations, dehy facilities, meter and regulation stations. The last 3 years have been in his current position as President of Basic Systems. Tom is responsible for the leadership of the company. Basic Systems is continuously evaluating the industry and looking into the future. As such, Tom can provide valuable business experience into new areas of development as the Consortium moves into the future.

### **Larry Kennedy** (*El Paso Corporation*)

El Paso pipeline group is the largest United States pipeline. El Paso Corporation's pipelines (CIG-Colorado Interstate Gas Company, SNG-Southern Natural Gas, TGP-Tennessee Gas Pipeline, and EPNG-El Paso Natural Gas Company) operate 43,000 miles pipelines and transporters ¼ of the total throughput in the United States. In addition El Paso's pipelines operates 9 natural gas storage fields and 450+ storage wells in Colorado, Kansas, New Mexico, Pennsylvania, Mississippi, and Louisiana and jointly owns 3 fields in New York and Pennsylvania.

I have been employed by the El Paso Corporation for 22 years. Prior to 2001, I held various engineer and supervision positions in the reservoir and production departments within CIG. In 2001, I became Manager of El Paso's Western Pipelines storage department and my responsibilities included monitoring the integrity and reliability of the CIG and EPNG storage fields. Beginning in February 2006, my responsibilities were expanded to include the storage fields on the TGP and SNG pipeline systems.

Since, 2002 I have been El Paso's representative on PRCI's Underground Storage Committee and participated on various research projects. The first two years of the Gas Storage Consortium I served a two year term on the Executive Council.

As a storage operator it is important that the storage industry continue to invest in research that ensures the storage fields continue to provide a safe, economical, and reliable service.

### **Brian Hall** (*Equitable Resources*)

Equitable Resources owns and operates gas transmission, storage and gathering facilities in southwestern Pennsylvania and north central West Virginia.

I graduated with a BS degree in Geology from West Virginia University in 1988 and have worked in the gas industry ever since, with a brief stint in environmental. Some of the positions that I have held during my career are, Core Analyst for Core Laboratories, Junior Field Engineer for Atlas Wireline, Production Geologist for two independent producers, Geologist and Project Manager for Strum Environmental and currently hold the position of Manager of Storage Well Operations. My current responsibilities include the planning and management of Surveillance Logging, Top Joint Repairs, Workovers, Well Testing, Coiled Tubing Clean-outs, New Drills and Plugging. I believe with my varying work experience I can address any aspect involved in the operations of gas storage facilities.

**GSTC Executive Council Nominees cont.**

**Andrew Hammerschmidt** (*Gas Technology Institute*)

The Gas Technology Institute is a private, not-for-profit research institute headquartered in Des Plaines, Illinois. It performs research and development in all phases of the gas industry, including underground gas storage. GTI has a staff of more than 250, approximately 40% of whom perform scientific research.

I have been involved in the natural gas storage industry for over 10 years, the past 3 in research and development as an employee of GTI. I am currently managing the Gas Storage and Transmission Pipeline Research Program as well as performing on individual gas storage focused projects. Prior to joining GTI, I spent 8 years with Nicor Gas, holding supervisory positions within Supply Operations, Storage Development, Reservoir/Production Engineering, and Distribution Operations.

**Ray Harris** (*National Fuel Gas Supply*)

National Fuel Gas Supply represents the Pipeline & Storage segment of National Fuel Gas, an integrated energy company with approximately 2,000 employees. Supply owns and operates 32 gas storage fields along its 2,972-mile transmission system located in western New York and western Pennsylvania. Other primary segments of the corporation includes Utility - Gas distribution in Western NY and northwestern PA, Exploration & Production - TX, LA, AL Gulf Coast, CA, and the Appalachian basin.

I am the general manager of gas storage at National Fuel and have combined gas storage experience of 21 years with National and Columbia Gas. I have been involved in gas storage research groups for 18+ years. I am the current chairman of the PRCI Storage Committee, past chair of the AGA Underground Storage Committee, and have served on the GSTC executive council. My involvement with the numerous groups has given me a broad base of understanding of the concerns of the industry. I have demonstrated the ability to pool resources together to further meaningful R&D programs in times of limited funding. I think my experience and enthusiasm will be helpful to the council over the next two years of changing times in R&D and the industry as a whole.

**Steve Bergin** (*Oneok, Inc.*)

Oneok is a diversified energy company and the general partner of Oneok Partners, one of the largest publicly traded limited partnerships. Oneok, Inc. and Oneok Partners gather, process, transport, store, distribute and provide energy services for both natural gas and natural gas liquids. Oneok Partners owns and operates natural gas underground storage facilities in: Kansas, Oklahoma, and Texas. Oneok Partners also owns and operates natural gas liquids underground storage facilities in: IA, IL, KS, OK and TX.

I have been employed for various aspects of underground storage engineering for the past 28 years. Currently, the Manager, storages and reserves for Oneok. Oneok owns and operates underground storage facilities for natural gas and natural gas liquids in depleted reservoirs, domal salt formations, bedded salt formations and in conventionally mined hard-rock formations. All storage operators share most of the same technology constraints and working together to address these constraints holds great promise for all involved in this critical segment of our energy infrastructure.

---

Reply to: **Joel L. Morrison** • GSTC Director

The Energy Institute, The Pennsylvania State University • C-211 CUL • University Park, PA 16802-2323  
phone – 814.865.4802 • fax – 814.863.7432 • email – [gstc@ems.psu.edu](mailto:gstc@ems.psu.edu)

Visit the GSTC web site at: <http://www.energy.psu.edu/gstc>

### **GSTC Executive Council Nominees cont**

#### **Ken Brown** (*Schlumberger Data and Consulting Services*)

Schlumberger is the leading oilfield services provider, trusted to deliver superior results and improved E&P performance for oil, gas, and gas storage companies around the world. The Pittsburgh DCS office, previously Holditch Reservoir Technologies, has been involved with numerous domestic and international underground gas storage projects since 1988, and has worked on several projects with GRI, DOE and NYSERDA.

Ken has BS and MS degrees in Petroleum and Natural Gas Engineering from the Pennsylvania State University. He worked for several major oil and gas operators including Marathon (in their offshore Gulf of Mexico operations), Shell (in their California thermal recovery operations), TOTAL (in their south Texas in-situ uranium leaching operations), and Michigan Consolidated Gas (now DTE) - a major Midwest Gas Utility (in their underground gas storage operations). Ken also has considerable experience in the consulting sector with S.A. Holditch & Associates and Schlumberger Data and Consulting Services, where he has focused primarily on gas storage projects during the last 15 years.

#### **John Jackson** (*Spectra Energy Transmission*)

Spectra Energy was spun off from Duke Energy in early 2007. Spectra operates about 17,500 miles of transmission lines primarily in the eastern U.S. and Canada. Spectra has about 265 Bcf of working gas storage capacity in the U.S. and Canada. Spectra operates reservoir, salt dome and bedded salt gas storage facilities (as well as one liquid storage facility) primarily in the Gulf Coast, the northeast U.S and Ontario Canada.

I have 25 years experience in the natural gas industry with over half of that time being directly involved in gas storage. My current responsibilities involve the operations and reservoir engineering of our U.S. gas storage fields. I believe that I could represent a diverse range of storage operators both geographically as well as type of storage facility.

.

---

**Reply to: Joel L. Morrison • GSTC Director**

The Energy Institute, The Pennsylvania State University • C-211 CUL • University Park, PA 16802-2323  
phone – 814.865.4802 • fax – 814.863.7432 • email – [gstc@ems.psu.edu](mailto:gstc@ems.psu.edu)

**Visit the GSTC web site at: <http://www.energy.psu.edu/gstc>**



**Appendix G**  
**Technical Feasibility Evaluation of Non-Intrusive Optical Detection,**  
**Monitoring and Preliminary Characterization of**  
**Casing Cement Leaks for Gas Wells**

***Technical Feasibility Evaluation of Non-intrusive Optical  
Detection, Monitoring, and Preliminary Characterization of  
Casing Cement Emissions of Gas Wells***

Final Report

Reporting Period Start Date: June 1, 2006

Reporting Period End Date: December 31, 2007

Principal Authors: Glenn DeWolf, Dr. Mark Eltgroth, Dr. Curtis Laush

February 28, 2008

Gas Storage Technology Consortium

Subcontract No. 3146-URSGI-DOE-1779

URS Corporation

9400 Amberglen Blvd

Austin, Texas, 78729

## **DISCLAIMER**

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## **ACKNOWLEDGEMENT**

The authors gratefully acknowledge the support of the GSTC for supporting this work and the co-funding support from Boreal Laser, Inc. and URS Corporation. Thanks are offered also to the operators who volunteered their facilities for the well tests.

## ABSTRACT

Natural gas losses from underground storage are an economic loss and are undesirable for other reasons. Pathways for surface emissions from gas wells are the deterioration of the exterior casing cement at the outer casing wall and the borehole wall and casing defects. Emissions from casing defects can occur as venting from annular spaces between casings even when cement is intact. The emission rate can be a measure of the integrity degradation of both casings and casing cement. The rapid and cost effective detection and measurement of surface emissions for both active and abandoned wells, has value to the industry in terms of economic, environmental, safety, and operational benefits.

This work was a trial feasibility evaluation of Tunable Diode Laser (TDL) remote optical sensing device for determining gas emissions in active or abandoned wells in gas storage fields. It is also applicable to surface seepage from natural fissures not associated with wells. In this project, TDL measurements of methane concentrations in the air near wellheads in a gas storage field were analyzed using a modified gas dispersion model to estimate the emission rate from active well vents. Qualitative observations were also made regarding requirements for a practical protocol for using the TDL method in the rugged and forested terrain areas of the type encountered in this project. The project has determined requirements for completing a practical protocol for such a detection and measurement method. Modeling of TDL measurements can reasonably estimate emissions. However, additional work beyond the current project would be needed to provide a fully developed practical method and protocol with a defined level of accuracy and precision.

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## **Technical Feasibility Evaluation of Non-Intrusive Optical Detection, Monitoring and Preliminary Characterization of Casing Cement Emissions for Gas Wells**

### **INTRODUCTION**

This report presents the results of an initial feasibility study: *Technical Feasibility Evaluation of Non-Intrusive Optical Detection, Monitoring and Preliminary Characterization of Casing Cement Emissions for Gas Wells*, Gas Storage Technology Consortium (GSTC) Subcontract No. 3146-URSGI-DOE-1779. It focuses on results from a preliminary field test for the application of a Tuned Diode Laser (TDL) for detecting and measuring airborne concentrations of methane from gas well surface emissions in gas storage fields. It describes the collection of data, analysis of the data, dispersion modeling associated with data analysis, and estimating emission rates from the measured ambient concentrations of methane in the downwind gas plume from the emissions. The purpose of this work is to provide a preliminary feasibility analysis of the TDL optical method as a potential low cost detection and measurement that might be amenable to routine field application by gas storage operators.

General practice today uses other methods of direct detection and measurement. However, many emissions are indirectly accounted for by differences between injection and withdrawal quantities. Differentiation between well emissions from downhole pathways and surface equipment emissions (equipment fugitive emissions) is not always made. Improving individual well emissions detection and measurement by low cost and easy to apply methods is a desirable goal for reasons of business economics, storage integrity enhancement, safety, and environmental stewardship, especially with regard to methane in natural gas as a potent Greenhouse Gas (GHG).

The intent of this study was to determine if a TDL method and field protocol might be technically and economically feasible and hence worthy of further development, based on some initial field tests and evaluation of the results. Various optical methods other than TDL are available, continue to be developed, and have been applied in the industry. However, it appeared that the TDL had particular advantages for the current application, and so it was selected for evaluation. It is believed that application of the TDL method in the current context was a new approach to a segment of the industry for which these methods had not yet been generally used, or used at all.

The overall project was conceived as a potential means to provide an additional tool to enhance gas well integrity management related to casing and cement deterioration over time. The incentive is ultimately the adverse impacts associated with:

- Uncontrolled gas losses;
- Unscheduled emergency well-maintenance interventions;
- Potential safety issues;



- Environmental issues associated with methane gas and other natural gas constituent emissions; and
- Regulatory and corporate image issues associated with well emissions.

The premise of the subject study is that TDL detection and measurement method might be integrated into an operational protocol that will enhance well integrity work processes, procedures, and practices, and add value in planning well maintenance and repairs. Using a TDL, the path-averaged concentrations of methane from well emissions would be detected and measured down wind from the emission source. At the same time meteorological conditions of wind speed, direction, and temperature would be measured. The time averaged data would be input to a dispersion model that would calculate an emission rate. The full details of method, data to be collected, and correlations necessary to allow the use of the data to estimate the emission rate will all have been established in a final Protocol. The current study is a preliminary screening to assess the feasibility of developing such a Protocol.

In conjunction with the TDL spectrometer used in this study, supplied by Boreal Laser, Inc. (Ref.1) the URS *Complex Hazardous Air Release Model* (CHARM®) gas and vapor dispersion model (Ref. 2) was used to process the measured field data into an estimated emission rate. Measurements were for the methane gas plume from well vents associated with well casing annulus emissions. Previous work by others has demonstrated the effectiveness of the TDL method for detecting and measuring methane emissions using releases metered from gas cylinders and actual fugitive emissions from operating natural gas facilities. It was not known to have been applied to gas storage field well emissions. A distinctive feature of the current work was also application of the method in spatially confined settings, close to the emission source compared with earlier tests by others in more open areas farther from the emission source. This difference affects the ease applying dispersion modeling for emissions estimation. The application is more difficult in spatially-confined settings.

Two volunteer operators offered wells for testing. Wells were selected for testing based on availability and known gas emission rates from previous measurements by other means. Other criteria included reasonable accessibility and “representative” well architecture and wellhead configurations. The timing of testing also had to coincide with acceptable weather conditions and other scheduling considerations. Because this was a relatively small project, there were other constraints on choices.

The original intent was to carry out tests for a single well. However, the proximity of several wells made it possible to test a total of six. Of these three were examined in detail and the others were used for additional measurements and qualitative data analysis. The tests were limited because the current project was conceived as a feasibility or proof concept study, the results of which would be used as a decision tool for determining if additional investigation was warranted. Field test results from this work would not necessarily be conclusive on a stand-alone basis. Tests were carried out during the week of September 22, 2006 in gas storage fields in the northeast.

The remainder of the report discusses the following items defined in the GSTC contract, Section 4.7, page 29 of 39 as required report content:

- Experimental Apparatus;
- Experimental and Operating Data;
- Data Reduction; and
- Hypothesis and Conclusions.

These items have been addressed as content in the following, remaining sections of this report:

## EXECUTIVE SUMMARY

## EXPERIMENTAL

- 1 Test Apparatus
- 2 Methodology
- 3 Test Data Reduction and Analysis

## RESULTS AND DISCUSSION

- 1 Data Analysis Results
- 2 Discussion of Findings
- 3 Technical Feasibility Evaluation
- 4 Economic Feasibility Evaluation
- 5 Proposed Protocol Outline

## CONCLUSIONS

## REFERENCES

## EXECUTIVE SUMMARY

Natural gas losses from underground storage are an economic loss and are undesirable for other reasons. Pathways for surface emissions from gas wells are the deterioration of the exterior casing cement at the outer casing wall and the borehole wall and casing defects. Emissions from casing defects can occur as venting from annular spaces between casings even when cement is intact, in the borehole. The emission rate can be a measure of the integrity degradation of both casings and casing cement. The rapid and cost effective detection and measurement of surface emissions for both active and abandoned wells, has value to the industry in terms of economic, environmental, safety, and operational benefits.

This work was a trial feasibility evaluation of Tunable Diode Laser (TDL) remote optical sensing device for determining gas emissions in active and abandoned wells in gas storage fields. It is also applicable to surface seepage from natural fissures not associated with wells. In this project, TDL measurements of methane concentrations in the air near a wellhead in a gas storage field was analyzed using a modified gas dispersion model to estimate the emission rate from an active well's casing vent. Qualitative observations were also made regarding requirements for a practical protocol for using the TDL method in the rugged and forested terrain areas of the type encountered in this project. The project has determined requirements for completing a practical protocol for such a detection and measurement method. Modeling of TDL measurements can reasonably estimate emissions. However, additional work beyond the current project would be needed to provide a fully developed practical method and protocol with a defined level of accuracy and precision.

Results from the best data set in terms of minimal variability in wind direction and speed, and in TDL measurements data were used as data input to a commercial dispersion model. The basic model was fitted with a special input modification aligned with the specific needs of data analysis from TDL measurements. From the measurements, the emission rate of the well selected for final data analysis yielded an emission rate about four times the average reported from measurements by other means outside of this project. The project estimate was based on a short interval value where the least statistical uncertainty was likely in the computed result. The operator indicated that emissions from the wells can sometimes fluctuate significantly. Given the short data interval of about one minute used to estimate a near instantaneous emission rate, for modeling reasons with minimal uncertainty for the available data set, it was concluded that the result was reasonable.

Based on the testing, data analysis, and observations in this study, it is clear that additional work will be required in further testing under actual field conditions to finalize a protocol for the proposed methodology, in the kinds of settings encountered in the current tests. Special emphasis will be on better understanding the effects of wind conditions. With additional field work and modeling it is believed that a practical protocol will be feasible. The report discusses some the remaining technical needs in detail and some corresponding economic implications. It also outlines the contents of a proposed protocol. The protocol might include the combined use of other methods, in conjunction with and complementary to the TDL method.

## EXPERIMENTAL

### 1.0 Test Apparatus

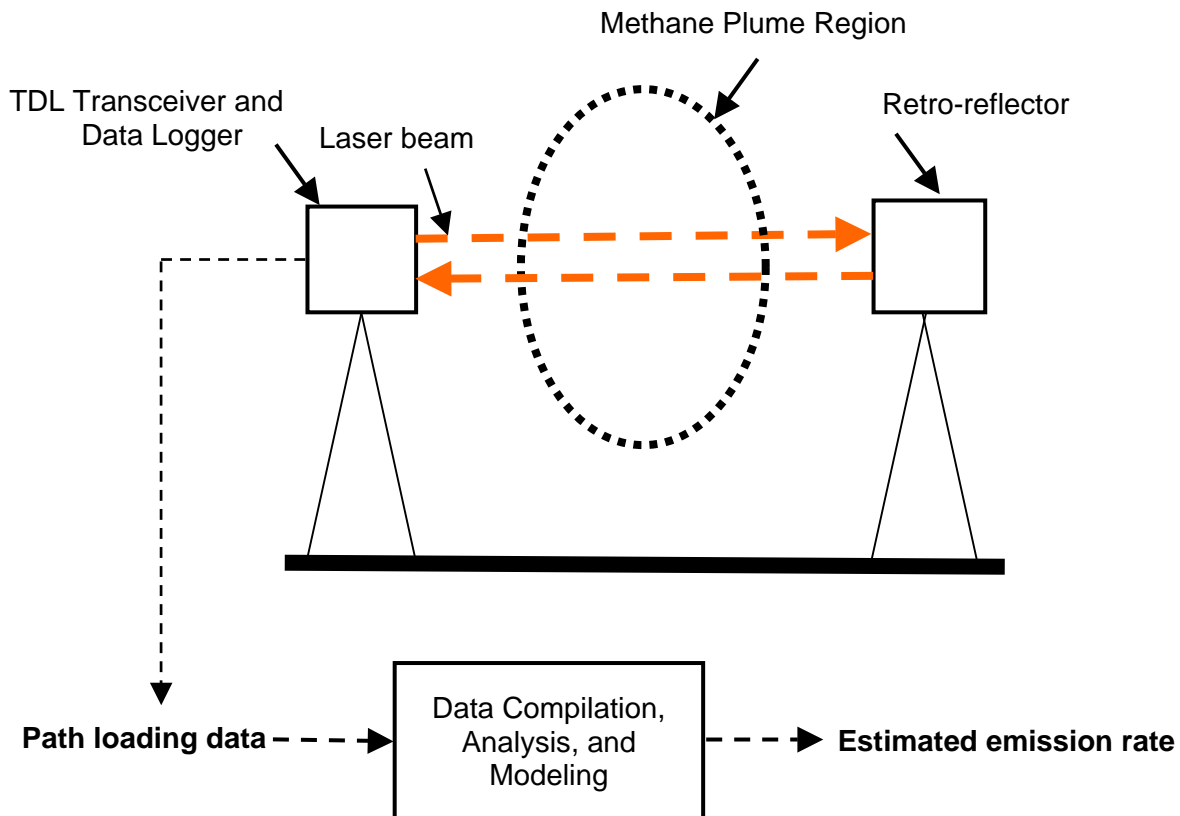
A Boreal Laser, Gas Finder – 2 (from Boreal Laser, Inc.), Tuned Diode Laser (TDL) transmitter/receiver and reflector system was used in this project (Ref. 1). The TDL equipment is described in detail in Appendix A. Other equipment consisted of a standard portable meteorological station (met station) and laptop computers for data transfer and analysis. The apparatus was used to detect and measure the concentrations of methane in the ambient air in the vicinity of the gas storage field wellheads. The data was input to a gas dispersion model to estimate the emission rate.

The emissions being measured can occur at two locations at the base of a gas well head. They can occur: 1) in the wall of production casing, which allows gas to migrate into an annular space between the production or inner casing wall and the next layer of concentric casing, and to discharge through an annular vent at the top of the well, or 2) from the production zone (or a higher geological stratum) up the borehole through defects in the outer casing cement.

Emissions are also possible from defects or loose joints in aboveground piping components in the wellhead. In order to distinguish between these and borehole or casing flaw emissions it is necessary to conduct separate measurements. For this study the above ground equipment was believed to be tight with no fugitive emissions.

The measurements comprised transmitting the laser beam across several paths in the ambient air region downwind of the wellhead at a convenient elevation. The TDL emits a laser beam from a transceiver unit through the atmosphere to a retro-reflector positioned at a distance referred to as the path length. A reflected beam travels back to the transceiver unit where the signal is converted to concentration data (e.g., units of parts per million by volume, ppm) or path-loading data (e.g., ppm-meter) and electronically logged. The concentration is recorded electronically in the instrument electronic memory and can be observed on a digital readout screen on the back panel of the apparatus. The instrument yields a direct reading the methane concentration for the selected path based on an electronic sampling interval of about one to three seconds. Measurements for a given path were recorded for periods of about twenty minutes or more and subsequently downloaded to a computer for data processing and use in the dispersion model. Various paths can be scanned to provide a spatial concentration profile according to the purpose of the measurements. The path length is defined by the distance between the TDL transmitter and retro-reflector. Modeling is described later in this report.

A schematic representation of the method's measurement set-up is shown in Figure 1.



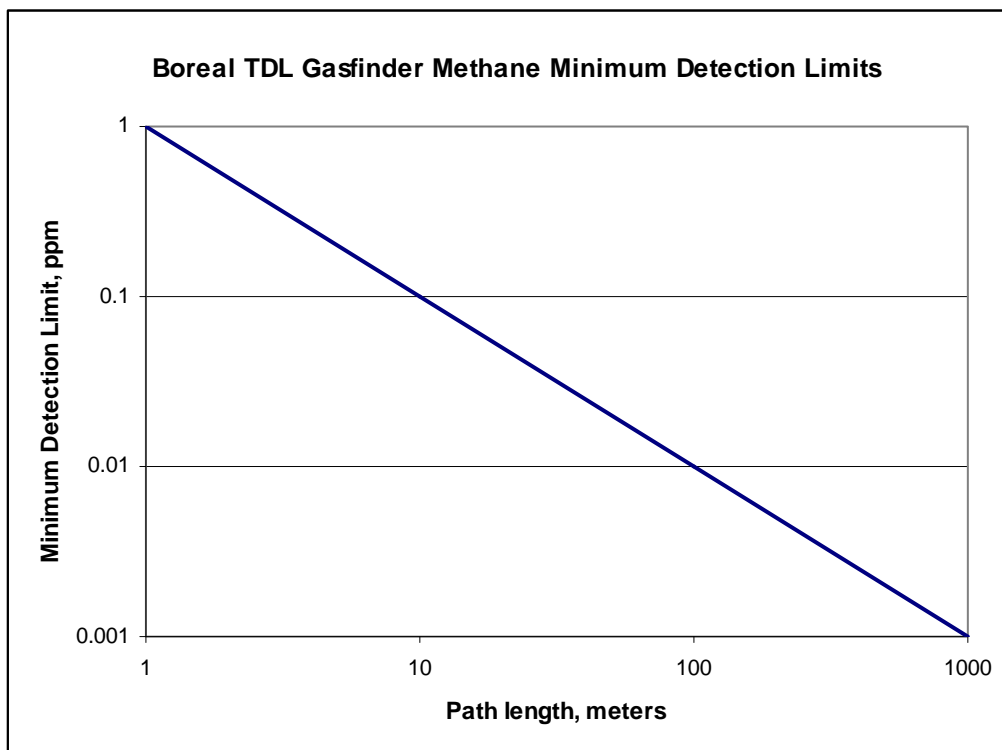
**Figure 1. General Set-up Schematic for a Measurement Path**

In addition to the TDL devices, a standard met station measured wind speed, direction, and ambient air temperature, data for which were automatically recorded and downloaded to a computer for later data processing. Sampled met data were averaged over one minute intervals with the particular device used. The met station consisted of the following equipment:

- MetOne 010C wind speed;
- MetOne 020C wind direction;
- MetOne 064A-5980 ambient temperature with gill, naturally-aspirated housing; and
- Campbell Scientific 10X datalogger.

The TDL detection limits depend on the gas or vapor species and the path length. A minimum detection limit (MDL) can be specified based on the path length available. Conversely the path length required can be determined based on the desired MDL. At some point the path length becomes limiting for a given device and corresponding electronics configuration.

Figure 2 shows the TDL minimum detection limits (MDL) for methane with path length, based on technical literature data (Ref 5). The detection limit decreases linearly with the increasing path length. A typical path length in many applications has been about 100m, but a path length up to 1 km is possible (Ref 5). For this project path lengths were in the range of 10 to 30 meters.



**Figure 2. Minimum Inherent Methane Detection Limits**

In the atmospheric environment, the TDL is operating in an environment with a background methane concentration of about 2 ppm. Therefore, the ability to detect small emission rates depends on the resolution of the TDL to detect concentrations above the background. That resolution is governed by the inherent stability of the background measurement relative to the difference in concentration above background. Assuming that for a given data set the background variability was less than  $\pm 25\%$ , the working baseline would be  $2 \text{ ppm} + (0.25/2 \text{ ppm}) = 2 + 0.5 = 2.5 \text{ ppm}$ . Consistent values above 2.5 ppm would represent a contribution from an emission source. In Table 1, the MDL range effectively demonstrates sensitivity, and implies resolution. Small changes above the background are easier to detect at greater path lengths.

**Table 1. Tuned Diode Laser Inherent Minimum Detection Limits (MDL) for Methane in Absence of a Background Level**

Path Length		MDL Range (ppm)
(m)	(ft)	
1	3.24	1 - 2
10	32.4	0.1 – 0.2
20	64.8	0.05 – 0.1
40	129.6	0.025-0.05

Figures 3 and 4 show the TDL equipment used in the current project and Figure 5 shows a typical field set up with the transceiver and retro-reflector in place of a specific path. Figure 6 shows an infrared video camera also used to observe methane plumes at the well emission source. Descriptive material on this equipment is available from the vendor (Ref. 3). Its use and significance to the project is discussed later in this report.



**Figure 3. Boreal Laser TDL Transceiver**



**Figure 4. Example of TDL Transceiver in Field Position**





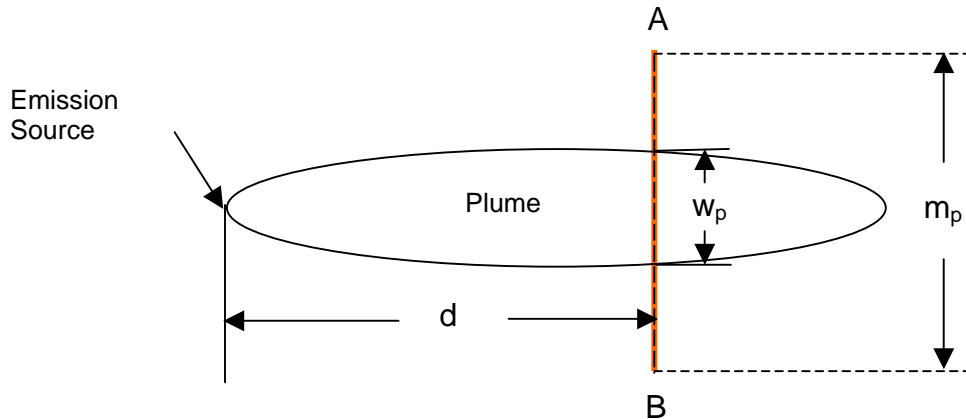
**Figure 5. Example of TDL Retro-reflector in Field Position**



**Figure 6. Infrared Video Camera Used for Spotting Emission Plume at Source**

## 2.0 Methodology

Figure 7 illustrates the concept of TDL gas plume concentration measurement. The TDL device measures a path across the plume of high methane concentration as well as some distance outside of and on each side of the plume as illustrated in Figure 7.

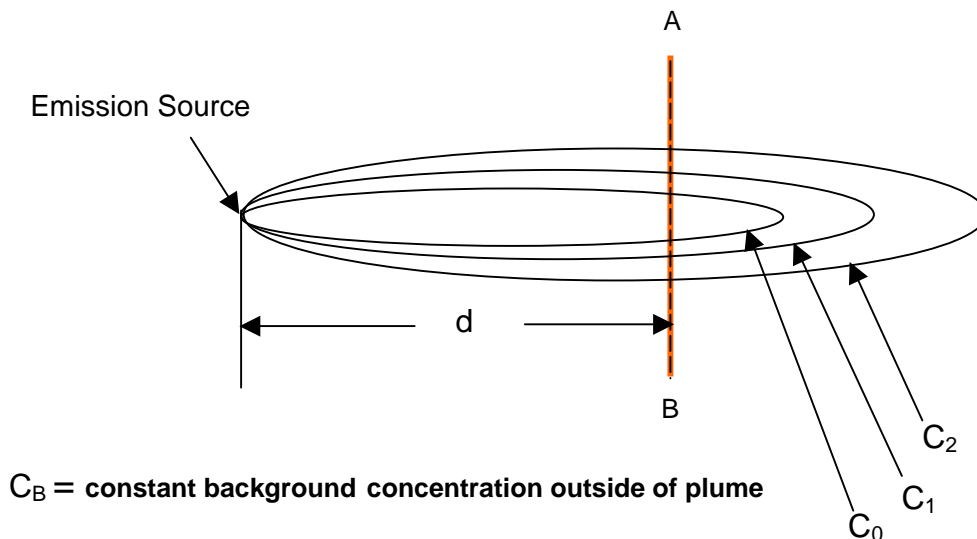


**Figure 7. Illustrative Diagram of Relationship between Plume Measurement Location Parameters**

For any distance “ $d$ ” along the plume centerline, there is a path length, “ $m_p$ ”, and a plume width “ $w_p$ ” along the path. The TDL instrument reading is the average methane concentration along the path length, where the transmitter is at A and the reflector at B.

Depending on the specific conditions of an emission and positioning of the TDL equipment, the path may lie partly within the plume and partly outside the plume as shown in Figure 7, or lie entirely within the plume. The plume boundary is defined as the concentration contour where plume methane concentration matches the background methane concentration. The plume boundaries represent the average boundary of the plume over a specified averaging time. The exact location and extent of the plume boundary is an unknown until after measurements are taken. However, it does not matter for emission detection or emission rate estimation based on dispersion modeling. Detection merely requires that a path cross the plume at some point. Estimation of emission rate merely requires that the path be accurately mapped relative to the emission source. The path measurement averages the concentration gradient within the plume and outside the plume.

Figure 8 is an illustrative schematic the concentration gradient within the plume represented by three isopaths (contours of constant concentrations). Outside the plume the background concentration remains essentially constant.



**Figure 8. Illustrative Diagram of Relationship between Plume Isopleths along Measurement Path**

The field activities consisted of the following general steps:

- Reviewing site conditions and the prevailing wind direction for placement of the measuring equipment in a downwind direction;
- For each path: positioning the equipment relative to a best estimate of the probable plume location;
- Setting up and aligning the equipment;
- Taking the measurements; and
- Taking down the equipment.

Apparatus was set up with an appropriate positioning of the tripod mounted TDL transceiver and retro-reflector, each tripod mounted, to provide a measurement path across the estimated gas plume location, downwind of the emission source at the wellhead. In these preliminary tests, positioning was intended to provide at least indicative and not necessarily conclusive results of specific plume positions or paths within the plume. Positioning was based on previous staff experience with plume measurements, the available equipment, and some rough preliminary modeling of plume behavior using the URS Complex Hazardous Air Release Model (CHARM®).

The data for an individual measurement path is expressed as a path-loading in units of concentration-length (e.g., parts per million (ppm) – meter (m)). The loading divided by the path length yields the average gas concentration for the optical path.

The background methane concentration was obtained by positioning the apparatus upwind of the wellhead. This was done to confirm that the background in the work areas was comparable to the general atmospheric background of approximately 2 ppm. Higher levels would indicate the proximity of an emission source other than the one being measured. This background level was confirmed in the field and had also been confirmed in a lab with the equipment prior to going into the field.

Operation of the TDL detector followed the procedures outlined in the manual included in Appendix A. A sampling rate of one per second was used.

The met station was set up near the measurement path in a manner that would not interfere with the optical line of sight. Meteorological data was acquired at a 1 to 2 second sampling rate and collected at 15-second, 1-minute and 5-minute averaging intervals.

Tests were conducted with site conditions as they were at the time, conditions that were not always ideal, but were, in fact, what the methodology would face in actual practice. This was deemed to be a better approach for an initial feasibility study than consuming resources in controlled conditions that might not prove practical in a field application. Other studies had shown the capabilities of the TDL so that the emphasis in this initial study was to subject the method to conditions not explored before that were specific to the current proposed application.

The field conditions had relatively calm wind conditions overall, but the characteristics of the test sites are believed to have contributed to local turbulence effects that had to be accounted for in the data analysis. Temperature and humidity were measured but are not a highly significant factor with the outcome. Both wind speed and direction were measured. Wind direction was the dominant variable that affected results.

All tests were conducted on emissions from well casing vents. The location of the height of the vents and the orientations of the vents varied for each of the wells tested. Sites 1, 2, and 3 had the vent heights and orientations as listed below. The positions of the various measurement paths for each site are shown in Figures 1, 2, and 3 in Appendix B.

Two GSTC member operating companies volunteered sites for testing. The wells were located in several northeastern U.S. gas storage fields. All wells were located in eastern hilly, mountainous, and forested terrain. The wells were in clearings in the forest accessible by dirt roads. There was sufficient clearance at the selected sites to set up the equipment and take the required measurements. The particular wells were selected because emissions were occurring from a casing annulus, which had open venting to the atmosphere, making the testing convenient. For these sites, the emissions rate is routinely measured by other means, the rate is relatively large and easy to detect, and venting occurs from the end of a vent pipe. These factors were favorable for the tests of this project by easing the data reduction and modeling issues. Results from these tests can be readily translated into comparative projections for the behavior of emissions that might occur directly at the ground surface associated with direct well bore emissions.

The original proposal called for measurements to be made on one well and given the ultimate data quality it was with a single site that we were most able to successfully analyze the data. However, because opportunities presented themselves, quantitative measurements were made on three wells and indicator measurements made on three others. This provided valuable information related to potential setup issues for real well locations and supplementary information on plume behavior beyond what could have been obtained from tests on a single well.

Tables 2 and 3 summarize the overall characteristics for the tests. Detailed path measurement data are found in Appendix C. Table 4 presents equipment position coordinates. Direct data averaging for all runs includes implicit averaging for changes in wind direction.

**Table 2. Overall Collected Data Summary for Sites 1, 2, and 3**

Site 1 Path	Path Load Average (ppm-m)	Concentration Average (ppm)	Time (EDT)			Average Wind Direction (degrees)
			Start	End	Total (min.)	
1	35.1	2.2	10:40	11:06	26	
2	145.4	8.8	11:29	11:53	14	
3	81.0	3.9	12:00	12:20	20	
4	122.3	6.3	12:24	12:32	8	
						123
Site 2 Path	Path Load Average (ppm-m)	Concentration Average (ppm)	Time (EDT)			Average Wind Direction (degrees)
			Start	End	Total (min.)	
1	878.6	73.2	15:29	15:53	24	
2	215.1	15.9	15:59	16:19	20	
3	169.3	8.5	14:33	14:54	21	
4	108.2	5.4	15:01	15:18	17	
						106
Site 3 Path	Path Load Average (ppm-m)	Concentration Average (ppm)	Time (EDT)			Average Wind Direction (degrees)
			Start	End	Total (min.)	
1	100.3	14.6	10:03	10:24	21	
2	447.2	23.5	10:39	11:17	18	
						106

Direct data averaging for all runs includes implicit averaging for changes in wind direction.

**Table 3. Overall Collected Data Summary for Sites 3, 4, and 5.**

Site 4 Path	Path Load Average (ppm-m)	Concentration Average (ppm)	Time (EDT)			Average Wind Direction (degrees)
			Start	End	Total (min.)	
1	82.1	7.7	9:26	9:47	21	
2	159.4	12.5	9:54	10:20	26	
3	150.4	8.4	10:24	10:46	22	
4	33.0	2.2	10:52	11:10	16	
5	66.2	3.5	11:14	11:34	20	
						182
Site 5 Path	Path Load Average (ppm-m)	Concentration Average (ppm)	Time (EDT)			Average Wind Direction (degrees)
			Start	End	Total (min.)	
1	48.6	3.2	13:03	13:20	23	
2	46.5	3.1	13:22	13:30	7	
3	38.4	2.4	13:33	13:49	16	
						170
Site 6 Path	Path Load Average (ppm-m)	Concentration Average (ppm)	Time (EDT)			Average Wind Direction (degrees)
			Start	End	Total (min.)	
1	61.0	6.1	8:09	8:33	42	
2	45.9	4.2	8:39	9:01	38	
3	92.9	8.4	9:04	9:26	30	
4	52.6	4.8	9:30	9:51	21	
5	33.2	2.8	9:53	10:16	22	
						Not measured.

**Table 4. Equipment Position Coordinates**

<b>Equipment*</b>	<b>Source Height (m/ft)</b>	<b>North Position (m/ft)</b>	<b>East Position (m/ft)</b>	<b>Path Length (meters)</b>	<b>Path Elevation (ft)</b>	<b>Centerline Path Range (ft)</b>
<b>SITE 1</b>						
<b>Source</b>	7	382	367			
<b>T2</b>		372	375		3	
<b>R2</b>		420	342	16.5	3	6
<b>R3</b>		452	376	21.0	3	8
<b>R4</b>		437	396	19.5	3	11
<b>T1*</b>		333				n.a.
<b>R1*</b>		---	---	16.0		n.a.
<b>SITE 2</b>						
<b>Source</b>	2					
<b>TR</b>		136	471			
<b>R1</b>		158	476	12	4	15
<b>R2</b>		168	507	13.5	4	25
<b>R3</b>		171	539	20	4	36
<b>R4**</b>		147	426	20	4	n.a.
<b>SITE 3</b>						
<b>Source</b>	1	880	415			
<b>T</b>		893	382		4.5	
<b>R2</b>		870	455	19	4.5	5
<b>R1**</b>		866	421	14.6	4.5	n.a.

\*Key: T refers to “Transceiver.”  
R refers to “Retro-reflector.”  
The numbers refer to path or position as recorded in the original data logs.



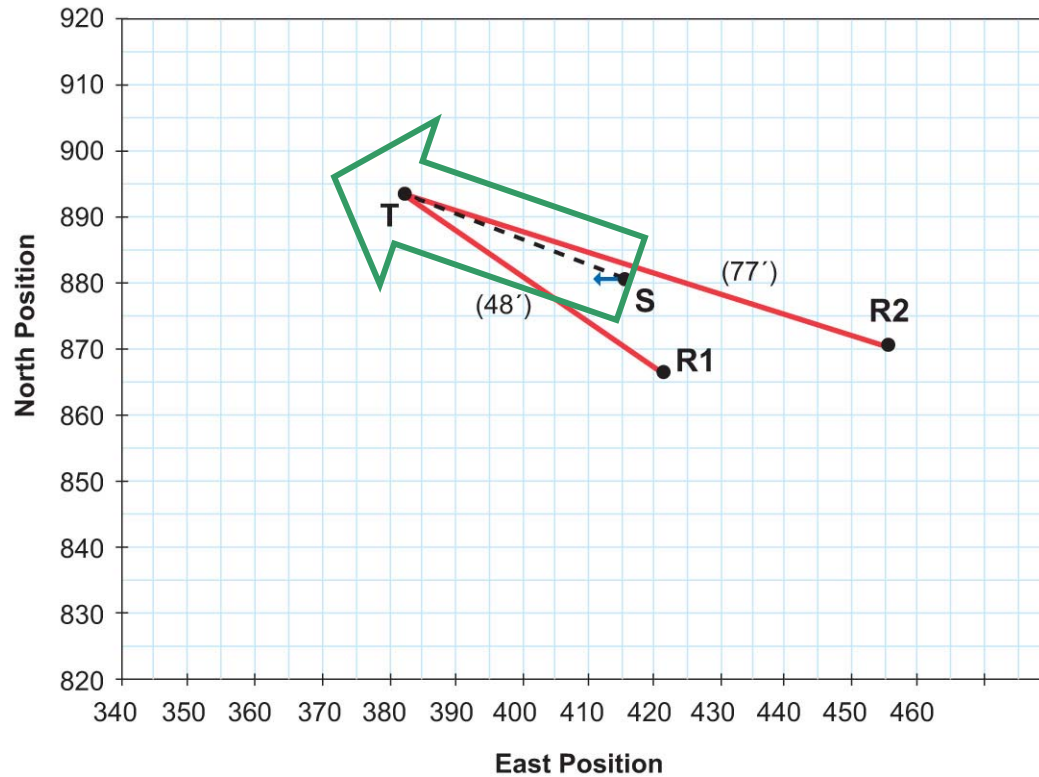


**Figure 9. Example of a Field Equipment Set-Up Close to Wellhead**



**Figure 10. Example of Field Equipment Set-Up at Moderate Distance from Wellhead.**





**Figure 11. Site 3 Path Positions**

Notes:

T = Transceiver.

R1, and R2 = Retro-reflectors for corresponding measurement paths.

S = Source.

Small blue arrow indicates orientation of horizontal vent.

Green arrow indicates approximate average prevailing wind direction.

Meteorological data of wind speed, wind direction, and temperature were automatically logged with a conventional portable met tower with a one minute averaging of met conditions.

An example of the collected path data is shown in Table 5 for Site 3. The complete data for Sites 1, 2, and 3 is presented in Appendix C. An example of the corresponding meteorological data is shown in Table 6. The complete data for Sites 1, 2, and 3 is shown in Appendix D.

**Table 5. Selected Path-Loading Data for Site 3 - Path 2.**  
(See Appendix C for complete data set.)

<b>Site 3 - Path 2</b>	<b>Path length = 19 m</b>	<b>9/20/2006</b>
<b>Average path-loading (ppm -m)</b>	<b>Average path concentration (ppm)</b>	<b>Date and time (EDT)</b>
1247	65.6	11:06:00 AM
1263	66.5	11:06:02 AM
1159	61.0	11:06:04 AM
2099	110.5	11:06:06 AM
1850	97.4	11:06:08 AM
1996	105.1	11:06:09 AM
2233	117.5	11:06:11 AM
1841	96.9	11:06:13 AM
2164	113.9	11:06:17 AM
1593	83.8	11:06:18 AM
1858	97.8	11:06:20 AM
2353	123.8	11:06:22 AM
1747	91.9	11:06:24 AM
1197	63.0	11:06:26 AM
2868	150.9	11:06:27 AM
2935	154.5	11:06:29 AM
2405	126.6	11:06:31 AM
1928	101.5	11:06:36 AM
1218	64.1	11:06:38 AM
1363	71.7	11:06:40 AM
1373	72.3	11:06:42 AM
1161	61.1	11:06:43 AM
1366	71.9	11:06:45 AM
1492	78.5	11:06:47 AM
1575	82.9	11:06:49 AM
1586	83.5	11:06:51 AM
1677	88.3	11:06:53 AM
1948	102.5	11:06:55 AM
1790	94.2	11:06:57 AM
1177	61.9	11:06:58 AM

**Table 6. Portion of Meteorological Data for Site 3****Date: 9/20/2006**

(See Appendix D for complete data set.)

<b>Time (hhmm)</b>	<b>Wind Speed (1- min. average) (mph)</b>	<b>Wind Direction (1-min. average) (degrees)</b>	<b>Wind Speed Standard Deviation</b>	<b>Wind Speed Resultant</b>	<b>Wind Direction Resultant</b>	<b>Wind Direction Resultant Standard Deviation</b>	<b>Wind Gust (mph)</b>	<b>Tempera- ture (F)</b>
1100	1.5	143	25.2	1.4	142.6	25.26	1.9	50.3
1101	2.5	45	27.4	2.3	44.0	25.58	3.2	50.36
1102	1.8	67	5.3	1.8	66.9	5.134	2.2	50.34
1103	1.5	72	4.9	1.5	71.4	4.889	1.8	50.44
1104	1.7	73	15.6	1.6	74.4	16.47	2.7	50.51
1105	3.4	141	38.7	2.8	142.1	34.75	5.2	50.54
1106	2.9	130	22.9	2.7	132.6	22.63	4.4	50.97
1107	2.5	154	51.8	1.8	157.7	42.21	3.5	50.91
1108	2.2	96	17.9	2.1	96.2	17.24	2.6	51.01
1109	2.8	118	87.4	0.4	128.4	74.3	4.0	51.08
1110	2.5	144	8.8	2.5	143.4	9.63	4.3	51.41
1111	2.0	126	13.7	1.9	123.9	12.79	2.4	51.33
1112	2.6	117	30.6	2.3	114.9	27.93	3.3	51.32
1113	2.6	156	83.4	0.9	143.1	66.06	3.6	51.29
1114	1.8	63	39.2	1.5	58.6	36.29	2.6	51.42
1115	1.8	153	75.9	0.6	160.4	64.6	2.2	51.28

The data show considerable variation with time. These data are all for optical paths relatively close to the emission source and close to the ground. Such locations have high concentration gradients and near ground atmospheric turbulence from obstacles. This is characteristic of the relatively confined, forest-bordered clearings for the subject test sites.

It is believed that the emission rate over time is relatively stable based on the nature of the emission source. It is known that local turbulence can cause significant variations in wind direction and speed and corresponding variations in the plume concentration profile. Therefore, it is believed that the apparent variations in the estimated rates are due to modeling wind conditions that do not represent the actual conditions seen along the measurement path.

Comparing the estimated rates to the met data shows that the estimates most closely matched the reported emission rates when met conditions were most stable.

In addition to TDL measurements, the incidental availability of an infrared video camera from one of the operators, while not part of the original test plan, offered a unique opportunity for the project. It provided a clear visual image of the initial several inches of the methane gas plumes from the emission sources. The flow pattern and overall appearance of the methane plumes was similar to a steam plume rising from the spigot of

a teapot with boiling water. When combined with prior knowledge from field and modeling experience these images were a valuable additional tool for positioning the TDL equipment and later interpretation the TDL measurement data. The video photos confirmed that the gas plumes had very little momentum (as would be expected from the low emission rates), and began dispersing quickly, even in the low wind conditions encountered during the tests. The also showed clearly how the direction of the plumes could shift abruptly directly opposite to the prevailing wind direction as the result of momentary local turbulence in the wind field. These images also showed the plume rise of the escaping natural gas from buoyancy. These images made clear that that attempts to take measurements close to the source will ultimately require a very sophisticated approach for placement of equipment and especially for measurements of wind speed and direction.

Used with dispersion modeling results, these observations also provide a basis for estimating the lower detection thresholds for both the infrared video compared with TDL method of detection.

### **3.0 Test Data Reduction and Analysis**

#### **Collected Data**

The field data consisted of the path data and met data.

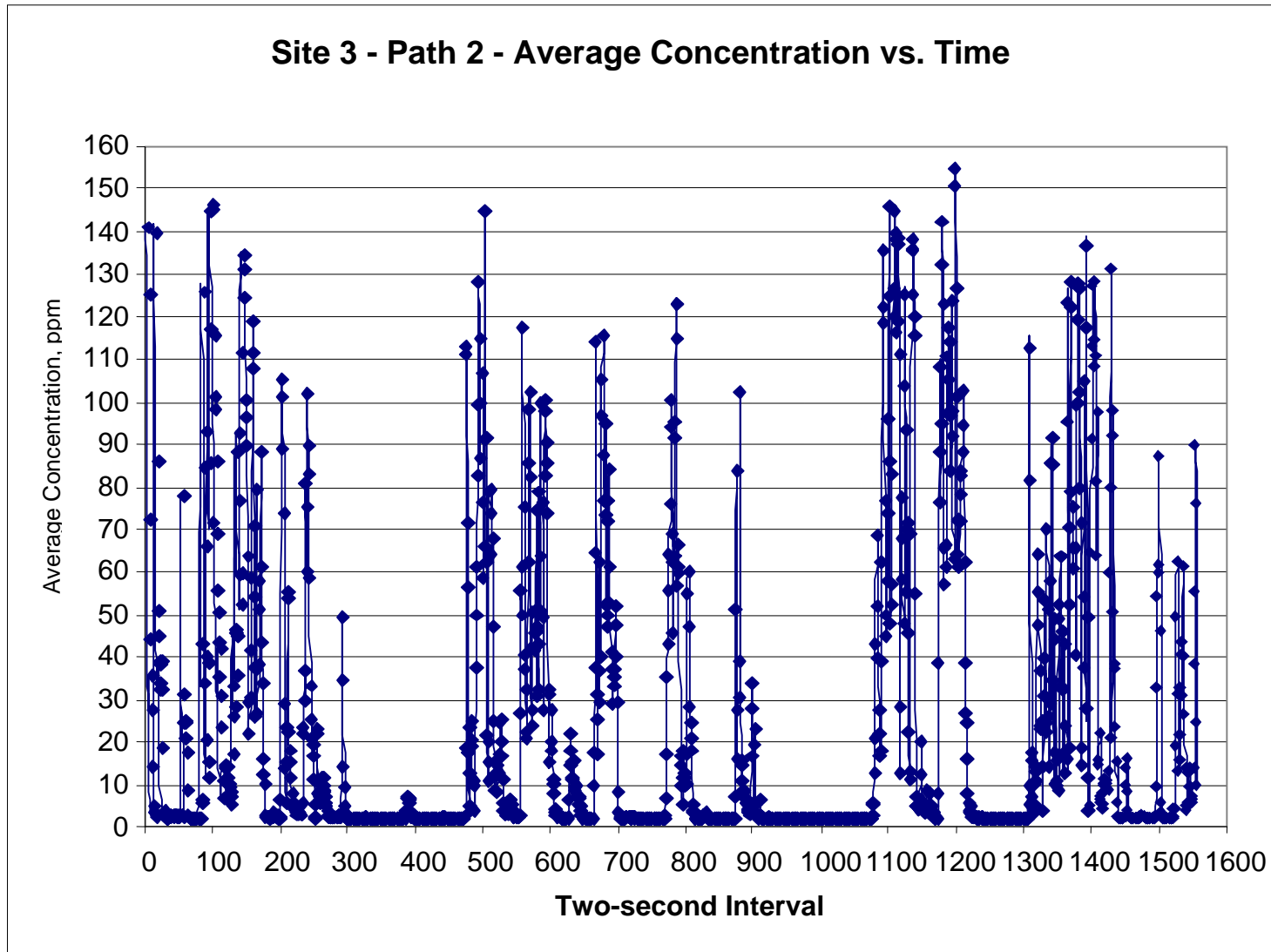
The measured result from the field is the average value over the path length of the measurement. The model, to which the measured emissions are being compared, yields average point values of concentration. These must be converted to path length averages for comparison with the field measured data.

The larger the plume dispersion, the greater the path length in which the gas is found and the lower the actual average concentration level than can be detected.

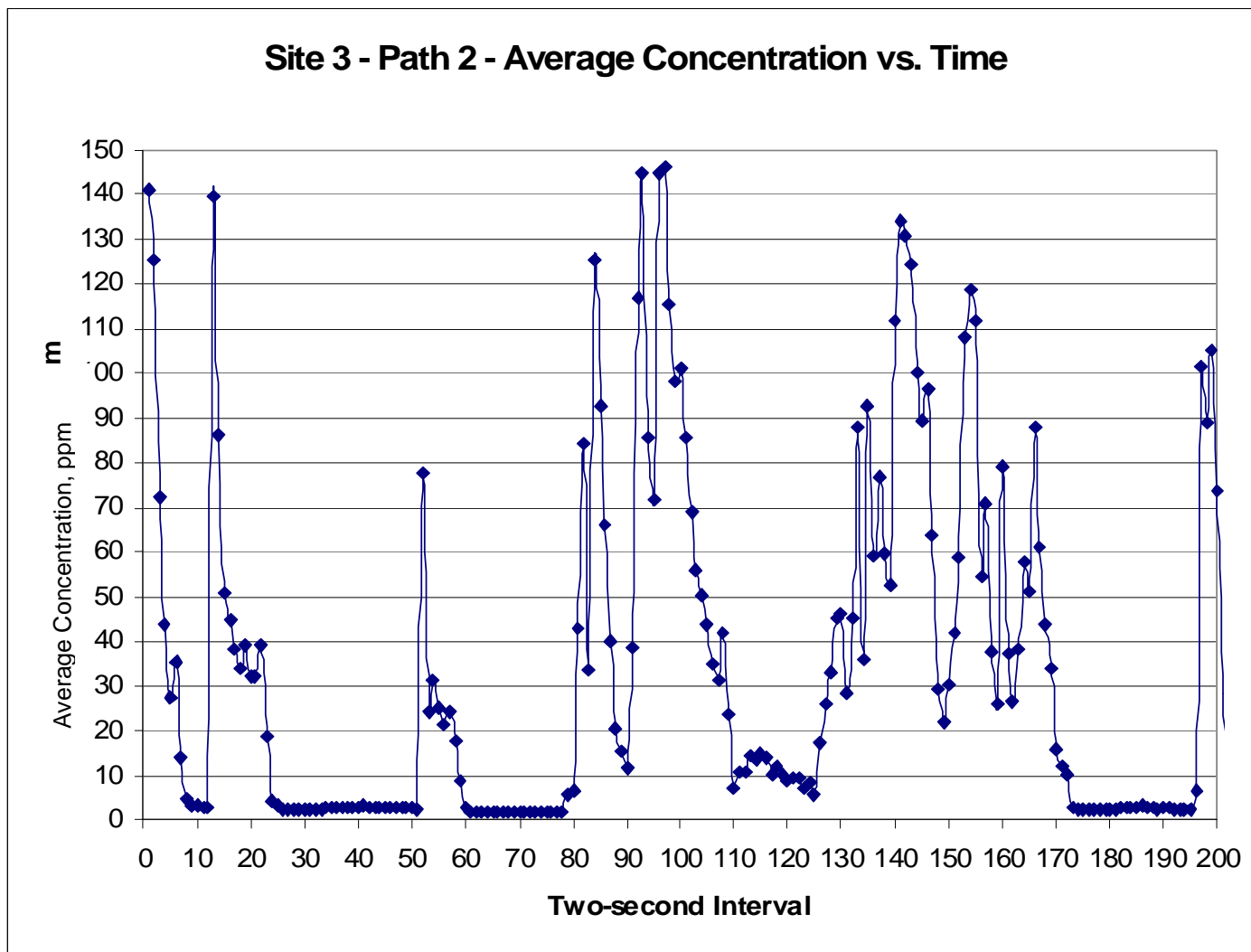
For the wells tested, within about 30 feet of the wellhead, and downwind, ambient concentrations ranging from about 8 ppm to 12 ppm were typical. These are in the range estimated by modeling.

These data are shown plotted in Figure 12. The high variability of the individual measurement readings at 2 sec intervals within any one minute period is evident. Figure 13 shows a shorter time region. These large variations are attributable to mixing effects for paths near the source due to wind turbulence and are primarily associated with rapid local fluctuations in wind direction.

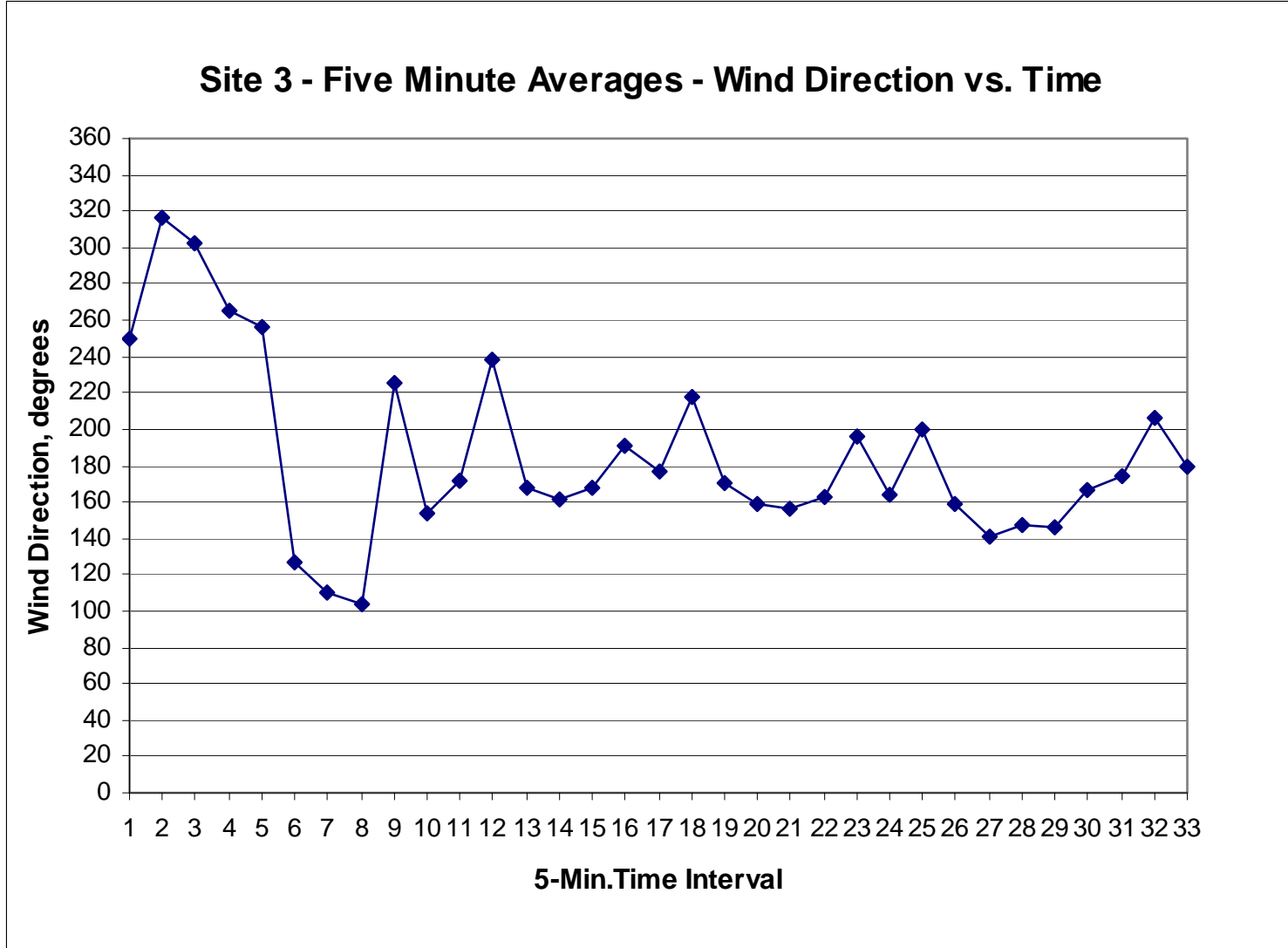
These variations can be seen in the plot of Figure 14, which shows the variability in wind direction associated with the meteorological station. A portion of the data as collected and processed is shown in Table 7. The full met data record is in Appendix D.



**Figure 12. Site 3 Path-Loading Data as Concentrations at Approximate Two-Second Intervals**



**Figure 13. Reduced Scale Partial Site 3 Path-Loading Data at Approximate Two Second Intervals (partial data record at reduced scale from previous figure)**



**Figure 14. Site 3 Wind Direction Data at 5-Minute Averaging Interval**

**Table 7. Data Used for Modeling Emission Estimate**

<b>Path Load Measurements</b>		<b>Meteorological Data (1 minute average)</b>	
Date and Time	ppm-m	Spd_Avg_mph	2.495
9/20/06 11:06:00	1247	Dir_Avg_deg	153.9
9/20/06 11:06:02	1263	Sigma_Avg_deg	51.79
9/20/06 11:06:04	1159	Spd_Res_mph	1.818
9/20/06 11:06:06	2099	Dir_Res_deg	157.7
9/20/06 11:06:08	1850	Sigma_Res_deg	42.21
9/20/06 11:06:09	1996	Gust_mph	3.463
9/20/06 11:06:11	2233	Temp_F	50.91
9/20/06 11:06:13	1841	End_Date_Time	9/20/06 11:07:00
9/20/06 11:06:17	2164		
9/20/06 11:06:18	1593		
9/20/06 11:06:20	1858		
9/20/06 11:06:22	2353		
9/20/06 11:06:24	1747		
9/20/06 11:06:26	1197		
9/20/06 11:06:27	2868		
9/20/06 11:06:29	2935		
9/20/06 11:06:31	2405		
9/20/06 11:06:36	1928		
9/20/06 11:06:38	1218		
9/20/06 11:06:40	1363		
9/20/06 11:06:42	1373		
9/20/06 11:06:43	1161		
9/20/06 11:06:45	1366		
9/20/06 11:06:47	1492		
9/20/06 11:06:49	1575		
9/20/06 11:06:51	1586		
9/20/06 11:06:53	1677		
9/20/06 11:06:55	1948		
9/20/06 11:06:57	1790		
9/20/06 11:06:58	1177		



## Data Reduction

Data reduction consisted of three distinct parts:

1. Downloading path measurement and meteorological field data and aligning the path and met data by time period.
2. Compiling the field data in a format specific to this project, review of the data, and selection of data for further processing and analysis;
3. Applying customized modeling of the data to estimate emission rate, and modifying the model as needed.

After review of the data, Site 3 data were selected for detailed analysis based on having the least uncertainty for estimating emission rate. Data from other wells and observations for all wells and the general characteristics of the gas field in which these wells resided provided additional information used in the overall feasibility evaluation.

The path-averaged concentrations of methane were aligned with the meteorological data (wind speed and direction, temperature, and pressure). The data were time averaged. Combined with the geographical layout of the path relative to the emission source, these data provided input to the dispersion model for estimating the emission rate.

Data tables are included in Appendix C.

## Data Analysis and Emission Estimating by Modeling

Previous researchers have used the TDL together with dispersion modeling software to estimate the emission rates. Bauer et al. outlined a protocol based on these investigations for a specific method of monitoring fugitive methane emissions (Ref. 4).

The dispersion model used in this study is a variation of the URS commercial version of its *Complex Hazardous Air Release Model* (CHARM®). A discussion of CHARM® is provided in Appendix E. Version 11 was used in this work. The model is a grid based, LaGrangian model, in contrast with the more commonly used Gaussian dispersion models. These designations refer to the mathematical algorithm by which the emission source characteristics and wind field conditions into which a gas or vapor is emitted estimate the airborne concentration distribution of the gas or vapor cloud or plume. A LaGrangian model facilitates more sophisticated modeling.

The met term defines wind direction, atmospheric stability, and other variables that will influence dispersion. In this project, part of the effort is modifying the existing model to better estimate near field emissions for correlation of emission rates with concentrations in the dispersion plume region near well head. At this stage, the extent of such modifications and their form are being investigated.

The two types of source characteristics for a well head are the relatively uniform orifices of casing vent pipes and non-uniform orifices of borehole seepage through cracks in cementing and gaps between the cement and casing wall or cement and borehole wall.

Both types of situations can be modeled, and within typical measurement distances from the source, the non-uniform source plume should not differ greatly from the more uniform case.

Besides the stand-alone version of the software, as a calculation tool for estimating dispersion patterns associated with specific emission rates, a data reduction tool has been developed using the standard set of CHARM® library functions. The program tool is called EmissionEstimate11 and is described in the next section.

The CHARM® model, Version 11, was used to generate the measured path data and back-calculate the emission rate that would yield those conditions. This was done at one minute intervals for Site 3. The back-calculated emission rate for each one minute interval was then compared with the reported emission rate for the test site that had been previously determined by another method, outside of the current project.

The values of interest that were to be used in the modeling are:

- Resultant wind speed;
- Resultant wind direction; and
- Average standard deviation of the horizontal wind direction ( $\sigma_{\theta}$ ).

Because the meteorological data was an average over a longer time period, the path loading data was averaged over the same time periods as the meteorological data. This resulted in a large number of data pairs of meteorological conditions and path loading over a concurrent time period. To select the best data sets to be used for analysis a number of criteria were applied, as described below.

Of the six sites where measurements were taken only the first three could be used because the last three had no GPS measurements. The meteorological data at Site 1 was recorded as five minute averages. Other than the first measurement at Site 2, all other meteorological data was recorded as one minute averages. The first measurement at Site 2 was a five minute average. Path-loading data was collected approximately every two seconds.

For each of the five minute meteorological averaging periods there were up to 170 path-loading data values. For each of the one minute meteorological averaging periods there were up to 35 path-loading data values. A total of 166 data collection periods containing both average meteorological and path-loading data were available for further analysis.

The average and the standard deviation ( $\sigma$ ) of the path loading data were calculated for each data collection period. With a background methane concentration of 2 ppm, an expected background path load was also calculated.

To find the data set with the least uncertainty for modeling, the criterion to qualify a period for further analysis was that the average measured path load had to be greater than twice the calculated expected background path load and the  $\sigma$  of the path loading had to

be less than one-half the average measured path load. This culled the original 166 data collection periods down to 10. The path loading measurements displayed a wide variation over the meteorological time intervals. Of the 166 data collection periods, 109 failed the test for the  $\sigma$  to be less than one-half the average measured path load. In fact, 47 data collection periods failed the test of the  $\sigma$  to be less than the average measured path load.

Finally, a calculation was carried out to see which of the data collection periods was consistent with when the view path would be most likely to intersect the horizontal plume centerline (as determined using the average wind speed). When this criterion is applied, only one data collection period passes. That period is the 37<sup>th</sup> time interval measured along Path 2 at Site 3. Data used as input to the CHARM® modeling is summarized in the table in Appendix F.

This data analysis shows that there are periods of relative uniformity with the concentration measurements for a given path. Such uniformity would be expected with a relatively stable emission rate under stable and low wind speed atmospheric conditions. Based on previous measurements of emission rates from these gas wells, emission rates can fluctuate erratically around an average for some periods. It is believed that the frequency for atmospheric variations is likely to be greater than the frequency for emission variations. The variations therefore can reflect intermittent plume turbulence variations of concentration across a path caused by changes in wind conditions at the time of measurement as well as fluctuations in actual emission rate.

The meteorological equipment used was only capable of one minute averaging. This was less than the period of the measurements shown and the capability of the TDL equipment, which used a 1-second sampling rate with nearly instantaneous recording of the observed concentration. Therefore, it is believed that changes in local wind direction are the predominant reason for variations in the observed methane concentrations in the measurement path at any moment.

Using these measurements shown in Table 7 results in combination with the CHARM® model, the path location and length information was used to back calculate an estimated emission rate based on the plume measurement.

#### **Emission Rate Calculation Tool (EmissionEstimate11)**

A program was developed that will allow a user to input measured data on-site and then calculate an emission rate that would give a path-load that agrees with the measured value. The program displays a single dialog interface, which is shown in Figure 15.

**EmissionEstimate11**

**Input Files**

Base Release File (\*.emg) BaseWellRelease.EMG Browse...

Base Met File (\*.met) BaseWellWx.met Browse...

Base Grid File (\*.grd) BaseWellGrid.grd Browse...

**Locations**

**Source**  
 5299880 Northing 11622415 Easting 1 Altitude

**Transceiver**  
 5299893 Northing 11622382 Easting 4.5 Altitude

**Retro**  
 5299870 Northing 11622455 Easting 4.5 Altitude

Surface altitude at source 0 Units Feet

Temperature 50.91 Fahrenheit Background conc 2 ppm

**Wind**  
 Speed 1.818 mph Direction 157.7  
 Direction sigma 51.79

Measured load 1748.73 ppm-m Save Input... Load Input...

Calculate Done

**Figure 15. Dialog Form for Entering Measured Data for CHARM® Calculation of an Emission Rate.**

The Input Files provide the CHARM® engine with the basic and default values that are going to be used in the calculation. Short descriptions of each are:

- Base Release File specifies that methane is being released and that it comes from a small hole;
- Base Met File specifies some default meteorological conditions, such as the pressure is at one atmosphere, the relative humidity is at 50 percent, and that there is no inversion height; and
- Base Grid File specifies a flat terrain grid with dimensions of 51 feet North/South, 17 feet East/West, and 15 feet in the vertical. The grid region is made up of cells that are all of 1 X 1 X 1 foot dimension. The surface roughness is set at 3 cm.

These files can be edited or new ones created by using the stand-alone version of CHARM®. Help information supplied with the stand-alone version can be used to aid in creating and modifying the files.

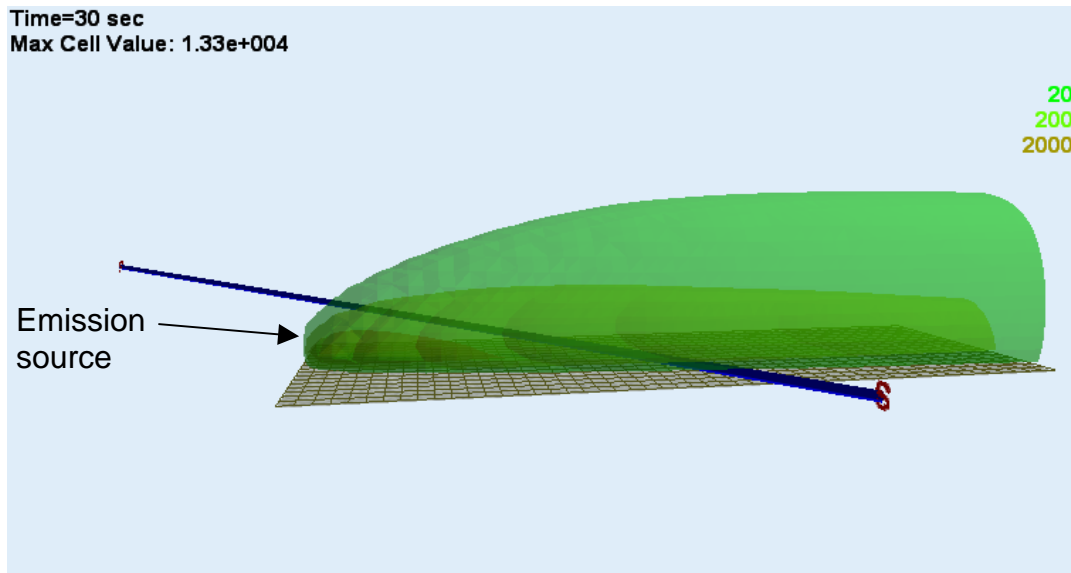
All the other information that needs to be supplied should be available from on-site measurements. The Easting, Northing, and Altitude of the source and each end of the view path should be able to be measured from GPS equipment. The altitudes can be given in heights above ground or absolute heights. If absolute heights are used the Surface altitude at the source should be supplied so that the calculator can determine the height above ground for each point. The distance measurements can be supplied in either feet or meters. The temperature, wind speed, direction, and direction sigma are available from the meteorological data. Various units are available for each. In the program, the calculation accounts for the background concentration of methane. If the background concentration gives a higher path-load than actually measured, the calculation stops and a warning message is given. The final input required is the path-load number given from the path equipment. Once all input is provided, the entries can be saved in a file by pressing the “Save Input” button. Correspondingly, the Load Input button can be pressed to find and open a file with saved entries.

To have the program calculate an emission rate, the “Calculate” button needs to be pressed. When this happens the program will begin the calculation. An iterative approach is used in the calculation. An initial emission rate is used and the calculation is carried out until steady-state conditions have been reached. Then a path-loading is calculated for the path provided and compared to the measured value. If the measured value is higher than the calculated value, the emission rate is increased by a factor equal to the ratio of the measured to calculated path-load. If the measured value is lower than the calculated value, the emission rate is decreased by the same factor. This continues until the measured load and the calculated load are within 1 percent of each other. This calculation can take anywhere from a few minutes to more than an hour. When complete, the program will display a dialog box with the calculated emission rate. When finished performing calculations, the “Done” button can be pressed and the program will exit.

## **RESULTS AND DISCUSSION**

### **1.0 Data Analysis Results**

The calculated emission rate for the path data set with the least uncertainty (Site 3, Path 2) is 8.2 mcf/d. This is about four times larger than the reported emission rate, determined previously by other means, by the operator. Figure 16 shows the modeled plume configuration and path location for Site 3 upon which emission estimate is based.



**Figure 16. Modeled Plume and Measurement Path for Site 3,  
11:06 AM, September 20, 2006**

For the wells tested at Sites 1, 2, and 3, previous measurements by the operator using the cylindrical orifice cap and manometer flow meter method for several minutes had yielded the following average rates (thousands of standard cubic per day (mscfd):

- Site #1 – 1.8 mscfd
- Site #2 – 1.5 mscfd
- Site #3 – 1.8 mscfd

Well characteristics are such that these can be averages of significantly varying “instantaneous” emission rate values, from near zero to several times the average. Surges of high rates can occur. As will be seen later in the report modeling suggested a higher rate during one of the test intervals of this project.

The standard deviation of the horizontal wind direction for the overall data collection period is 52°. The CHARM® model was used with the assumption of a constant wind direction and speed. A standard deviation of the horizontal wind direction of 25° is considered large. Of the 166 data collection periods available, 101 have standard deviations of the horizontal wind direction of more than 25°. Larger standard deviations indicate a large amount of mixing and that the plume is probably discontinuous. By averaging the collected data some of the variability’s effect on the calculated emission can be reduced but not eliminated.

Examination of the data and field conditions suggested that there would be sensitivity in the measurements to the positions of the transceiver and the retro-reflector. This sensitivity would increase the closer the measurement path is to the source. The horizontal placement of the transceiver and retro-reflector is relatively easy to manage

and measure. The vertical placement is less so. Small elevation differences between the transceiver and retro-reflector were not recognized as a variable for close monitoring in the current tests, the modeling sensitivity of this variable was determined after the tests. A model sensitivity analysis was run to determine how much the estimated emission rate determined by the model would be affected by a vertical disparity between the elevation of the transceiver and retro-reflector when the model assumed equivalent elevations in the data analysis modeling. As discussed in the next section, this analysis showed that a displacement on the order of 1 to 1.5 feet could affect the results by a factor sufficient to cause a true value of near 2 to be rendered as 4. Given the rough terrain, such vertical alignment differences could have contributed to a difference of the observed magnitude. This would be a technical issue to be further explored in any additional field tests.

## **2.0 Discussion of Findings**

This discussion examines the results of the field data analysis in terms of the project objectives and possible future emission detection and measurement protocol development. It addresses field data results, further development needs, and implications for final protocol development.

### **Data Sensitivity to Path Location**

The variability the path-loading data is similar to what has been observed in other studies (Ref. 4). Magnitudes were within expectations for the reported emission rates and measurement locations. The variability in wind direction and speed, especially direction for a given measurement path, was more than had been expected for a given measurement path, based on other experience in remote emissions monitoring. There are several possible reasons for this. The measurement paths were all within about 20 to 30 ft of the emission source, which in this type of work, is considered close. Most studies of optical systems have used greater distances from the source and longer path lengths. For example, one detailed study of emissions from a gas processing plant was done at distances of over 300 ft downwind from the source with a path length of over 500 ft. (Ref. 4). However, one of the objectives in this study was to determine how feasible closer measurements to the source would be because of practical limits for some typical gas storage field well locations.

The sites volunteered in this study, are in rough, hilly terrain, often in forest clearings with limited access for optical view paths and choice positioning of the equipment. Tall trees at the forest's edge bounded the sites. This was helpful in limiting the average wind speed but might have increased turbulence resulting in large and frequent fluctuations in local wind direction. This was anticipated to some extent, but initially wind speed was believed to be the primary met variable of concern. In fact, wind direction appeared to be the greater issue.

The result is that measurements were taken in plume regions of relatively high concentration gradients where slight changes in local wind direction and speed cause rapid temporal and spatial variations in the concentration for a given view path, and uncertainties in positioning of equipment can have a significant impact on the modeling

results if the actual path positions, including TDL transceiver and retro-reflector elevations, were different enough from the recorded data and displaced enough from those used in modeling.

Another factor contributing to data variability was that for this study was that standard meteorological monitoring equipment was used for wind measurements. The variation over a relatively small spatial scale suggests that the standard met station may not have adequately represented wind conditions along the measurement path. Additional measurements might be beneficial for comparing conditions closer to the measurement paths with conditions at differing met station positions nearby. Both the positioning and type of met equipment used is a factor contributing to some of the data uncertainties for a given path.

It is clear that more tests are required to better understand the relationship between positioning of the measurement equipment, the sampling rates and averaging times, and the number and location of measurement paths relative to the emission source.

These field tests have helped to refine several important working parameters involved in using the proposed method to determine emission rates under “real world” circumstances. The importance of averaging time and the positioning of the transceiver and retro-reflector has been quantitatively recognized. The averaging time must be adequate to smooth out the frequency and significant variations in the gas concentration seen across any measurement path. Video observations of the plume behavior at the source indicated a complete reversal of plume flow direction, on occasion, due to momentary wind shifts. This explains the abrupt drops from time to time of measured path concentrations observed in the data.

The length, width, and depth of the plume will vary with emission rate, the size of the emission orifice, and wind conditions. The emission rate determines when the demarcation between a momentum-controlled plume region and a dispersion-controlled region occurs. This has implications for observed concentrations and their distances downwind from the emission source, in other words, the plume shape and concentration distribution within the plume.

These issues will have to be accounted for in the measurement protocol. The measured concentrations will vary with these conditions as well as the path length over which the measurements are taken.

The protocol will have to specify designated path lengths according to these conditions. It might be possible to establish a fixed path length and develop correlations in future based on that length. The protocol would also specify limits to wind conditions, and downwind distances under which measurements would be taken.

Plume rise is the second factor that affects the shape and concentration distribution within the plume. These plumes were the result of emission rates high enough such that they were visible as index of refraction disturbances in the air just at the vent orifice and a few



inches beyond. Infrared videos also showed clearly the plume rise and rapid dispersion of the escaping gas, even at the low wind speed conditions.

#### **Emission Rate Estimate Sensitivity to Path Elevation Orientation**

When the model is used to estimate the emission rate by varying it until the calculated path load is equal to the measured path load, the result can vary significantly if the location (x, y, and z) of the transceiver and retro-reflector are incorrect. This is especially true if the path traverses very near the source where the vertical concentration gradient can be very large.

In the measurement with the best chance for having a large enough signal-to-noise ratio the viewing path does travel near the source, as can be seen in Figure 16. The calculation grid is assumed to be flat in the model simulation. In reality slight terrain variations would be expected. The altitudes (4.5 feet) of both the transceiver and retro-reflector are both with respect to the ground. If the ground altitude varies between the two pieces of equipment then the relative position of the plume and path is incorrect. The actual ground altitude at sufficient resolution at the measurement site is not known. The model can take terrain altitude variation into account if it is available.

To determine how sensitive the emission rate may be for conditions modeled, the heights of the transceiver and retro-reflector were varied to indicate what size of variation could be expected in the calculated emission rates. The emission rate at different transceiver and retro-reflector altitudes was estimated assuming an inverse relationship between the estimated path-loading to the estimated path load for the base case where both instruments are at 4.5 feet. The range of emission rates are given in Table 8.

**Table 8. Model-Estimated Emission Rates at Various Transceiver and Retro-reflector Elevations**

<b>Transceiver Elevation (ft)</b>	<b>Retro-reflector Elevation (ft)</b>	<b>Emission Rate (mcf/d)</b>
4.5	4.5	8.2
3.0	3.0	2.0
4.5	3.0	4.4
3.0	4.5	3.6
1.5	1.5	0.8

As can be seen in Table 8, a small variation in elevation of one or both of the TDL devices (transceiver and retro-reflector) can result in significant variations in estimated emission rate. The reported emission rate of 1.8 mscfd discussed earlier is within the range that could result with possible field variations in relative elevations of the TDL equipment. A difference of 1.5 ft over the path length of Site 3 would account for the reported compared with modeling estimate of emission rate. This effect indicates that, because of the large vertical concentration gradient, it is better to have the view path traverse the plume downwind farther from rather than nearer to the source.

### Effect of Emission Rate on Plume Pattern

To further examine sensitivity to system parameters, the stand-alone version of CHARM® was used to estimate concentration impacts from several emission rates. The Meteorological conditions are the same as for the field test emission rate estimate using CHARM®. The release height is one foot above the ground.

The simulations use emission rates of 0.2, 2.0 and 20.0 mcf/d. The meteorological data used is from an actual measured time period in the field data. The conditions are shown in Table 9.

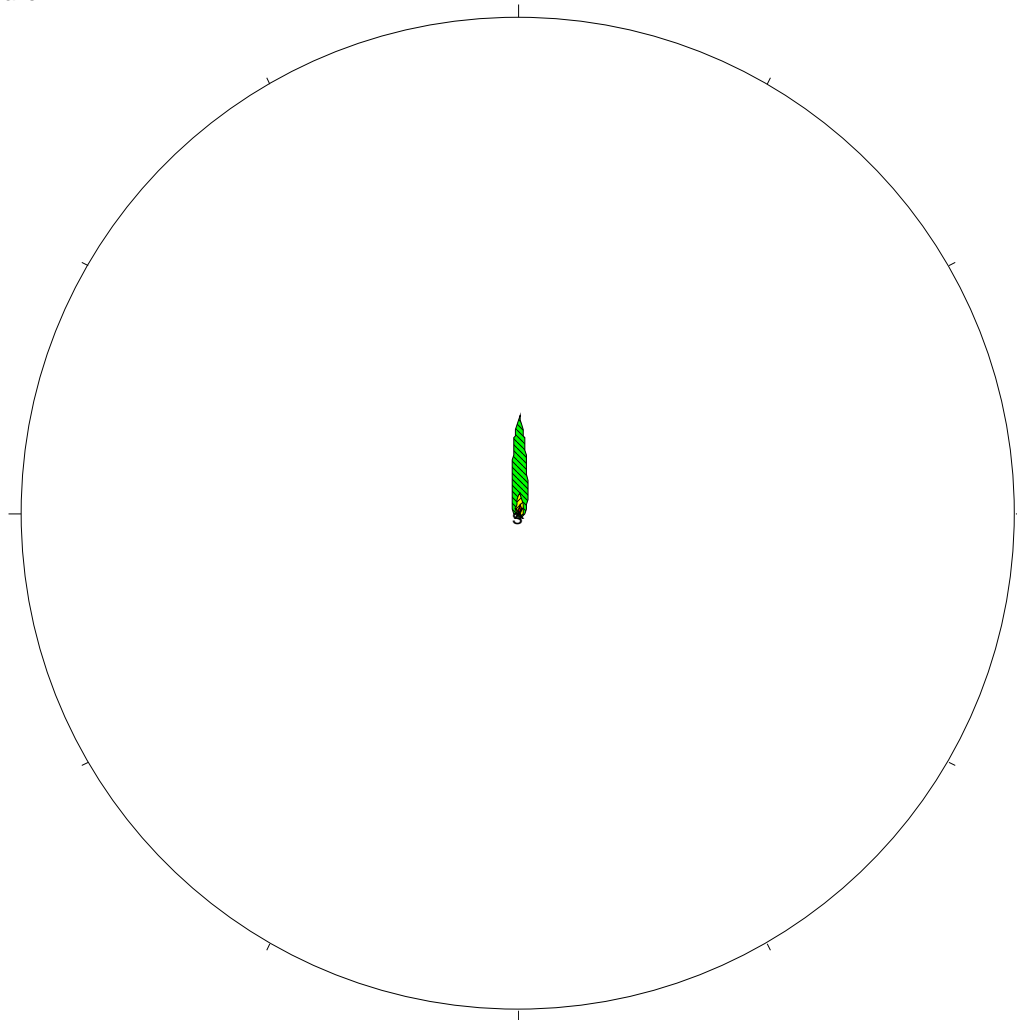
**Table 9. Meteorological Data Used in Simulations**

Parameter	Value
Relative Humidity	50 %
Ambient Temperature	50.9 °F
Ambient Pressure	1 atmosphere
Cloud Cover (tenths)	0
Stability Class	A
Solar Radiation	0 kW/m <sup>2</sup>
Inversion Height	No inversion present
Wind Measurement Height	8 ft
Wind Direction	180°
Wind Speed	1.8 mph

The implications are that the exact location for the placement of equipment becomes more critical for paths closer to the emission source. In the current application, where a site can be in a forest clearing, this establishes the need for more precautions than would occur in more open settings.

Figures 17 through 22 show the modeled concentration fields downwind of a release from an example well. The figures show plan views and vertical elevation views of each plume. All plan views are at the same scale. All vertical cross-sections are at scales chosen to show the entire plume nearly filling the display area. Note that the distance scale [Dist (ft)] in each vertical cross-section is with respect to the left extent of the region selected for plotting. The actual release location is at a distance of about 2 feet in all the vertical cross-sections. Each of the figures uses the same isopleths (contours of constant concentration). The effect of dilution by dispersion from atmospheric mixing for low flow rates is clearly apparent for the lowest modeled emission rate of 0.2 Mscfd.

Site3 Path2\_37  
Species: Methane



Snapshot Plume  
Time: 00=30  
Height: 2 ft  
Above Ground  
Radius: 100 ft  
Plot Scale 1:378

Hatch	Conc(ppm)	Max Dist
Green	1e+003	20 ft
Yellow	5e+003	4 ft
Red	1e+004	2 ft

Hatch	Conc( $\mu\text{g}/\text{m}^3$ )
Green	6.89e+005
Yellow	3.45e+006
Red	6.89e+006

Max Conc  
x = 1.33e+004 ppm  
Dist: 1 ft Ang: 13  
Max Conc at hgt 2 ft  
1.33e+004 ppm  
Dist: 1 ft Ang: 13

**Figure 17. Plan view of plume footprint 2 feet above ground. Emission rate is 2 mcf/d.**

Site3 Path2\_37  
Species: Methane

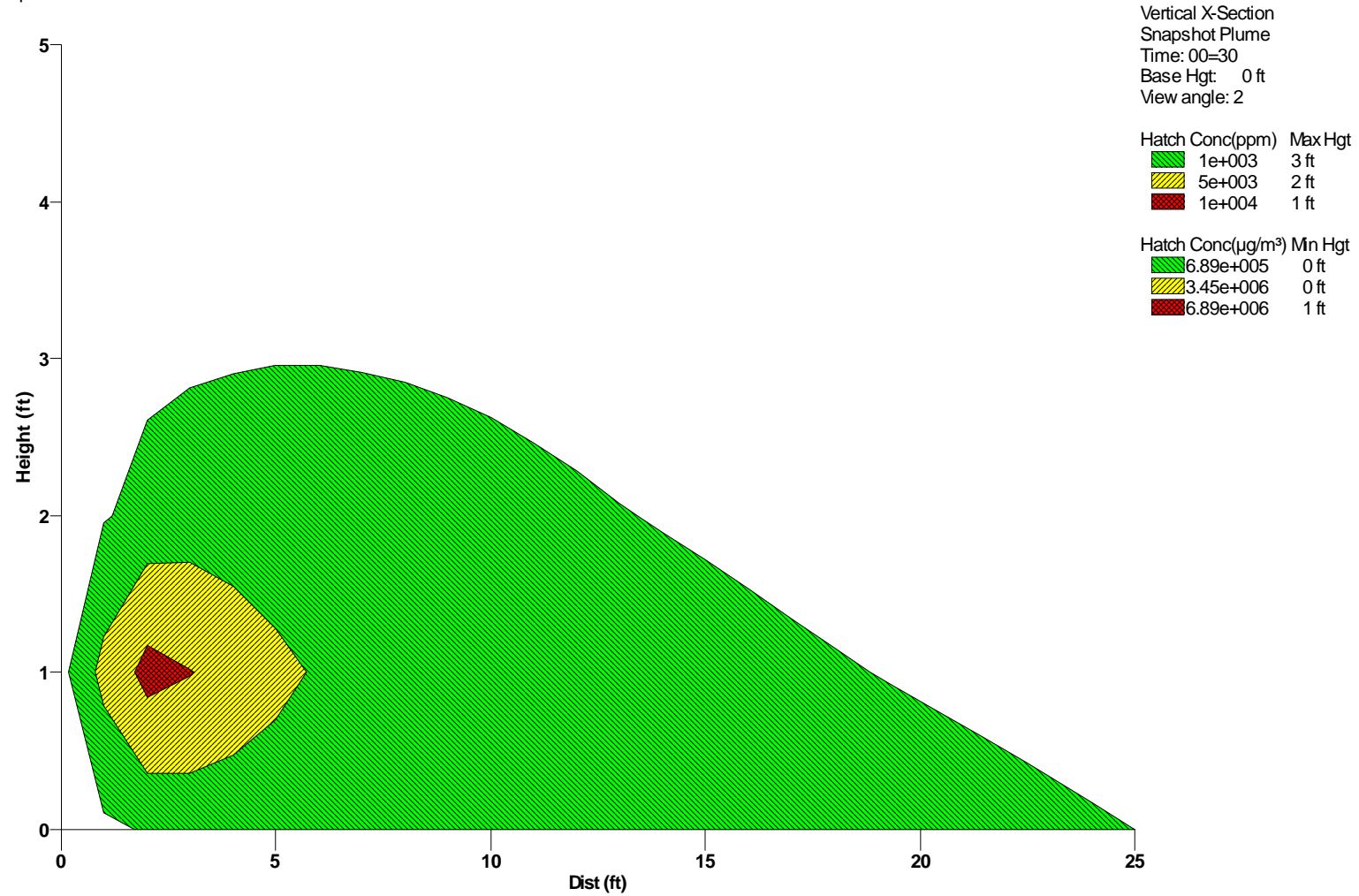
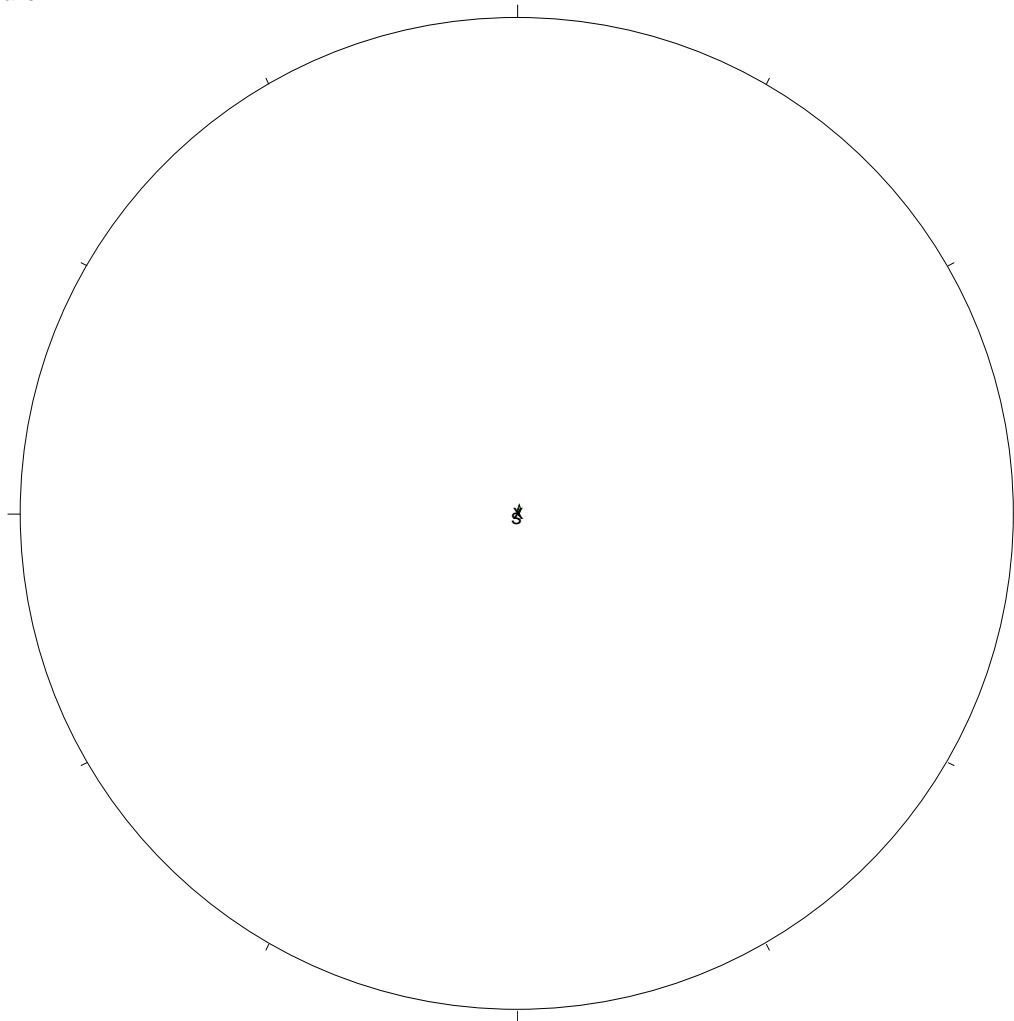


Figure 18. Vertical cross section near plume centerline. Emission rate is 2 mcfd.

Site3 Path2\_37  
Species: Methane



Snapshot Plume  
Time: 00=30  
Height: 2 ft  
Above Ground  
Radius: 100 ft  
Plot Scale 1:378

Hatch Conc(ppm)	Max Dist
1e+003	2 ft
5e+003	0 ft
1e+004	0 ft

Hatch Conc( $\mu\text{g}/\text{m}^3$ )
6.89e+005
3.45e+006
6.89e+006

Max Conc  
x = 1334 ppm  
Dist: 1 ft Ang: 13  
Max Conc at hgt 2 ft  
1334 ppm  
Dist: 1 ft Ang: 13

**Figure 19. Plan view of plume footprint 2 feet above ground. Emission rate is 0.2 mcfd.**

Site3 Path2\_37  
Species: Methane

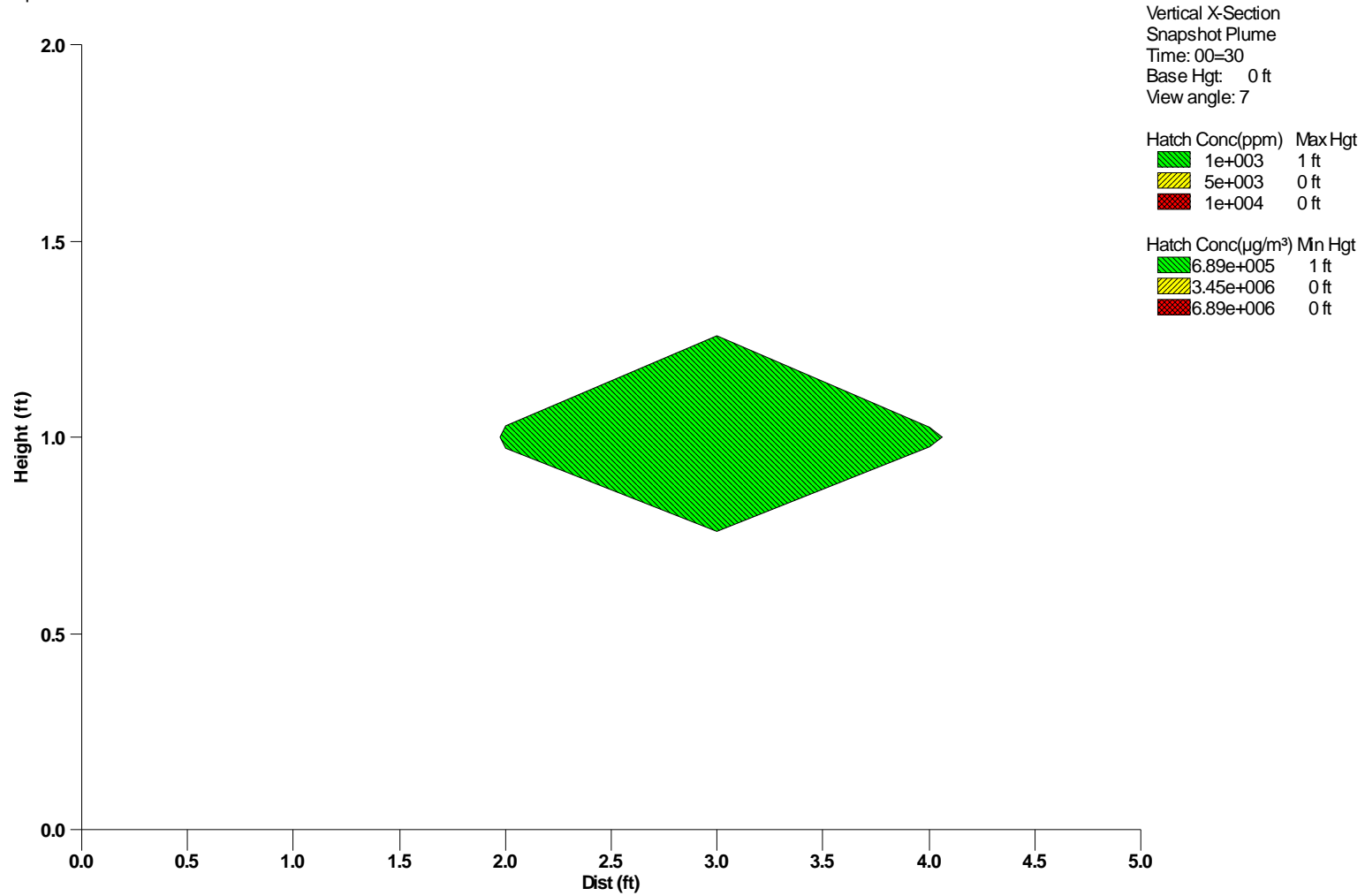
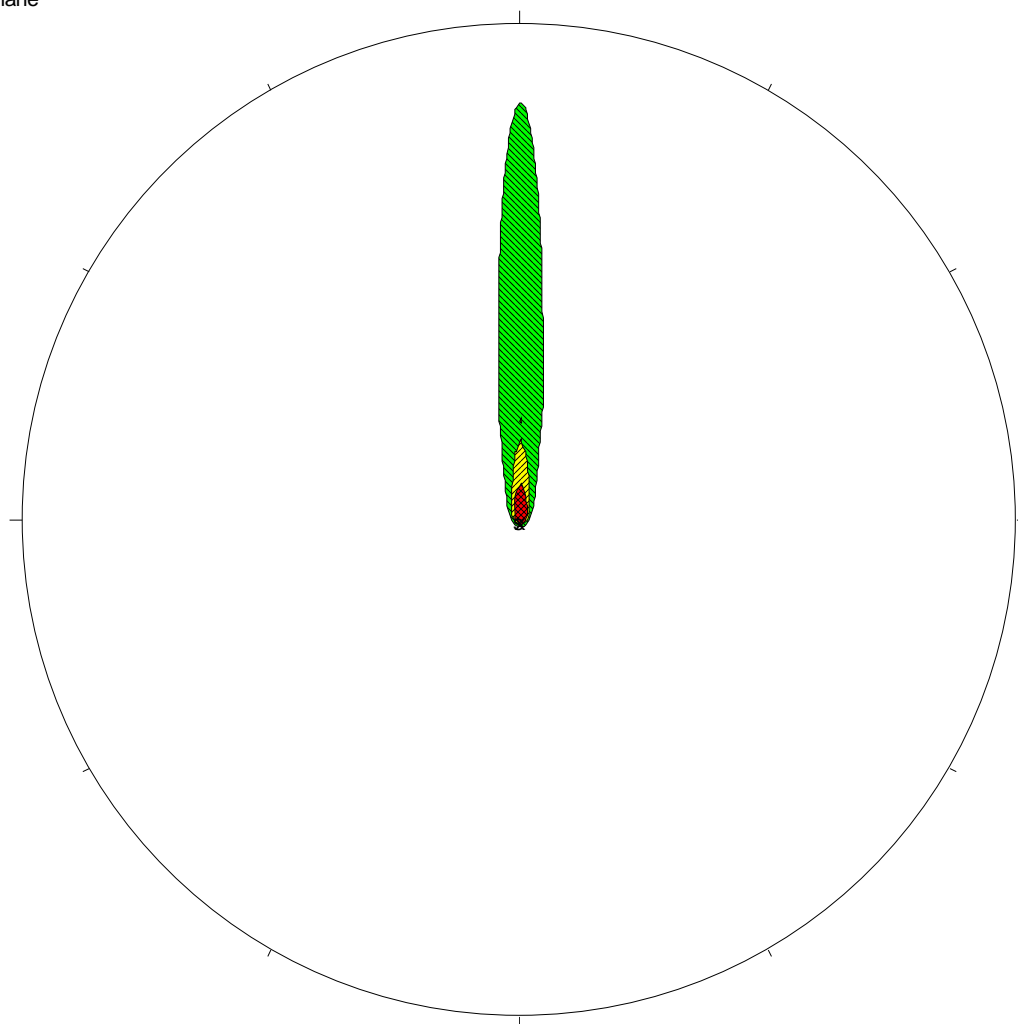


Figure 20. Vertical cross section near plume centerline. Emission rate is 0.2 mcf/d.

Site3 Path2\_37  
Species: Methane



Snapshot Plume  
Time: 00=45  
Height: 2 ft  
Above Ground  
Radius: 100 ft  
Plot Scale 1:378

Hatch Conc(ppm)	Max Dist
1e+003	84 ft
5e+003	21 ft
1e+004	7 ft

Hatch Conc( $\mu\text{g}/\text{m}^3$ )
6.89e+005
3.45e+006
6.89e+006

Max Conc  
x = 9.499e+004 ppm  
Dist: 0 ft Ang: 125  
Max Conc at hgt 2 ft  
9.499e+004 ppm  
Dist: 0 ft Ang: 125

**Figure 21. Plan view of plume footprint 2 feet above ground. Emission rate is 20 mcfd.**

Site3 Path2\_37  
Species: Methane

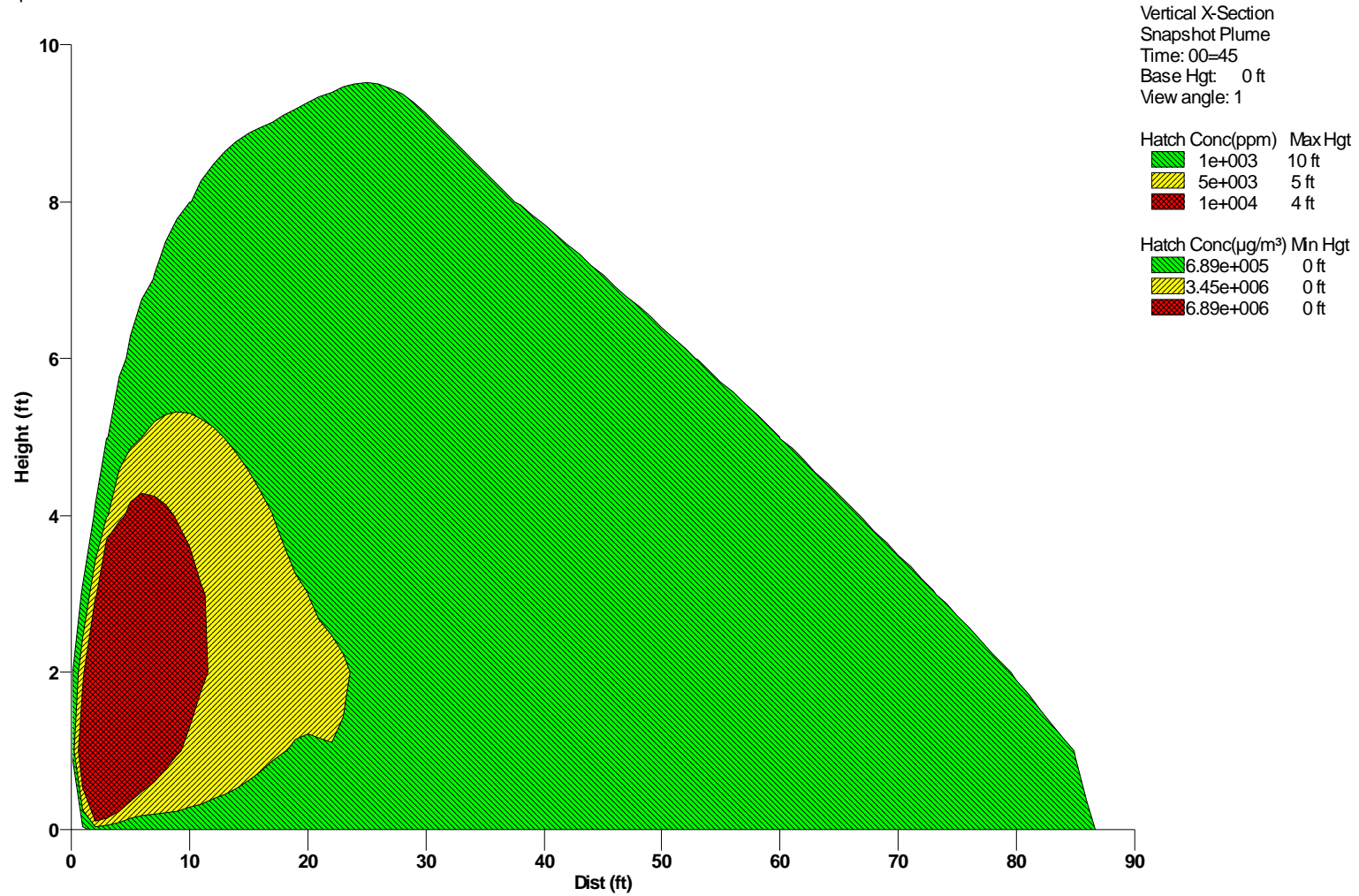


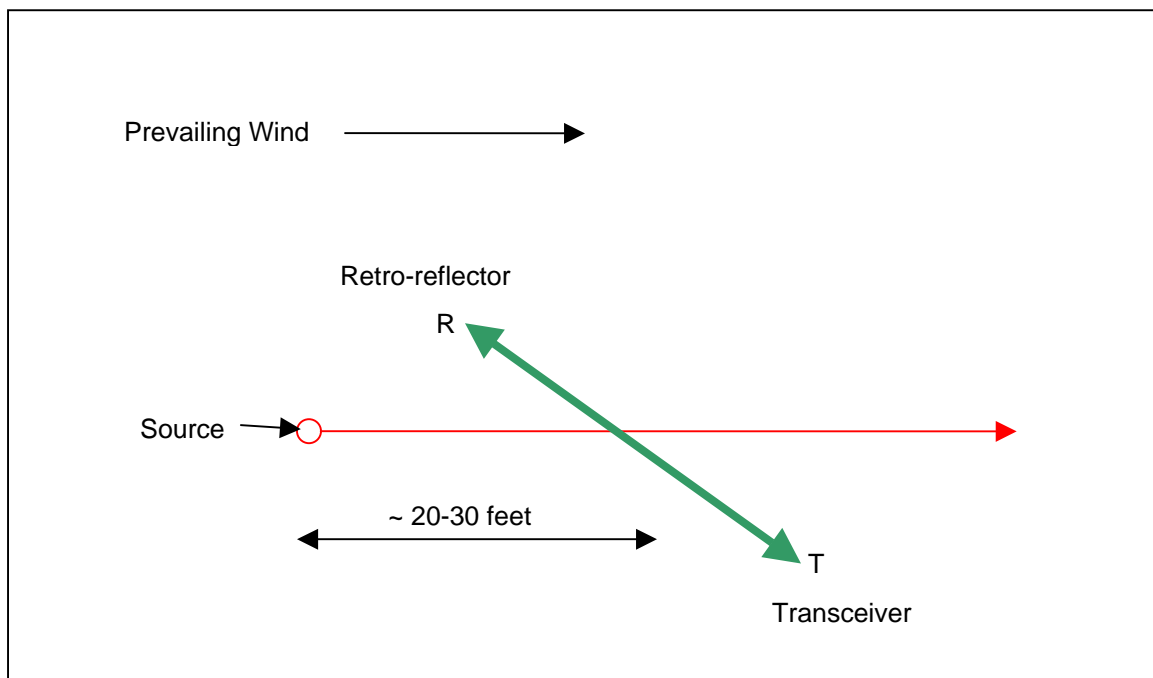
Figure 22. Vertical cross section near plume centerline. Emission rate is 20 mcfd.



### 3.0 Technical Feasibility Evaluation

It appears that the measurement method used in this project could be successful for its intended purpose with further development. That development requires testing with better meteorological measurements to reduce uncertainty concerning conditions closer to the measured path. It also requires testing at additional path positions. More sophisticated meteorological measurements at multiple locations near the measurement path and source appear to be desirable. Testing additional methods of measurement and positioning the equipment would be a specific goal of any future testing. Careful measurement of the elevation of the transceiver and retro-reflector relative to each must be included in the setup protocol, in addition to horizontal alignment. The measurement duration of the meteorology and path-loading is adequate. The averaging that takes place eliminates some of the variability in the data. The major need is to use a view path that intersects the plume further from the source at about 20 to 30 feet downwind as a minimum.

An illustrative example of a typical acceptable view path/wind direction orientation is provided in Figure 23.



**Figure 23. Example Preferred Configuration for Acquiring a Path-load**

The Boreal TDL equipment performed according to expectations for collecting the required data. For a given set of electronics the equipment can be limited to a not-to-exceed concentration when used for short measurement paths. In any future testing, additional paths would be run farther away from the source, field conditions permitting, as well as closer to the source for reasons explained elsewhere in this technical note. The current model should be usable, without modification for that purpose. Within a few inches of the emission source, a model modified to have lower sensitivity would be helpful to allow easier measurement of high concentrations near the source at reasonable path lengths. Other than that the current equipment appears to meet all the necessary requirements for the intended use.

Near real time data analysis would greatly facilitate the effectiveness of the field measurements. It would allow adjustments on the spot to ensure good data collection. From a practical point of view as a field tool, such analysis would appear to be a requirement of a final protocol.

Based on results of the current study, it should be possible to estimate the best positioning of the TDL equipment through modeling with a minimal effort. The results of these tests underscore the benefit of conducting tests under relatively calm and spatially stable wind conditions to the extent possible. Correspondingly the additional modeling would be conducted for a limited set of conditions consistent with such wind conditions.

Another means of accounting for varying met conditions would be to introduce a second “tracer” gas source into the same region as the methane gas plume. The tracer gas would be metered at a known rate and released in the same region as the emission source. A second TDL would be set up tuned to the tracer gas. By comparing the tracer measurements with methane measurements, a de facto calibration of the effects of wind conditions on plume behavior could be established.

During this project one of the operators asked about the suitability of the TDL method for Emissions’ speciation beyond methane. The short answer is that Fourier Transform Infrared (FTIR) Spectroscopy, another method of measuring ambient air concentrations of gases, would likely be used if speciation were the primary measurement to be made. The reason is that TDL uses electronic circuitry tuned to a specific spectral region of a single specific compound. Other compounds can be identified and quantified but it requires, with current technology, a hard-wired change in the transceiver. FTIR captures absorbance data for an entire spectral region, which can then be analyzed for individual species comprising that absorbance spectrum. The logistics and operational costs would be similar, equipment costs would be higher, but positioning of the equipment would be easier for an open path measurement. The method can be used also in a closed path sampling mode.

#### 4.0 Economic Feasibility Evaluation

To be feasible, the TDL method and Protocol for gas well and gas field seepage emission measurements must be economically competitive with alternative means for detection, monitoring, and measurement of gas emissions. The total cost includes the cost to complete methods and protocol development to provide a basis for routine operational use by a storage field operator. Further development costs are assumed to be funded through additional GSTC development. At this time a fixed cost is assigned to that item.

On a preliminary basis, the most direct way is to compare the cost of the TDL method with the cost of alternative methods of emission detection and measurement. A preliminary, simple estimate is presented for the costs of completing development and providing a Protocol as a routine, field-ready operational method.

It assumes that a gas storage operator would implement such an emission detection and measurement protocol using a contractor under the supervision of the operator's staff. The estimate examines the operator's one time cost for implementation and recurring annual expense costs to conduct the well monitoring.

Tables 10 and 11 summarize the results of the cost analysis. Table 10 is an estimate of development costs to complete development of the method and Protocol for commercial application. It includes the following pre-field test activities: additional emissions modeling, path positioning and analysis based on modeling, pre-field test planning based on a complete draft protocol, and future field work, data reduction and analysis, reporting, and final protocol preparation, including criteria for positioning the TDL equipment.

Table 11 shows operating costs for uses of the protocol by a base case operator. It includes one-time and recurring costs as defined previously. The estimate is based on the following assumptions:

The operator will train at least two persons to coordinate and supervise the field work, and at least two other persons to analyze the data and prepare appropriate internal reporting of results.

The actual field work will be conducted by a contractor. The contractor will provide the TDL and infrared video camera, and other materials for the field testing. It is assumed that contractor could cover one well per day with two technicians on an annual round of well tests.

For the hypothetical base case operator, it is assumed that there will be a need to test 25 wells per year in a rotational monitoring program through the entire system of wells.

One time costs will be incurred in the first year and will be allocated over the first five years of operation.

Recurring annual expenses will occur every year. (The exact scheduling of a monitoring program depends on the timing required to remedy emissions according to an optimal economic benefit plan. This means that for each well or group of wells there will be an emission rate

threshold that will be reached before remedial action is taken. It is also assumed that this work all takes place in the absence of any regulatory driver that requires emission reduction at a mandated threshold. It should be clearly understood that because the costs and economic benefits will vary by individual operator the example given here is for conceptual illustration only).

**Table 10. Estimated Development and Deployment Costs**

Activity	Cost, \$
<b>Pre-field Testing</b>	
Methane - controlled gas release set-up	15,000
Testing 2 weeks	
Plan	5,000
Staff	20,000
Data analysis and reporting	15,000
<i>Sub-total pre-field testing</i>	<b>55,000</b>
<b>Field Testing</b>	
Plan	7,000
Mobilization	5,000
Equipment	20,000
Field supervision labor, one person, 4 weeks, 40 hr/wk	16,000
Field measurements staff labor, two persons, 4 weeks, 80 hr/wk	32,000
<i>Sub-total field testing</i>	<b>80,000</b>
<b>Data Analysis and Reporting</b>	20,000
<i>Sub-total data analysis and reporting</i>	<b>20,000</b>
<b>Protocol Preparation</b>	50,000
	<b>25,000</b>
<b>Subtotal Labor</b>	<b>180,000</b>
<b>Equipment and Material Costs</b>	
Equipment	20,000
Materials	10,000
Shipping	15,000
<b>Subtotal Other Direct Costs</b>	<b>50,000</b>
<b>Travel Costs</b>	25,000
<b>Subtotal Travel Costs</b>	<b>25,000</b>
<b>Total Completion Development Costs by GSTC</b>	<b>255,000</b>

**Table 11. Approximate Implementation and Operational Expenses  
for Base Case Operator**

Expense Item	Cost, \$
<b>One-time Implementation</b>	
Implementation plan	10,000
Staff training (Basis: 3 operator staff, 1 week, 120 hrs)	12,000
<b>Total one-time implementation expense</b>	<b>22,000</b>
<b>Annual Operating Expense (Basis: 25 wells per year)</b>	
Operator field labor (Basis: 1 person, 8 hrs per well allowing for travel between wells)	20,000
Contractor fee (Basis: 2 persons, 16 hrs per well allowing for travel between wells)	40,000
Data review and operational integration (Basis: 40 hrs per year)	4,000
<b>Total annual application expense</b>	<b>64,000</b>
<b>Unit cost per well</b>	<b>2,560</b>

All of the preceding costs are preliminary estimates only, and subject to further modification in future work.

At this time it is assumed that the TDL protocol would compete with an aerial monitoring approach that in some circumstances might achieve the same results. At this time it is not clear that the aerial method could in fact accomplish everything that the proposed TDL method could accomplish, especially in rugged terrain and heavily forested areas. An aerial detection and measurement cost on an equivalent performance basis is necessary to complete an economic feasibility analysis.

## **5.0 Proposed Protocol Outline**

Assuming that all technical issues can be resolved, and that the protocol would be economically feasible, the field protocol that would be fully developed in a future phase of work to the current project would take a form similar to that described here. It is assumed that the protocol would involve the combination use of infrared videography and TDL technology, rather than TDL technology alone.

The protocol would be implemented by two trained field technicians working as a team. The monitoring program would monitor all wells on a rotating schedule and previously identified emitter wells on a risk-based schedule. The schedules would be established according to prior knowledge and an appropriate risk assessment method determined by the operator from their own experience and criteria.

The protocol would comprise the following basic steps recoding data specified by the protocol for each step:

Technicians would arrive at the site on a day and time where favorable weather conditions are expected.

After unpacking equipment, one or more met stations would be set up at designated locations near the test well. These locations would be specified according to specific criteria in the protocol document. These criteria would have been established in the Phase 2 development program. The wind conditions would be monitored for a protocol specified time establish the prevailing wind direction and wind speed for the site.

The technicians might first apply infrared videography to the emission source according to protocol criteria. A videographic data analysis, perhaps using video-image analysis software, would be applied to estimate the emission rate. TDL would also be applied according to protocol criteria. This assumes that the two methods could have complementary roles based on current observations.

For the application of the TDL, at least three paths would be selected for measurement. The technicians would position the TDL equipment appropriately. In addition, to the basic GPS position of the well and the TDL equipment and other data to be recorded, the distance downwind from the source for each path and the orientation and elevation of that path would be recorded, as specified in the protocol.

The technicians would then set up the TDL apparatus and conduct a series of path measurements as specified by the protocol.

Technicians would field-evaluate the collected data based on a software data reduction and analysis algorithm loaded on their field computers and on receiving real time or near real time data directly from the TDL and met station data loggers. A determination would be made whether the data session was satisfactory or additional data were required. When acceptance criteria were met the data collection session would end.

At the end of the session the technicians would pack up the equipment and leave the site.

The expectation is that when fully developed the protocol could be executed within three hours from initial arrival at the well site to departure with all equipment packed up.

Final data analysis and reporting would take place off site.

The above general steps would be covered in a protocol document following an outline similar to that shown on the next page.

### **Proposed Outline of Content for TDL Detection and Measurement Protocol**

- 1.0 Introduction
  - 2.0 Purpose and Need
  - 3.0 Initial Site Survey
  - 4.0 Infrared Videography Screening
  - 5.0 TDL Execution Decision
  - 6.0 TDL and Meteorological Station Equipment Preparation
  - 7.0 Setting up the Meteorological Station
  - 8.0 Met Data Collection and Analysis
  - 9.0 Setting up the TDL Apparatus
  - 10.0 TDL Data Collection and Analysis
  - 11.0 Concluding the Test
  - 12.0 Re-packing Equipment and Site Departure
  - 13.0 Final Data Analysis, Interpretation, and Reporting
- Appendices

## CONCLUSIONS

1. Preliminary field tests have applied a TDL for detecting and measuring airborne concentrations of methane, relatively close to the well heads, from gas well surface emissions in gas storage fields. Such emissions occur through cement defects such as fissures and cracks, and between cement and the outer walls of casing and the borehole wall. The current work constitutes screening tests and has established the directions of future work for developing the TDL method for the subject application.
2. Dispersion modeling was able to reasonably estimate emission rate within the uncertainties of the current data. An updated Version 11 of the CHARM® dispersion model was used. The result with the least uncertainty was estimated emission rate of 8.2 mscfd. This compares with the operator-reported well vent average emission rate of 1.8 mscfd from other types of measurement. This does not, at first, appear to be very good agreement. However, there is no assurance that during the time of the TDL tests the actual emission rate was the average reported by other means. Also, modeling effects of differences in emission rate and positioning of equipment showed significant sensitivity to minor differences in elevation between the TDL transceiver and retro-reflector relative to gas plume position. These issues should be explored further in any future tests.
3. Additional field tests are needed to provide more comprehensive data for confirming the requirements for determining emission rates by modeling the measured ambient concentrations of methane in the vicinity of emission sources. Specifically, the greatest needs are: 1) better measurements of the wind field in the vicinity of each measurement path; 2) more measurement paths positioned closer to a right-angle with the plume axis; and 3) more accurate and precise measurement of elevation differences between the transceiver and retro-reflector. For the current data set, a modeling sensitivity analysis revealed that an elevation distance of about 18 inches over a 60-ft path length could alter the calculated result by the magnitude of the difference between reported and calculated. The modeling assumes a horizontal path through the gas cloud, not one at an angle.
4. The actual tests were conducted on emissions from casing annuli vented to the atmosphere. These types of emissions were present for the wells available to the project. The data allow a preliminary assessment of feasibility and definition of a preliminary protocol for field application of the method for monitoring, detecting, and measuring emissions from gas seepage from cement casing and cement defects.
5. The ambient methane concentration measurements over short durations of a few minutes show extensive variability as would be expected from atmospheric turbulence and measurements in regions close to the emission source with incomplete mixing. This is consistent with other data from the technical literature for similar testing (Ref. 4).
6. Wind speed did not appear to be major factor at the relatively low average wind speed during the tests. Wind direction is important as is the frequency and duration of shifts in wind direction.



7. The TDL can detect very low methane concentrations and can find emission locations easily. There were cases where levels or changes as low as 1 ppm (or less) above a background methane concentration of about 2 ppm would show up on the TDL transceiver monitor very quickly when it was obvious there was a momentary wind shift. In one case the detector responded so quickly that when the wind shifted 180 degrees the detector would drop or rise to a reading within about 1 sec of the wind shift. The concentration at a given distance and height will vary with emission rate and met conditions. The farther one moves from the source, the less variation there is in the time variation in the measurements, but the greater the uncertainty relating the measurements to the emission rate. This is the core issue that must be further explored to better define at which locations measurements would be most favorable to the desired objective and what changes need to be made to the field protocols to accomplish those measurements. The sensitivity of the instrument should make possible the measurement of emissions at far lower rates than was occurring at the wells tested. The wells had rates in the range of a few hundreds to a few thousands standard cubic feet per day of gas. Based on observations of field conditions, the measurements taken, and modeling to date, detection and measurement of concentrations should be possible for lower rates.
8. An infrared video camera was used to scan the area of the wellhead and identify emissions from piping components. The value of the TDL method can probably be enhanced when used in combination with infrared photography, especially video photography. The TDL would be used to find the general location of an emission from a distance, and the IR could show an image where the concentration was high enough to be detectable by that means. The video also helps to detect changes in nearby wind direction, at least close to the emission source, which helps in the interpretation of the down wind gas concentration measurements by the TDL, and conversion of those measurements in to emission rate. It would be advantageous to also apply infrared videography in conjunction with TDL measurements in future tests. It is not clear at this time how infrared videography detection sensitivity compares with TDL at low emission rates.
9. More work needs to be done in optimizing the selection of the downstream measurement path(s) distance. This can probably be done by modeling, with a future phase of field work needed for confirmation, along with further work on the items discussed above.
10. For open field gas seepage the TDL could be used to scan a large field, or with appropriate modifications a forested area. The basic techniques of data collection and analysis would be similar to the other applications.
11. Before such testing is conducted, it would be beneficial to modify the TDL equipment used and establish other field test equipment needs for complementary measurements such a meteorological conditions and infrared imaging data capture and analysis.
12. Provision should be made for real time or near real time data reduction and analysis to guide changes in measurement set-up locations and settings during measurements and field tests. The current study analyzed captured field data off-site after the tests were run. The real time or near real time analysis of field data would require loading

appropriate software routines into the computers used for data transfer from the field data loggers that would allow direct transfer in real time from the commercial equipment to the data processing routines in a field computer. This would allow a technician to validate results in the field and make appropriate testing adjustments while in the field.

13. "Common wisdom" is that it is better to take measurements far from the source, where high variability has been smoothed out in the plume concentration. In the era before rapid measurements and computer tools, this was reasonable. However, the disadvantage of far field measurements is that concentration gradients are dampened so that relating the plume concentration to an emission rate requires more measurements. Moving closer to the source seems desirable.
14. The high concentrations nearer the wellhead, at the source of the emissions, would require shorter path lengths and or a less instrument sensitivity than was used in the current tests.
15. There is the issue of how to configure the field equipment set up for flexibility in very difficult terrain conditions, such as highly convoluted hilly or mountainous terrain where some gas storage field reside. The task of measurement using optical systems is far easier in more open and flat areas.
16. Location constraints in the placement of the equipment caused by some individual well locations offer challenges in developing an appropriate protocol. However, at this stage these do not appear to be insurmountable challenges. This issue might be addressed through mathematical means to define modified instrument requirements, and modified methods field methods to acquire additional data and resolve questions arising from the work to date. As we move forward we will be attempting to define the feasibility envelope based on location factors.
17. Other optical methods have been and continue to be under investigation. From the present study it is the opinion of the authors that there would be value to a comparative analysis of the various methods that have been proposed and to seek a clear identification of their relative merits in the interest of defining a broader protocol that may include multiple methods. The TDL method tested here could be part of suite of tools each with its optimal application.
18. Further development of the TDL method is believed to capable of providing a fully developed protocol for the stated purpose. The final protocol should include the combined use of infrared videography and TDL as complementary tools for monitoring and measuring gas emissions. This tool kit would provide the gas storage industry with a better and more accurate means to detect low gas emission rates, to measure and monitor changes in these rates, and improve the well integrity maintenance process.
19. A preliminary cost estimate to complete development of the method and protocol for the subject applications was generated and is included in the body of the report. A proposed outline of the contents of a final protocol is also presented. Further experimental work would be required to provide the necessary data to complete development and a full protocol. The cost effectiveness and value of the method to meet targeted operator needs must be determined by the individual operators.

## REFERENCES

1. Boreal Laser, Inc. *Gas Finder2.0 Portable System Operation Manual*, Boreal Laser, Inc., #13, 51127 RR255, Spruce Grove, Alberta, Canada T7Y 1A8. (Included in Appendix A of this report.)
2. *CHARM® User's Manual*, URS Corporation, Austin, Texas. (Included in Appendix E of this report.)
3. "ThermaCAM® GasFindIR, Infrared Camera for Leak Detection and Repair." Brochure, FLIR Systems, Inc., Portland, Oregon.
4. Bauer, J., J. Tulip, P. Kain, M. Paulson, J. Ondreck. "Results of the Application of a New Laser Based Open-Path Spectrometer for the Measurement of Fugitive Emissions from Gas Processing Plant." Boreal Laser, Inc. #13, 51127 RR255, Spruce Grove, Alberta, Canada T7Y 1A8.
5. Adam, H. and J. Bauer, Boreal Laser, Inc. #13, 51127 RR255, Spruce Grove, Alberta, Canada T7Y 1A8, J. Tulip University of Alberta, Edmonton, Alberta, Canada, "Greenhouse Gas Emissions and Reduction Studies Using a Portable TDL Gas Monitor."

## **APPENDICES**

Appendix A – Boreal Laser Gas Finder 2 User Manual

Appendix B – Path Positions

Appendix C – Path Data

Appendix D – Meteorological Data

Appendix E – CHARM® Information

Appendix F – Input Data Used for Site 3 Emission Estimate Modeling

**BOREAL LASER INC.**

# GasFinder2.0

Portable System

## Operation Manual

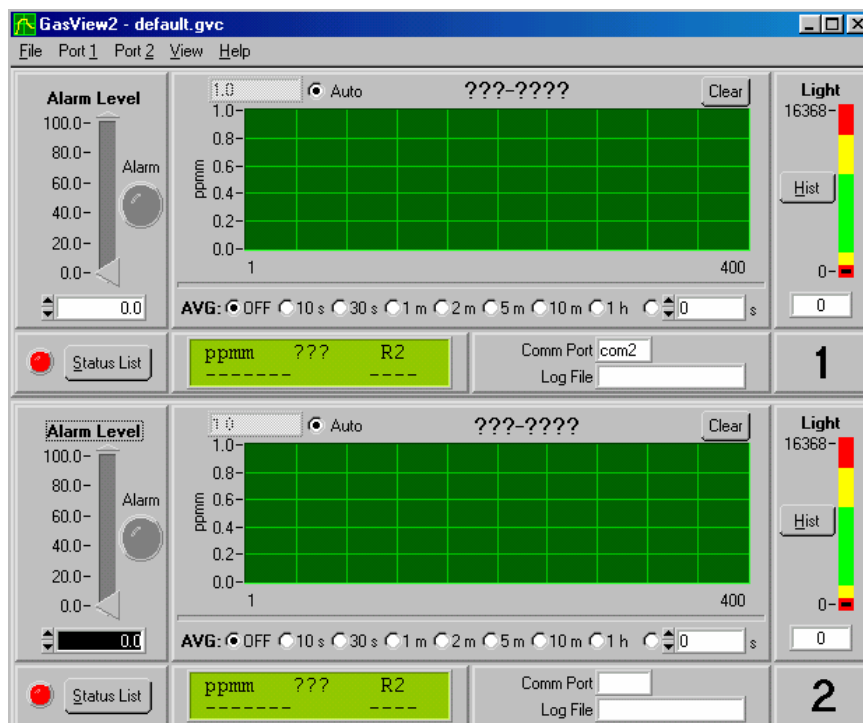


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# BOREAL LASER INC.



**GasFinder2.0 shown on different mounts**



**GasView2 Software Display**

# BOREAL LASER INC.

## GasFinder2.0

### Operation Manual

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## System Description

Boreal Laser's patented (US Patent 5,637,872) TDL (Tunable Diode Laser) Open-Path Monitor, measures gas concentration over an open path. It consists of an integrated transmitter/receiver unit and a remote, passive retroreflector array. The remote retroreflector is initially targeted by the operator using a two-axis instrument mount assisted by a alignment scope and an on-board visible aiming laser.

The transceiver houses the laser diode source, the transmitter and receiver electronics, the detector module, and microcomputer subsystems. The transceiver unit is contained in a weatherproof enclosure and has connectors for 12V power input and data I/O. A schematic representation of the **GasFinder2.0** system is shown below.

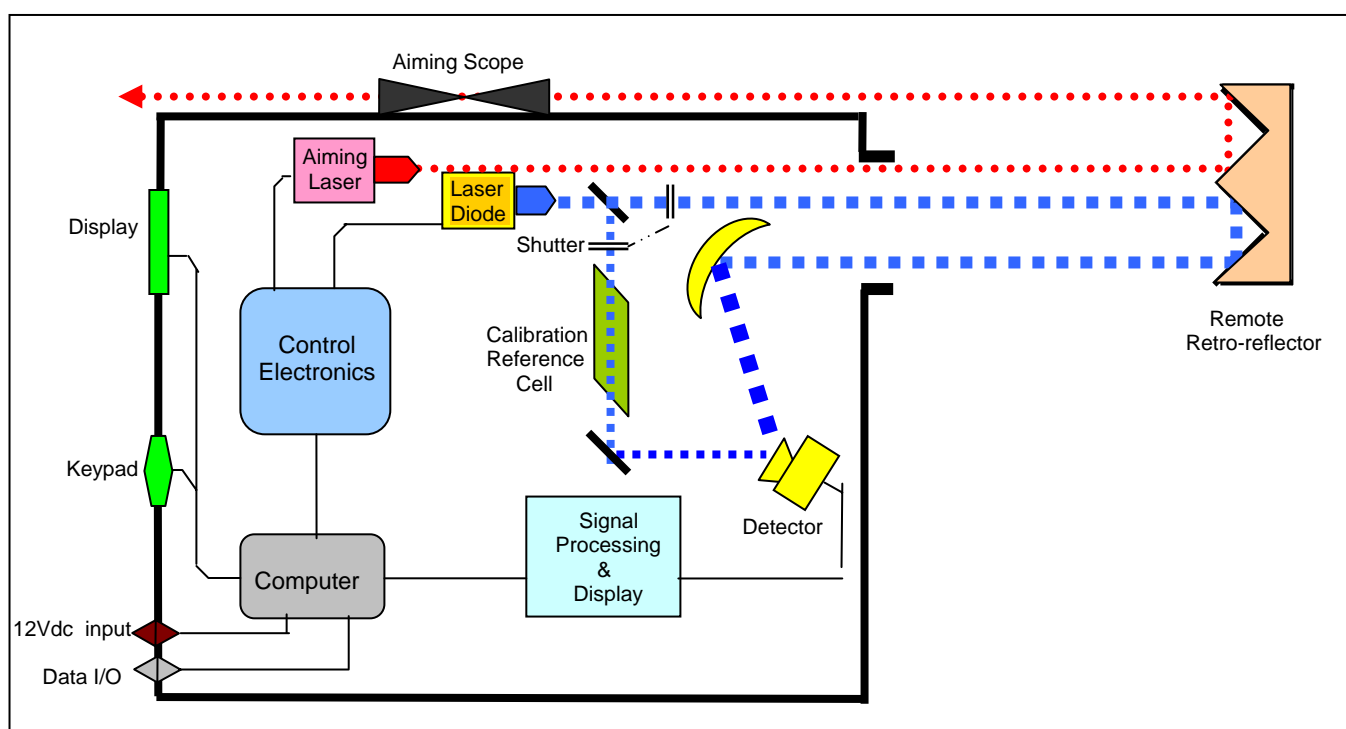


Fig. 1 Schematic representation of **GasFinder2.0**

The laser light emitted from the transceiver unit propagates through the atmosphere to the retroreflector and returns to the **GasFinder2.0**, where it is focused onto a photodiode detector. A portion of the laser beam is passed through an onboard reference cell to provide a continuous calibration update. These two optical signals are converted into electrical waveforms, which the microcontroller processes to determine the actual concentration of gas along the optical path. The computed gas concentration is then displayed on the back panel of the instrument and can be transmitted to a coordinating computer where the data can be collected, stored and graphically displayed.



## **Specifications**

Scan Rate	1 sample/sec
Distance Range	0.1 - 1000 m

## **Certification**

CSA	Class 1, Division 2, Groups A, B, C and D* NRTL/C
CE	EN 50082-1 : 1998
ATEX	Pending

\* The input power must be connected to a NON-Incendive source of supply that does not exceed 12.5Vdc and 3A.

## **Physical Data**

Weight	5.2kg
Dimensions (LxWxH)	290x195x150mm
Power Requirements	2A @ 12Vdc
Operating Temperature Range	-30°C to +50°C
Sighting Optics	3 - 9 x 40 scope (also an on-board visible aiming laser)
Display Options	2 x 20 character Liquid Crystal Display
Data I/O Interface	RS232, 1200/2400/9600 baud (N-8-1) optional 4-20mA Current Loop
Laser Type	Semiconductor laser
Eye Safety Class	IIIa (as per ANSI Z136)

## **Sensitivity**

Sensitivity: <b>HF</b> System	0.1 ppmm
Sensitivity: <b>H<sub>2</sub>S</b> System	30 ppmm
Sensitivity: <b>NH<sub>3</sub></b> System	10 ppmm
Sensitivity: <b>CH<sub>4</sub></b> System (long path)	100 ppmm
Sensitivity: <b>CH<sub>4</sub></b> System (short path)	(high sensitivity) 2 ppmm
Sensitivity: <b>CO<sub>2</sub></b> System	1000ppmm

## Dimensions

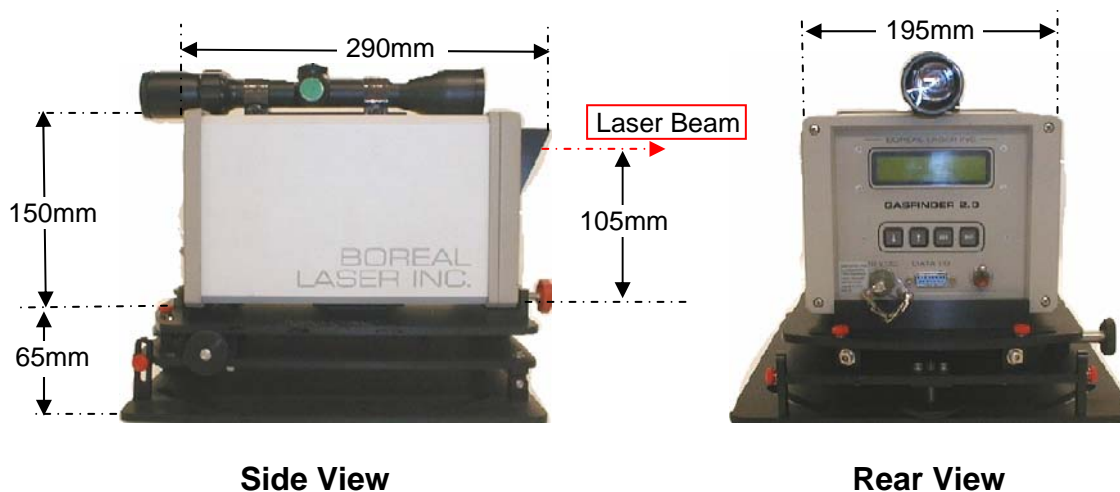


Fig. 2

For mount dimensions see Fig. 7

## Power Supply

Any regulated 12 volt supply capable of delivering 2A d.c. will power the **GasFinder2.0**. The battery unit supplied by Boreal Laser Inc. for portable use, shown in Fig. 3, lasts about 6 hrs. A car or truck battery will last about 48 hrs.



Fig. 3



Fig. 4

A regulated power supply, shown in Fig. 4, connects to 110v / 220v and 50~/60~, and is recommended for fixed operation. A dual channel power supply is also available which can operate two **GasFinder2.0s** simultaneously.

## Installation

### Portable Use

When the **GasFinder2.0** is to be used as a portable instrument, there are two different configurations to consider.

For rapid deployment on a tripod over short paths(<30m), a tilt/pan head camera mount can be used (see Fig. 6). The tripod should be placed on a firm base, and the 'pan head' mounted to the top of the tripod. If a hex plate is attached to the base of the quick-release fitting on the **GasFinder2.0**, the instrument can be attached to the pan head. The instrument can be aligned using the visible laser.

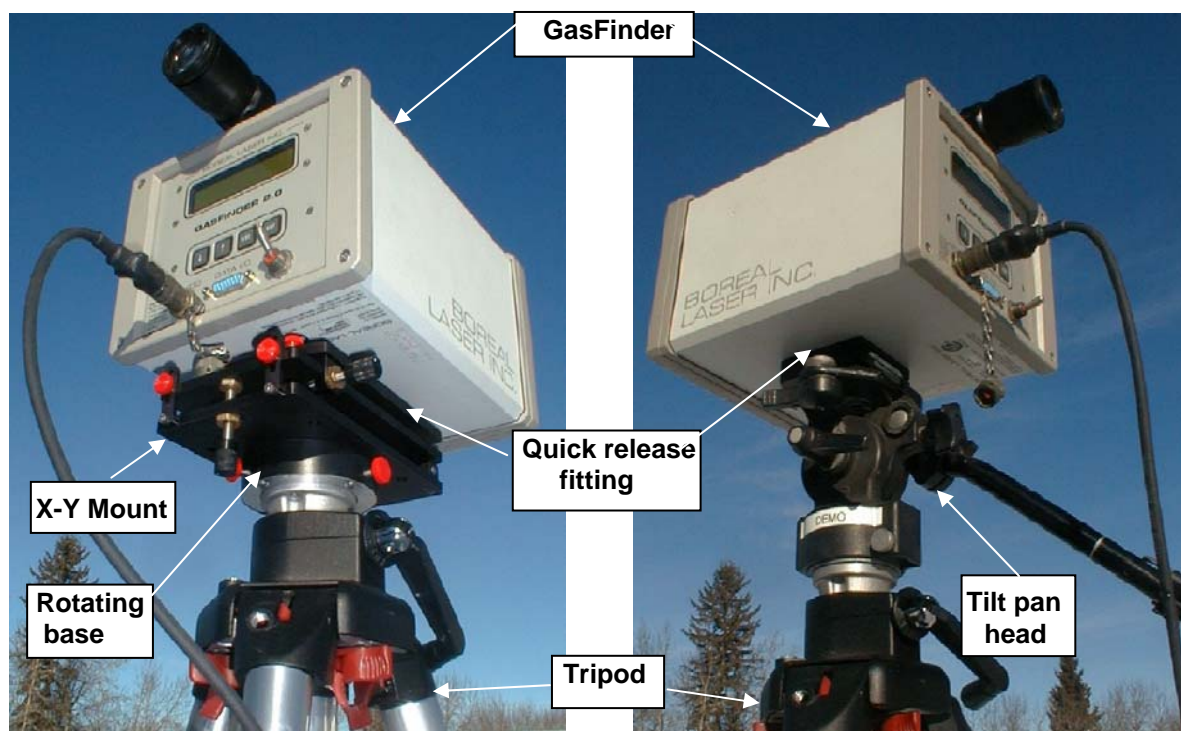


Fig. 5

Fig. 6

For longer paths, a small X-Y mount can be mounted directly to a tripod (see Fig.5). The tripod legs and the rotating base can be adjusted so that the mount is roughly aligned with the retroreflector. The **GasFinder2.0** is attached to the mount with a quick-release fitting. Precise alignment can be made with the X - Y mount. If the tripod base is firm, path lengths up to 600m can be achieved easily. The stability of the tripod can often be increased by tying a heavy weight such as a car battery to the central hub of the tripod. The tripod is adjustable to give a laser operating height from 620mm to 2,340mm.

## Fixed Use

### Large X – Y Alignment Mount

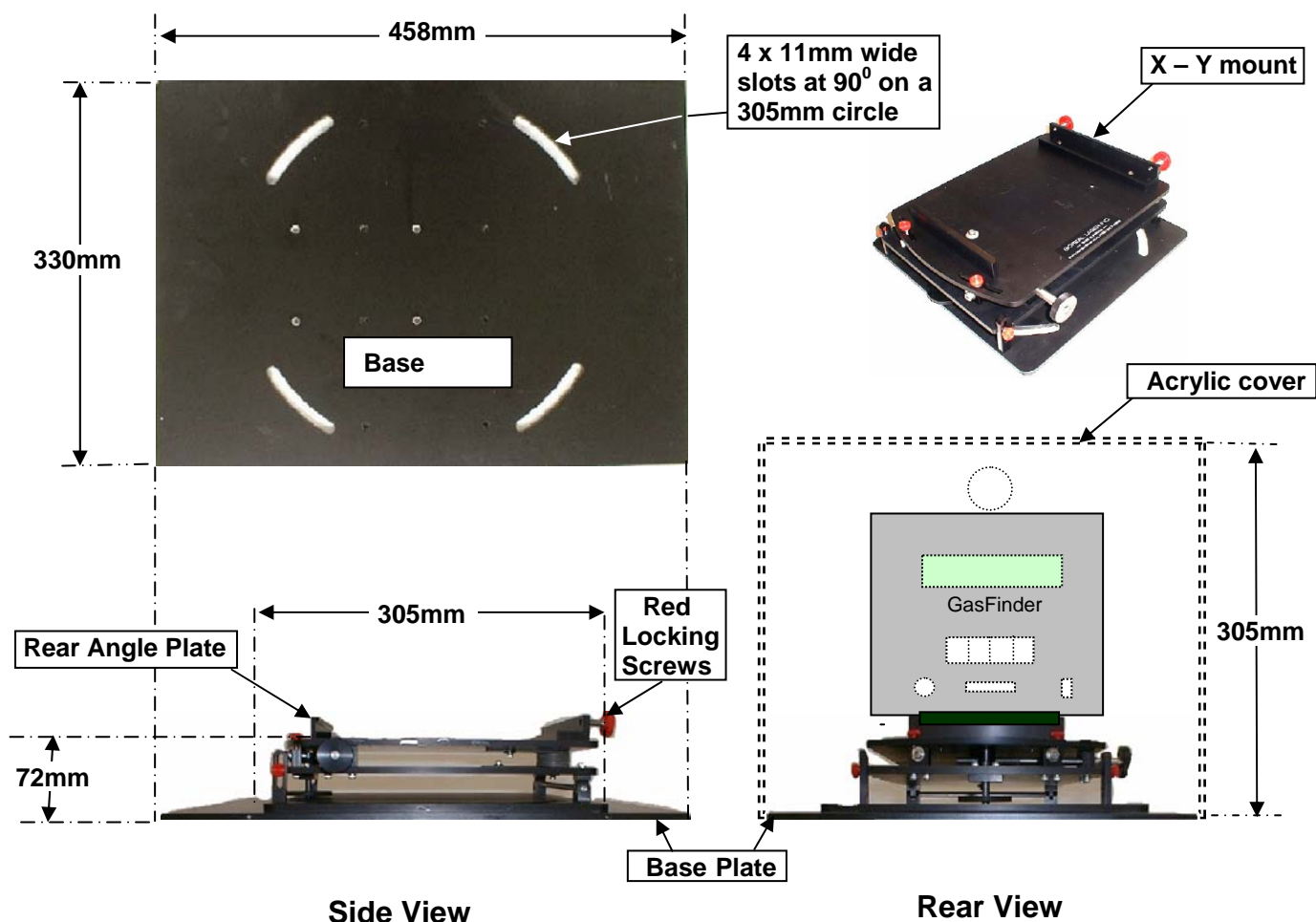


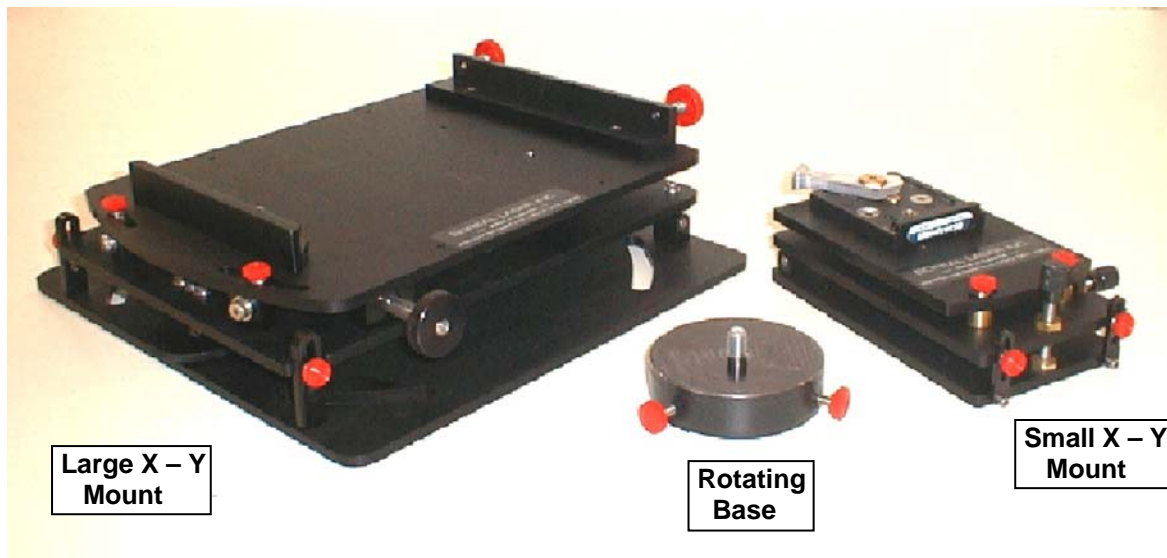
Fig.7.

### Installation Guidelines

With bolts going through the four slots of the mount and base plate, roughly align the X – Y mount to face the retro reflector. Tighten the four mounting bolts. Place the **GasFinder2.0** on the mount such that the rear panel of the **GasFinder2.0** locks under the rear angle plate on the mount. Tighten the two red locking screws on the front of the mount into the holes at the bottom of the front panel on the **GasFinder2.0**. Connect the power supply and data cables. For precise alignment procedures refer to Operating Instruction #6.

**Note:** The minimum recommended separation between multiple **GasFinder2.0** transceiver units is 300mm. Due to the modulation techniques employed in the **GasFinder2.0** system, interaction or “cross-talk” with other types of monitoring instruments should be negligible.

## Illustrations of Mounts



## Illustrations of Enclosure



Rear



Front



## **Retroreflectors**

The type of reflector used will depend on the path length, atmospheric conditions such as dust or fog, and the type of laser. When choosing a reflector, the prime concern should be to keep the returning light level value between 2000 and 12,000. The following reflectors are suggested only as a guide. Consultation with Boreal Laser is recommended before choosing a reflector.

**Note:** It is possible to get too much light returned (>16,368). When this happens the receiver saturates and the displayed light value will read very low (<200).

For distances 1m to 10m use reflective traffic tape. #RFTP

For distances 5m to 30m, use grey reflective tape. #RFGT

For distances 20m to 70m, use plastic highway reflectors. #RFHWY

For distances 60m to 120m, use one 1" corner-cube retroreflector.

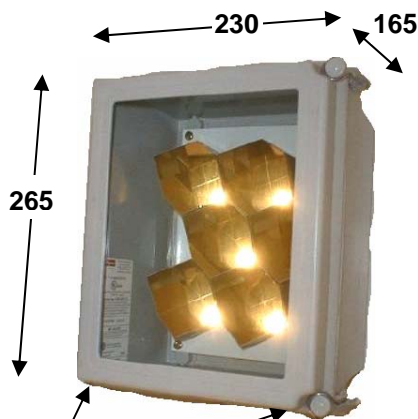
For distances 100m to 150m, use one 2½" corner-cube retroreflector.

For distances 150m to 200m, use two 2½" corner-cube retroreflector.

Reflector enclosures are available with enough retros inside to measure gas concentrations over path lengths up to 1km. Consult Boreal Laser for more information.

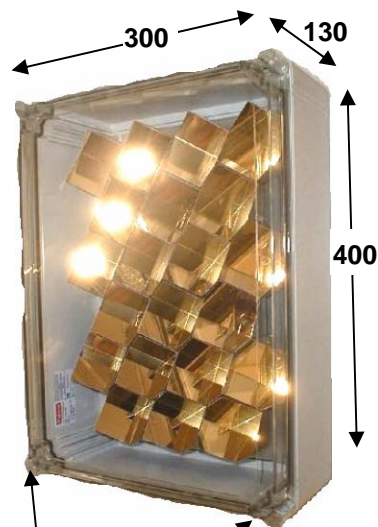
**6 - Retro enclosure**

All dimensions  
In millimetres



4 mounting lugs, on a rectangle 153 x 278

**21 - Retro enclosure**



4 mounting holes, on a rectangle 280 x 380

## Operating Instructions

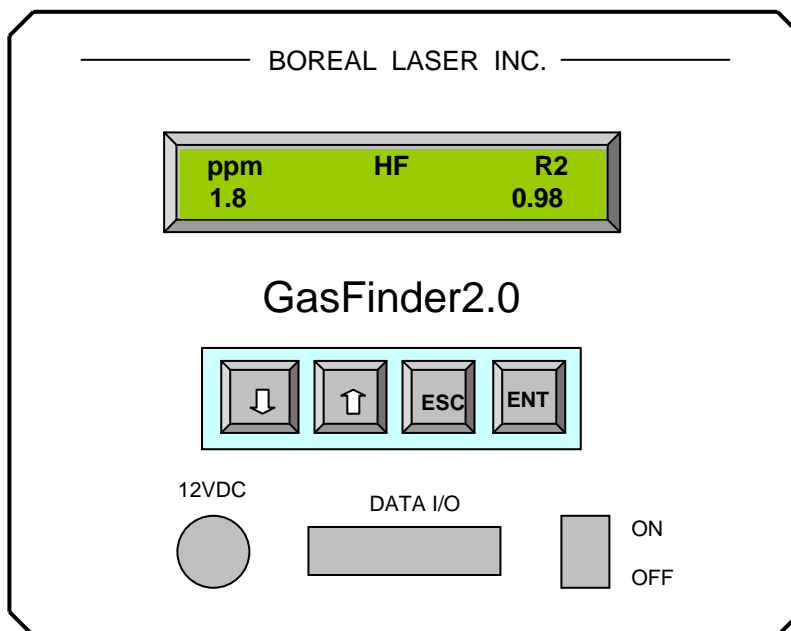


Fig. 8 Rear Panel Layout

1. Connect the **GasFinder2.0** to the 12V power supply, the data interface cable to the computer if required, and switch on. The display will read\*:

A green rectangular display with black text. The top line reads "GasFinder2.0 Warm\_up" and the bottom line reads "Ver:0.37 HF 180".

GasFinder2.0 Warm\_up  
Ver:0.37 HF 180

*This warm-up cycle lasts three minutes. The warm-up period for other gases maybe different.*

2. After the warm-up cycle, the following display may appear:

A green rectangular display with black text. The top line reads "Low Light" and the bottom line reads "No Reading".

Low Light  
No Reading

indicating that the **GasFinder2.0** is off-target and requires alignment with the retroreflector.

\* Throughout the manual, various gas types will be referred to in the displays. In this case the display refers to Hydrogen Fluoride.

- Press the **ENT** key on the keypad, then the  $\downarrow$  key twice, and the **Light Value** display will appear:

Light Value	dist m
64	10

indicating a pre-set default distance of 10 meters and a minimum returning light value of 64 (a light value of < 100 indicates a no-light situation)

- Adjust the distance to the retroreflector by pressing the **ENT** key again. A flashing "Adj." will be visible in the lower left corner of the display. Note that the **GasFinder2.0** does not measure the distance to the retroreflector. The distance, in metres, must be entered manually. It is measured from the front panel of the **Gasfinder2.0** to the retroreflector.

Light Value	dist m
Adj. 64	10

- Pressing the  $\uparrow$  or the  $\downarrow$  key increases or decreases the distance. Once the appropriate distance has been entered, press the **ESC** key. The display will now show the entered distance.
- The system is now ready for optical alignment. The red aiming laser will be visible. Using the attached scope, adjust the X – Y mount adjusting screws to locate the retroreflector in the cross hairs of the scope. Fine-tune the adjustment so that the displayed light value is in the optimal range (2000 – 12000).

If the light value is below this range, the system is in a low-light situation and may fail to make a correct measurement. When the light value drops below a factory set value of 500, the system will give a status message on the display indicating "low light - no reading". To increase the light value, move the cross-hairs closer to the center of the retroreflector array or increase the number of retros.

If the light value is above the optimal range, the receiver electronics may saturate and spurious readings may be displayed, e.g., unrealistically high concentration values and low confidence factors. To reduce the light value, move the cross-hairs slightly away from the centre of the retroreflector or cover some of the retros.

**Note:** At short distances of less than 50m, reflective tape should be used. The red aiming laser can be used for initial alignment. Do not look at the reflector through the scope over short distances when the red laser is operating.



7. Press the **ESC** key twice to return to the normal operating mode. After the computer checks the calibration, the display will read something like:

ppm	HF	R2
4		0.99

This indicates a measured path-averaged hydrogen fluoride concentration of **4ppm** with an **R2** of **0.99** (99%). Of course, this display will depend upon the type of gas, and the actual concentration. Note that to get the correct value for **ppm**, the path length (distance) has to be set correctly (see item 5).

**Note:** The **ESC** key returns to the *previous* menu item. So, if the user becomes “lost” within the menu system, press the **ESC** key until the system returns to the normal operation mode (as shown above in step 7).

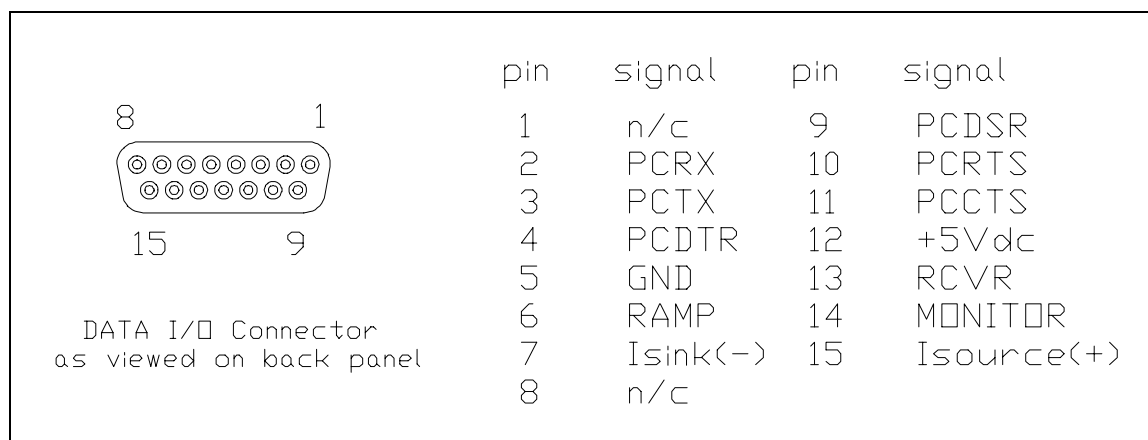
**Data I/O**

Fig.9

The DB15F connector on the back of the instrument is a hybrid data I/O connector, combining serial data output (RS-232) and analogue signals useful for examining system performance. The connections for a serial data cable are shown in [Appendix E](#).

**Signal Description**

(n/c = No Connection)

1	n/c		
2	PCRX	Data Receive at PC	digital output from GasFinder2.0
3	PCTX	Data Transmit at PC	digital input to GasFinder2.0
4	PCDTR	Data Terminal Ready	digital input to GasFinder2.0
5	GND	Signal Ground	digital / analogue
6	RAMP	System Timing Clock	analogue output from GasFinder2.0
7	Isink (-)	4-20mA Loop Return*	analogue output from GasFinder2.0
8	n/c		
9	PCDSR	Data Set Ready	not currently implemented
10	PCRTS	Ready To Send	not currently implemented
11	PCCTS	Clear To Send	not currently implemented
12	+5Vdc	System Voltage	digital / analogue
13	RCVR	System Signal	analogue output from GasFinder2.0
14	MONITOR	System Signal	analogue output from GasFinder2.0
15	Isource (+)	4-20mA loop source*	analogue output from GasFinder2.0

\*when option installed

**Note:** Data I/O equipment may be connected or disconnected while the system is operating. Caution should be observed as:

- during transition, data *may* be lost or altered,
- mechanical stresses on the system while plugging or unplugging connectors *may* misalign the system (see [Operating Instructions](#)).

## **Serial Communications**

The **GasFinder2.0** instrument will transmit serial data at 1200/2400/9600 baud, no parity, 8 bits, one stop bit, (i.e., 9600,N,8,1) after each scan. Two hardware handshaking options are available:

1. No Handshaking – Connect pin 4 (PCDTR) to pin 12 (+5Vdc) at the **GasFinder2.0** end of the data cable. Data will be sent automatically after every scan. This is the standard configuration of the cable as supplied by Boreal Laser.
2. DTR Handshaking – Control computer raises the voltage to +5Vdc on pin 4 (PCDTR) in order to request a data string. Data will be sent only when requested to by the control computer.

Appendix E shows details of the serial-data cable connections.

## **Data String Specification**

The data are transmitted as an ASCII string. The format of the string is as follows:

`concentration,R2,distance,light,date_time,ser_num,status_code,*checksum`

where:

concentration	in ppm (parts per million meter),	<i>Integer</i>
R <sup>2</sup>	between 0 and 99,	<i>Integer</i>
distance	user set distance to reflector in metres	<i>Integer</i>
light	returning light level,	<i>Integer</i>
date_time	current date and time, YYYY/MM/DD hh:mm:ss	
ser_num	identification number of the system,	<i>String</i>
status_code	code giving system operation parameters,	<i>Integer</i>
checksum	check summing option to verify data integrity,	<i>String</i>

These data are comma-delimited (,) and an asterisk (\*) signifies end of string. Each string is terminated by a carriage return and a line feed.

Status codes are described in detail in Appendix B of this manual.

## **Maintenance**

The **Gasfinder2.0** instrument requires no internal maintenance and **there are no user-serviceable parts.**

**Note:** The instrument relies on a clear optical path to obtain readings of gas concentration. Dust settling on the instrument's window and the window of the retro enclosure must be cleaned off whenever it degrades the instrument's performance. The average value for the light level should be kept between 2,000 and 10,000.

### **Cleaning the Windows**

Many dusts, especially aluminium oxide, are very abrasive and care must be taken not to scratch the windows when cleaning them. The recommended procedure for cleaning is as follows:

1. Blow off any dust using canned<sup>A</sup>, compressed air. Note that compressed "shop" air may contain oil from the compressor, and should not be used.
2. If the window is streaked with rain-deposited particles, wash it with copious amounts of water using a spray bottle (laboratory or other type), and clean fingers.
3. Gently wipe with a soft "Kleenex" tissue.
4. Spray a small quantity of an anti-static solution<sup>B</sup>, if one is available, on the window.
5. Gently wipe clean with a dry, soft tissue.

<sup>A</sup> This product is available from camera shops, electronic stores or directly from Boreal Laser Inc.

<sup>B</sup> A suitable anti-static solution is "Novus No.1", used by plastic fabricators and aircraft maintenance staff for cleaning windscreens, and can be obtained directly from Boreal Laser Inc.

**Note:** Extreme care should be exercised when cleaning the window on the front of the **GasFinder2.0**, as it is a very delicate plastic membrane.

### **Cleaning Intervals**

The need for cleaning will be indicated by a consistent loss of light, which may result in poor gas concentration readings. Cleaning intervals may vary from once per week to once per year.

Difficulty in obtaining an adequate light level after cleaning the windows may indicate that the instrument has moved out of alignment. This may be caused by movement of the base due to vibration or other factors. Details of the alignment procedures can be found in the Operation Manual.

## **Troubleshooting**

- **Symptom:** System not operating.
- **Solution:**
  - ✓ Check power supply integrity.
    - plugged in?
    - fuse intact?
    - power cable intact?
- **Symptom:** Status message: “Low Light - No Reading”
- **Solution:**
  - ✓ Check that open path is clear (see note below).
    - vehicle/personnel obstruction?
    - heavy fog?
    - heavy rain?
    - windows dirty?
  - ✓ Verify optical alignment (see Operating Instructions)

**Note:** If the system enters the “Low Light - No Reading” status condition due to temporary path obstruction, normal operation will automatically resume once obstruction has been removed (e.g.: fog lifts, rain stops or vehicle/ personnel is moved).

- **Symptom:** No data transmission.
- **Solution:**
  - ✓ Check that the correct handshaking option is selected.  
(see Serial Communications section)
  - ✓ Check that the correct baud rate is selected.  
(see Serial Communications section)
  - ✓ Check that the correct check sum option is enabled  
when used with the **GasView2** display program.
  - ✓ Check system.
    - on line?
    - data cable connected?

## **Safety Issues**

Boreal Laser's **GasFinder2.0** contains both visible and invisible (infrared) laser sources. Both sources conform to **Class 3a** as per **ANSI Z136.1-1993** and do not require the use of protective eye ware, protective equipment or special safety measures.

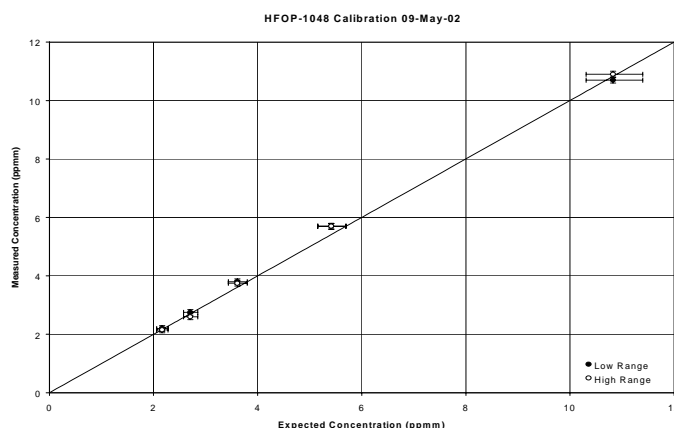
**Note:** Even though these lasers are considered to be "Eye Safe", it is the recommendation of Boreal Laser Inc. that, as with **ANY LASER SYSTEM**, the user/operator should avoid staring directly into the output aperture of the instrument.

- There is no optical ignition hazard presented by lasers of this type.
- The **GasFinder2.0** transceiver unit is suitable for operation in **Class I, Division 2, Groups A,B,C, & D** electrical areas *per CSA, NRTL/C*.

## Calibration

The **GasFinder2.0** is shipped already calibrated and does not require any calibration in the field.

The calibration of the **GasFinder2.0** is done by passing a known concentration of gas through a test cell, which is placed in the path of the laser beam. Gases which are very reactive or unstable, such as ammonia and hydrogen fluoride, are generated at the time of use with a permeation tube. The tube is placed in a temperature-controlled chamber and emits the calibration gas at a known rate. A measured flow of inert dilution gas creates a concentration of gas which is traceable to NIST standards. The calibration data are stored in the instrument's software as a standard reference waveform.



During operation, the **GasFinder2.0**'s internal reference cell is compared with this stored waveform at frequent intervals. Any significant deviation generates a status code to alert the user to a potential calibration problem. The **GasFinder2.0** software can be used to check the reference cell, as well as to download sample, reference and calibration waveforms to verify that the internal calibration system is functioning correctly. If **GasView2** is being used, these waveforms can be displayed on the computer (Port1/Arrays Plot Enable and then at the **GasFinder2.0** press the 'Internal Arrays Transfer' in Maintenance Menus).



Calibration Room



Test Cell

A technical note detailing the calibration procedure and quality assurance is available from Boreal Laser Inc.

## Main Display Menu

- **normal display:**

When the system is functioning normally, the display will read something like:

ppm	CH4	R2
8		0.99

Of course, the actual displayed values will depend on the particular gas concentration being monitored. In this example, the instrument is displaying a path-averaged methane gas concentration of 8ppm with an R2 of 99%. A detailed explanation of R2 is given in [Appendix D](#)

- **alarm display:**

If the system operation is outside the normal operating bounds, the display will provide insight into the abnormal situation. There are several possible displays.

**warm-up mode** - When the instrument is first turned on, the system requires a period of two to four minutes to establish and lock-in the required laser-diode operating temperature. During this period, the display will read:

GasFinder2.0	Warm_up
Ver:0.37	HFOP-10##

**During this phase the operator should refrain from adjusting the instrument.** A count-down timer in the lower right corner provides an indication of progress during this phase.

**low-light mode** - If the beam path is obstructed, there will not be sufficient returning light for the instrument to make a measurement of gas concentration. In this event, the display will be:

Low Light
No Reading

When this happens, the operator should remove the obstacle or reposition the instrument to provide a clear optical path.



**cooler failure** - If a problem develops with the internal thermoelectric cooler or the associated electronics, the system will protect the laser diode by shutting the laser off and displaying:

**TEC Failure  
Laser Diode Off Line**

**In this situation, the operator should contact Boreal Laser Inc. for further information as to resolving this problem.**

**receiver unlocked** - If the signal being analysed by the onboard electronics falls below a certain set value, and the returning light level is within the acceptable bounds, this may indicate a problem with the internal receiver electronics. In this event, the system will display:

**Unlocked  
No Reading**

**If this situation persists, the operator should contact Boreal Laser Inc. for further information as to resolving this problem.**

**low battery** - If the voltage of the portable battery or power supply goes below 11.5V, a 'B' will appear in the top right corner of the display. If the voltage goes below 10.0V, the **GasFinder2.0** will shut down and enter a "low power" mode after saving all the system variables. In this mode internal logging of the data will be suspended.

ppm	CH4	R2	B
8		0.99	

After a voltage greater than 11.5V is applied, the **GasFinder2.0** will resume normal operations.

## **Parameter Adjustment Menu**

If the operator presses the **ENT** key while the instrument is in the normal operating mode, the system will enter a parameter display/adjustment menu. The arrow keys ( $\downarrow$ ,  $\uparrow$ ) can be used to move between the various menu items. When the operator is in the menu system, pressing the **ENT** key will enter the adjustment mode of the displayed menu item. A blinking "**Adj.**" will be visible in the bottom-left corner of the display, and the value of the parameter displayed can be raised or lowered using the arrows. The **ESC** key always jumps back to the previous level; that is, if the user is in the adjust mode, pressing **ESC** once will move back to the display mode of that item, and pressing **ESC** again will return the user to the main display menu. The display/adjustment items are described below.

- **Concentration Units:** This is the first menu item accessed when the **ENT** key is pressed. This item displays the units chosen to display the concentration in the main display. These can be adjusted between **ppmm** (parts per million metre: the total amount of gas along the path) and **ppm** (parts per million: average concentration along the path).  
**ppmm / m = ppm.** See [Appendix C](#) for a more detailed explanation.
- **Light Value Dist:** This menu item switches on the on-board visible aiming laser and displays the returning light value as well as the entered distance to the retroreflector. The distance can be adjusted to correspond to the actual distance. The arrow key  $\uparrow$  increases the distance and  $\downarrow$  decreases the distance. This item is explained in detail in the [Operating Instructions](#) section in this manual.
- **Concentration Range:** (HF gas only) The user should select the low range if the concentration is expected to be below 450ppmm. Otherwise select high.
- **Average Window:** This item sets the number of samples to be averaged. When set to a value  $>1$ , the normal operating display will indicate "AVG". This average is an  $R^2$  weighted average: concentration values with low  $R^2$ s will have a smaller effect on the average than those with higher  $R^2$ s.
- **Min acceptable R2:** This item allows the user to specify the value of the confidence factor below which the concentration is deemed to be insignificant. Operators can adjust this value to reduce the occurrence of "noisy" readings in the presence of factors such as steam, traffic or thermal scintillation. *Consultation with Boreal Laser Inc. may be prudent before changing this value from the factory default value.*

- **Serial Baud Rate:** This item allows the user to select the baud rate at which data are transmitted from the **GasFinder2.0** instrument, depending on the storage device/computer used. Available options are: 1200, 2400, and 9600 baud. The serial data parameters are detailed in the Data I/O section of this manual.
- **Serial Checksum:** To ensure the integrity of the data when it is sent to a data logger or **GasView2**, a checksum string can be added to the serial data. This option can be enabled or disabled in order to achieve compatibility with all versions of **GasView2**.
- **Sample / ref. scan:** This item selects the number of times the sample path is measured before the reference cell is checked. With this option, the user can specify how often the reference cell is checked during the measurement period. *It should not be necessary to change this value from the factory default setting.*
- **Sweeps per reference:** This item displays the number of sweeps of the internal reference cell that are averaged to give a full reference scan. The more sweeps that are averaged, the more accurate the reference reading will be. However, there is a trade-off between accuracy and sample time. The user is cautioned that increasing the reference averaging time will have a minimal effect compared to increasing the sample averaging time (see next item). *It should not be necessary to change this value from the factory default setting.*
- **swps/ref swps/samp:** This item selects the number of sweeps averaged to obtain a sample scan. The number of sample sweeps is a multiple of the number of reference sweeps to a preset maximum value. *Consultation with Boreal Laser Inc. may be prudent before changing this value from the factory default value.*
- **Alarm ppm:** This item allows the user to select the set-point at which the optional audible alarm will sound. The displayed value for this item will be expressed in the units selected in the item dealing with concentration units described above. For more information on the audible alarm option, contact Boreal Laser Inc.
- **Baseline Adjustment menus:** These items allow the user to correct for background noise. This option is employed in situations where atmospheric interference may cause reduced sensitivity. The **Auto Baseline Acquire** and **Auto Baseline Adjust** menus permit automatic selection of the baseline adjustment function using various control parameters. *Consultation with Boreal Laser Inc. is **strongly recommended** before changing these values from the factory default value.*

- **Serial dump per sample sweep:** this item selects the interval at which serial data are outputted. **Serial Dump per Sample Window** will output data once every sample (default is approximately once per second). **Serial Dump per Average Window** will output data once every completed average. For example, in the default configuration, if the average window is set to 60 samples, the data will be outputted approximately once per minute. The actual rate can be determined by observing the `date_time` field in the serial data.
- **Log Menus:** This enables the **GasFinder2.0** to be used as a data logger. The storage capacity is about 10,000 lines. Recording a data point every second will give nearly three hours of recording. If the average is set to one minute using the **Average Window** set to 60, then the recording time is nearly seven days. The data can be stored in the buffer in a wrap-around mode where data overwrites the initial records when the memory is full. Thus only the latest data is recorded. Alternatively, if the **fill** mode is used, the data will fill the buffer and then all future data is lost. The data in the buffer can be downloaded to a computer using a terminal program such as Hyperterminal. Note that switching the **GasFinder2.0** off does not erase the data. This is done using **Clear Log** in the **Log Menus** option. For more detailed instructions on using the **Log Menus** options, see [Appendix F](#) on pages 29 and 30.
- **Serial ## version 0.37:** This item provides a convenient way of checking the serial number of the instrument and the software version currently installed. This is not an adjustable item.
- **Battery Voltage:** This provides a convenient way of checking the voltage of the 12V power input. This is not an adjustable item.

- **Maintenance Menu!:** This item allows the user access to internal settings of the **GasFinder2.0** instrument. ***These parameters should normally not be changed by anyone other than Boreal Laser personnel except for Internal Arrays Xfer, 4-20mA settings and Real Time Clock.***

The values in parentheses are examples only and may differ for each instrument.

- **Internal Arrays Xfer:** If Boreal Laser personnel need to check the system, the **Internal Arrays Xfer** allows the instrument's internal array configuration to be downloaded to a file. The operator can transmit this file to Boreal Laser Inc. for analysis. Boreal Laser personnel will instruct as necessary.
- **Periodic Array Transfer:** Downloads the previous item at selected intervals
- **Beam Block Safety:** Used to disable the laser beam when the path is blocked.
- **Sweep Light Minimum:** Used in variable light conditions, fog, etc. (0)
- **Sweep Light Maximum:** Used in variable light conditions (1023)
- **4-20mA Current Loop Settings:** When installed, this submenu allows the user to configure the 4-20mA current loop option.
  - **4mA ppm Set Point:** Used to set the value in ppm which corresponds to a loop current of 4mA.
  - **20mA ppm Set Point:** Used to set the value in ppm which corresponds to a loop current of 20mA.
  - **4-20mA enable:** Used to enable or disable the 4-20mA current loop output.
- **Reference Cell ppm:** Reference cell concentration (XX)
- **Points per Sweep:** Number of internal points on the graph (128)
- **Skip pts/swp start:** Initial points discarded (28)
- **Mirror flip delay:** Time delay before reading values (250ms)
- **Target Scan Peak:** Percentage where maximum value occurs (65% or 90%)
- **Min. acceptable light:** Lower level for light value (500)
- **Ref. Cell check:** Internal reference cell check (ppm & R2)
- **Ref. Swps/cal.check:** Frequency of reference checking (10)
- **Calibration centre line/light value:** Data for reference cell (65 & 4000)
- **Real Time Clock:** This submenu allows the user to set the Real Time Clock (RTC). Press **ENT** to cycle through the date and time entries, **↑** and **↓** to change the item, and **ESC** to back out of the submenu.  
***The values will automatically be saved.***

**Calibration Menus. !! Caution !!**

**Note!!:** This item allows the user access to internal calibration settings of the GasFinder2.0 instrument. ***This menu area should not be accessed by anyone other than Boreal Laser personnel .***

- **Reference Acquire:** Obtain reference waveform.
- **Store Calibration:** Confirmation of lock.
- **Calibration Storage:** Used to unlock and lock storage.

Pressing **ESC** twice will return the user to the main display menu.

## **Appendix A**    **Menu Structure**

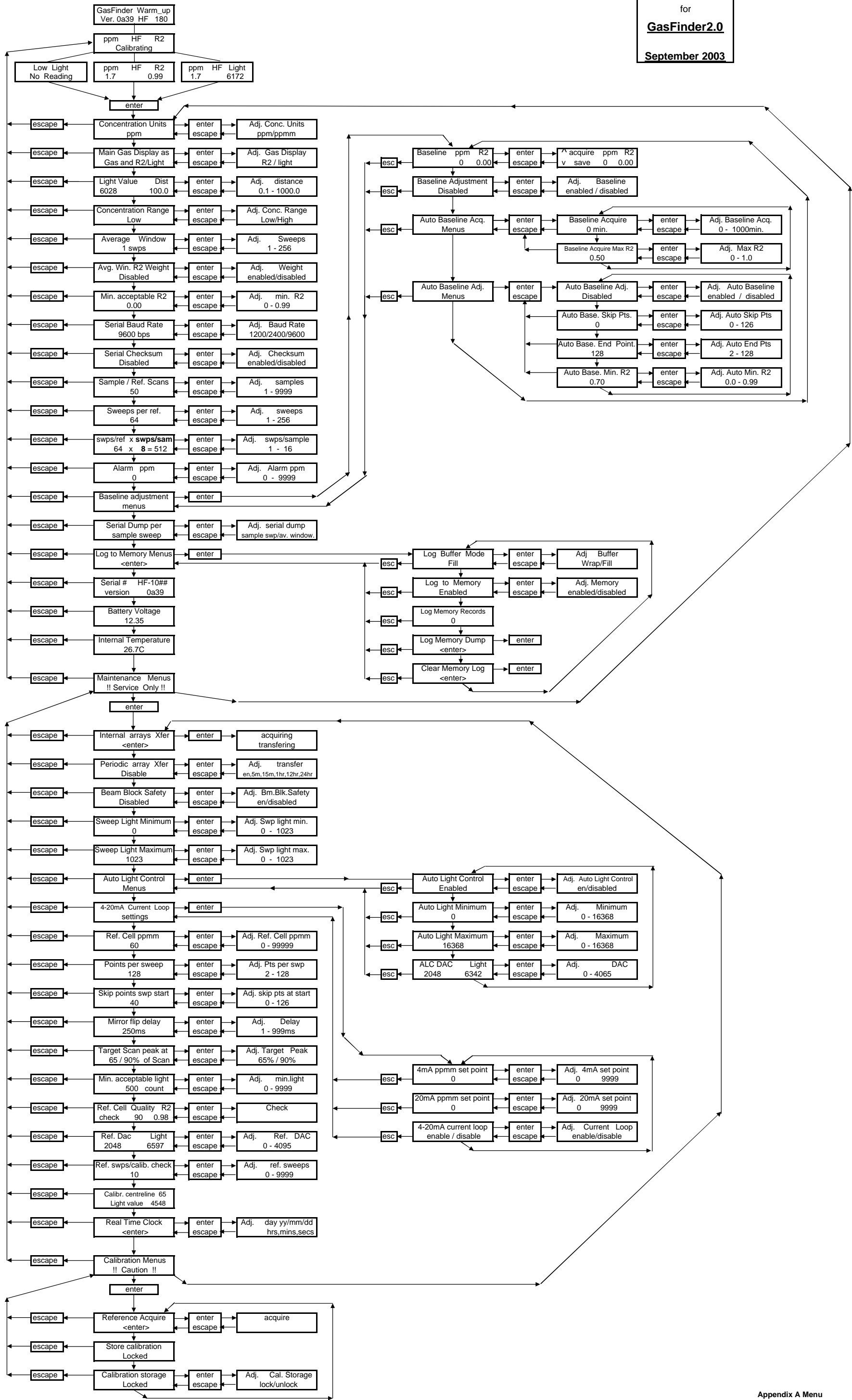
Appendix A Menu Structure

Menu Structure

for

GasFinder2.0

September 2003





## Appendix B Status Codes

When the **GasFinder2.0** is used in conjunction with 'Hyperterminal' or Boreal Laser's '**GasView2**' data-logging programs, the data stream output which is sent to the file is as follows:

122.8,99,235,8835,2002/03/01 10:21:25,HF-1015,2800,\*(2F)

122.8	99	235	8835	2002/03/01	10:21:25	HF-1015	2800	*	(2F)
ppmm	R <sup>2</sup>	Distance	Light Level	Date	Time	Serial Number	Status Code	End Of String	Checksum

Status Code					2	8	0	0											
Hex	n <sub>15</sub>	n <sub>14</sub>	n <sub>13</sub>	n <sub>12</sub>	Hex	n <sub>11</sub>	n <sub>10</sub>	n <sub>9</sub>	n <sub>8</sub>	Hex	n <sub>7</sub>	n <sub>6</sub>	n <sub>5</sub>	n <sub>4</sub>	Hex	n <sub>3</sub>	n <sub>2</sub>	n <sub>1</sub>	n <sub>0</sub>
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	1	1	0	0	0	1	1	0	0	0	1	1	0	0	0	1
2	0	0	1	0	2	0	0	1	0	2	0	0	1	0	2	0	0	1	0
3	0	0	1	1	3	0	0	1	1	3	0	0	1	1	3	0	0	1	1
4	0	1	0	0	4	0	1	0	0	4	0	1	0	0	4	0	1	0	0
5	0	1	0	1	5	0	1	0	1	5	0	1	0	1	5	0	1	0	1
6	0	1	1	0	6	0	1	1	0	6	0	1	1	0	6	0	1	1	0
7	0	1	1	1	7	0	1	1	1	7	0	1	1	1	7	0	1	1	1
8	1	0	0	0	8	1	0	0	0	8	1	0	0	0	8	1	0	0	0
9	1	0	0	1	9	1	0	0	1	9	1	0	0	1	9	1	0	0	1
A	1	0	1	0	A	1	0	1	0	A	1	0	1	0	A	1	0	1	0
B	1	0	1	1	B	1	0	1	1	B	1	0	1	1	B	1	0	1	1
C	1	1	0	0	C	1	1	0	0	C	1	1	0	0	C	1	1	0	0
D	1	1	0	1	D	1	1	0	1	D	1	1	0	1	D	1	1	0	1
E	1	1	1	0	E	1	1	1	0	E	1	1	1	0	E	1	1	1	0
F	1	1	1	1	F	1	1	1	1	F	1	1	1	1	F	1	1	1	1

n<sub>15</sub>

n<sub>14</sub>

n<sub>13</sub>

n<sub>12</sub>

n<sub>11</sub>

n<sub>10</sub>

n<sub>9</sub>

n<sub>8</sub>

n<sub>7</sub>

n<sub>6</sub>

n<sub>5</sub>

n<sub>4</sub>

n<sub>3</sub>

n<sub>2</sub>

n<sub>1</sub>

n<sub>0</sub>

n<sub>15</sub> - CAL\_ERR:

calibration line center error

n<sub>14</sub> - WAVG\_ENAB:

averaging enabled

n<sub>13</sub> - NOT\_CALIB:

calibration not verified

n<sub>12</sub> - LOW\_BAT:

low battery indication

n<sub>11</sub> - MENU\_MODE:

unit is currently in menu system

n<sub>10</sub> - CALIB\_ERR:

reference cell out of factory calibration

n<sub>9</sub> - OVERFLOW:

gas concentration >8 digits

n<sub>8</sub> - OVERRANGE:

receiver signal beyond gain switch control

n<sub>7</sub> - LD\_COLD:

TE Failure, laser diode off line

n<sub>6</sub> - Lt\_Lv\_ERR:

turbulence, timed out

n<sub>5</sub> - NOLOCKDET:

receiver unlocked, low signal

n<sub>4</sub> - LOW\_LIGHT:

laser path blocked, low light

n<sub>3</sub> - R2\_LOW:

R<sup>2</sup> lower than set minimum value

n<sub>2</sub> - NOT\_CTRD:

laser not centered on gas wavelength

n<sub>1</sub> - GAS\_HIGH:

concentration higher than set maximum

n<sub>0</sub> - NO\_ERROR:

normal operation, no errors

The above sample status code of "2800" corresponds to "0010\_1000\_0000\_0000". This indicates an instrument status of: **n<sub>13</sub> - NOT\_CALIB**, **n<sub>11</sub> - MENU\_MODE**

The following is another example:

Code "A42E" would correspond to "1010\_0100\_0010\_1110" and indicate an instrument status of: **n<sub>15</sub> - CAL\_ERR**, **n<sub>13</sub> - NOT\_CALIB**, **n<sub>10</sub> - CALIB\_ERR**, **n<sub>5</sub> - NOLOCKDET**, **n<sub>3</sub> - R2\_LOW**, **n<sub>2</sub> - NOT\_CTRD**, **n<sub>1</sub> - GAS\_HIGH**

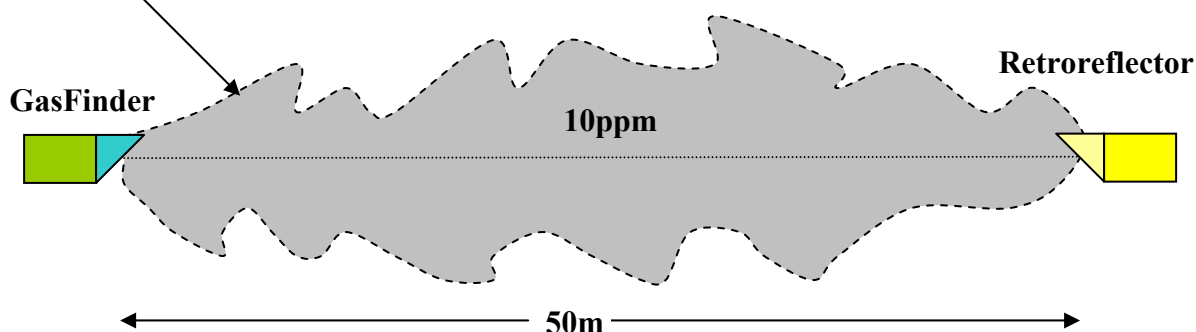
Under normal operating conditions, the most common status code is "1". This is actually 0001, but the software ignores the leading zeros and indicates a status code of "1". This corresponds to "0000\_0000\_0000\_0001", and indicates an instrument status of: **n<sub>0</sub> - NO\_ERROR**.

## **Appendix C**   **Explanation of ppmm**

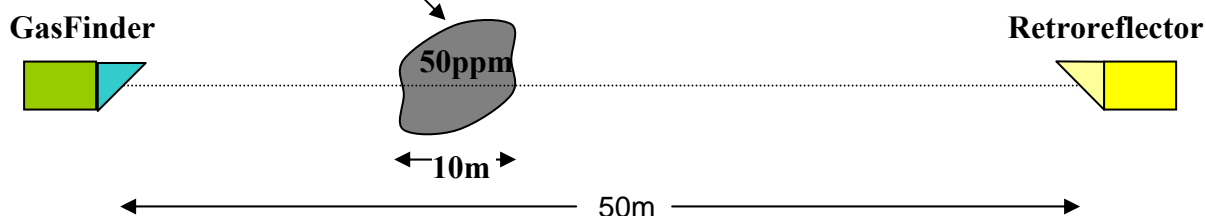
Gas concentration is measured in ppm, 'parts per million' by volume. If a room measuring 100m x 100m x 100m (1 million cubic metres) has 10 cubic metres of air replaced by a pure gas, then the gas concentration is expressed as 10ppm. A point sensor measures directly in ppm.

Open path monitors, like the **GasFinder2.0**, measure the total amount of a specific gas, for example HF, in the path of the laser beam between the transmitter unit and a reflector. This is a 'total path' measurement. The units are 'parts per million metres', or 'ppmm'.

*A uniform background concentration of 10 ppm over 50m gives a reading of 500 ppmm.*



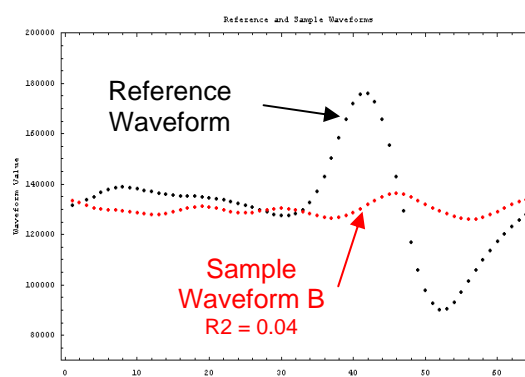
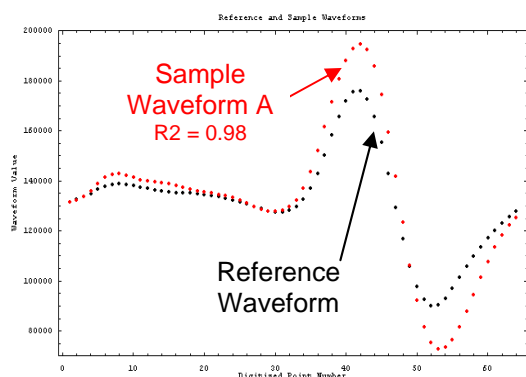
*A concentrated cloud of 50 ppm, 10m in diameter, in a background of 0 ppm also gives a reading of 500ppmm*



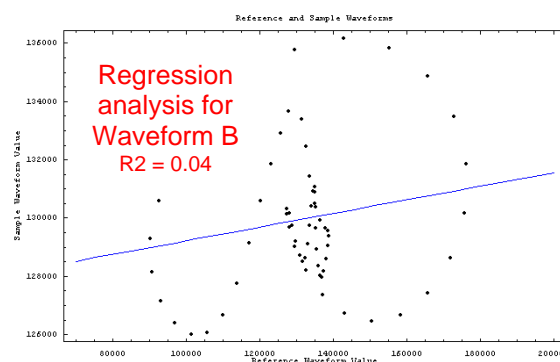
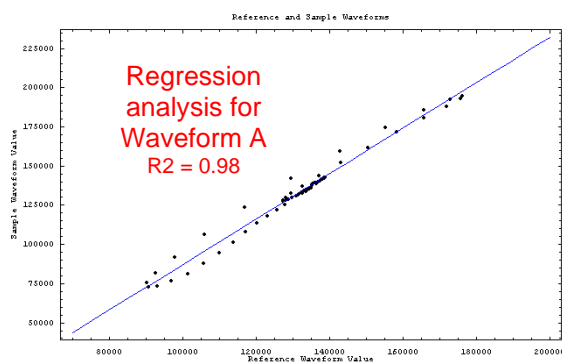
When the 500 ppmm is divided by 50m the result is a value of 10 ppm, which is the 'path averaged' concentration.

## Appendix D Explanation of $R^2$

When the **GasFinder2.0** receives the returning laser signal after it has passed through the sample gas, the receiver converts it to the shape of a specific waveform or curve. This is the sample waveform. The **GasFinder2.0** also receives a similar signal after the laser beam has passed through the internal reference cell. These curves are then digitised and compared as two numeric arrays.



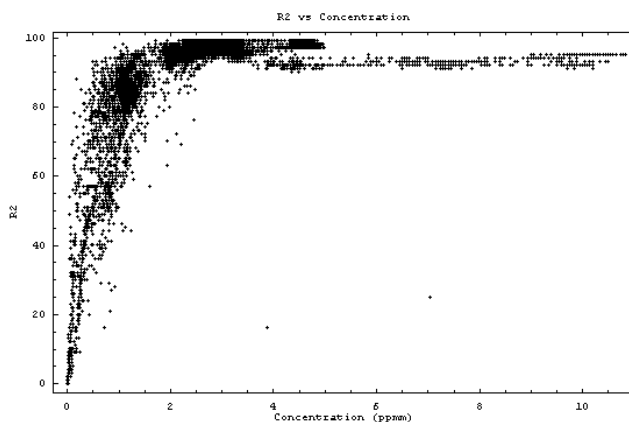
An accepted mathematical procedure to compare curves or numeric arrays is the **Linear Least Squares Regression** analysis. This analysis results in a measure of the similarity ( $R^2$ ), between the waveform of the **sample** gas and that of the **reference** cell gas. A perfect similarity would give a value for  $R^2$  of 1.0, and a total mismatch would be 0.0.



The blue line represents the **Linear Least Squares** fit of the data and is the best fit of a straight line between the reference (X) and sample (Y) data points. The slope is a component in the ratio-metric calculation of gas concentration.

(Explanation of  $R^2$  continued).

A typical plot of **concentration** versus  $R^2$  will give the following graph:



With lower levels of sample gas, the  $R^2$ s decrease, and equal zero when there is no gas present. As the signal from the gas becomes stronger, the effect of noise, both electronic and optical, is reduced and the  $R^2$ s will increase (i.e., the signal to noise ratio will increase). The general shape of the plot is the same for all gases, however, the x-axis values will depend on the sensitivity of the instrument to the gas species being observed.

### Measurement Accuracy

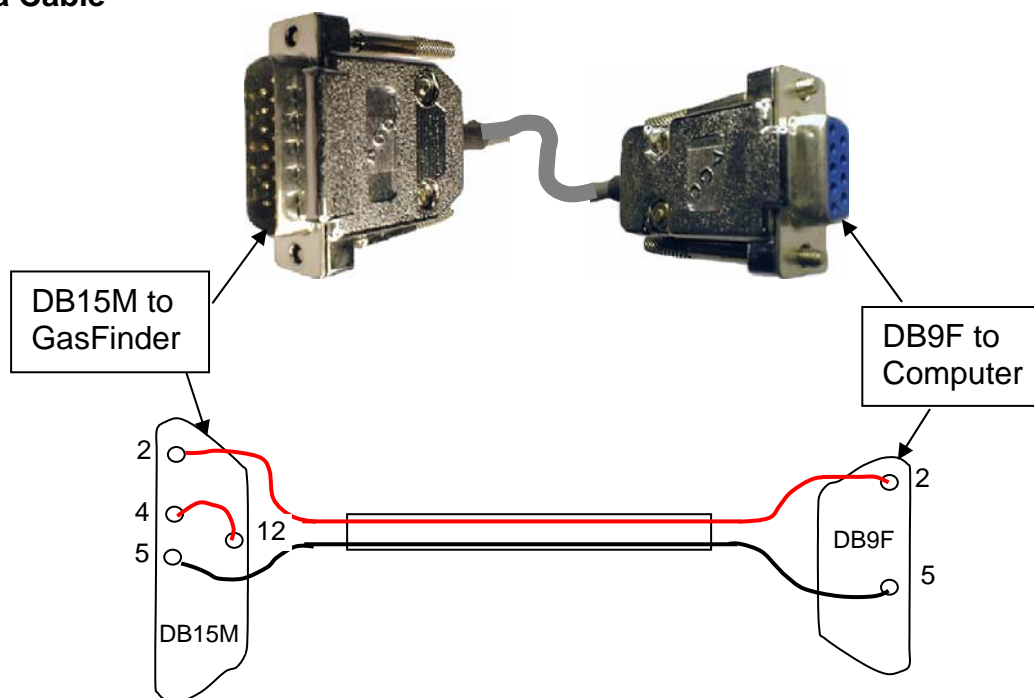
$R^2$  can also be used as an indication of the accuracy of the gas concentration measurement.

The following data were generated in the laboratory under controlled conditions using a 1m Teflon tube and a permeation source for the generation of the target gas.

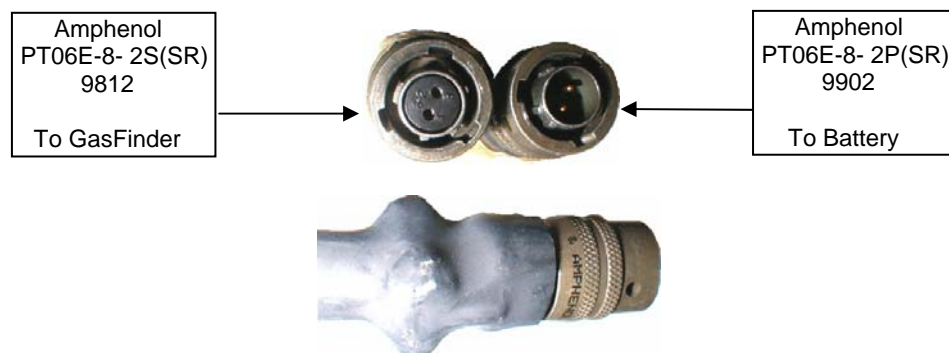
$R^2$	Measurement Accuracy
>0.95	±2%
0.9	±5%
0.7	±10%
0.5	±15%
0.4	±20%
0.3	±25%
0.15	±50%
0.1	±70%
<0.05	±100%

## Appendix E   Cables

### **Data Cable**



### Battery Cable



The battery cables use Amphenol connectors with two-wire connections marked 'A' and 'B'. 'A' is positive and uses a **white** or **red** wire; 'B' is negative and uses a **black** wire.

## **Appendix F Internal Logging Option**

**Log to Memory Menus:** To use this option, enter the **Parameter Adjustment Menu** by pressing **Ent** on the keypad. The display will read **Concentration Units**. Press the up arrow (↑) five times and the **Log to Memory Menus** will be displayed. Press **Ent** and **Buffer Mode** will be displayed.

- **Buffer Mode:** Pressing **Ent** again will enable the user to choose between **fill** and **wrap** mode. The data can be stored in the memory in a **wrap**- around mode where, when the memory is full, data overwrites the initial records. Thus only the last 10,000 readings are retained. Alternatively, if the **fill** mode is used, once 10,000 readings have filled the memory, all future data are discarded. Pressing **ESC** will return to **Buffer Mode**, and then pressing the down arrow (↓) will lead to the next item.
- **Log to Memory:** When this is **Enabled**, the internal logging option is activated.
- **Log Memory Records:** This item lists the number of records currently in the memory. The storage capacity is about 10,000 lines. Recording a data point every second will give nearly three hours of recording. If the data are averaged over one minute, the recording time is nearly seven days.
- **Log Memory Dump:** Pressing **Ent** will download the stored data to a computer terminal through the serial data port. See the description of **HyperTerminal** in Appendix G. Downloading the data will not erase the internal memory.
- **Clear Memory Log:** Pressing **Ent** will erase all data stored in the memory.

To return to the normal operating mode, press **ESC** twice.

Example 1: If data are to be recorded every second, '**Log to Memory**' should be **Enabled**, set the '**Serial Dump per Sample Sweep**' to '**Serial Dump per Sample Sweep**', and set the '**Average Window**' to 1.

Example 2: To record data with a one-minute average, '**Log to Memory**' should be **Enabled**, set the '**Average Window**' to 60, and set the '**Serial Dump per Sample Sweep**' to '**Serial Dump per Average Window**'. In this configuration, the recording time is nearly seven days.

**Note: !!:** To ensure that the logging proceeds correctly, three menu items should be checked: '**Log to Memory**', '**Serial Dump per Sample Sweep**' and '**Average Window**'.

**Note:**

- When the **GasFinder2.0** is in **Menu Mode**, the data output is set automatically to once per second. This can appear confusing if the **Average Interval** is set to a value other than one. However, when the **Menu Mode** is exited, data will be stored at the selected rate.
- Care should be taken if the **GasView2** program is used at the same time as the **Log to Memory** is enabled in an averaging mode. Due to possible re-averaging by the **GasView2** program, false values may be generated.
- Switching the **GasFinder2.0** off does not erase the data. Data are erased using **Clear Log** in the Log Menus option.

## **Appendix G    HyperTerminal**

HyperTerminal is a standard accessory in most '**Windows**' programs of '**95** or later.

### **To Use HyperTerminal**

On the computer, open '**Windows Explorer**'.

Choose '**Program Files**', '**Accessories**' and then '**HyperTerminal**'.

Choose '**HyperTrm - Application**'.

Choose a '**name**' and an '**icon**', and click **OK**.

In the '**Connect to**' display, bypass the phone connections and under '**Connect Using**', scroll down to the correct port (i.e. go directly to **com1** or **com2**). Click **OK**.

In the '**Port Settings**' display, change the '**bits per second**'(baud rate) to the correct value, typically **9600**. Also select '**8**' data bits, '**no**' parity, and '**1**' stop bit.

'**Flow control**' should be set to '**none**'. Click **OK**.

The data should now be appearing on the screen.

**Note:** Some versions of Windows may have a different path for obtaining HyperTerminal.

### **To record the data to a file**

In the upper Tool Bar click on '**Transfer**' and '**Capture Text**'.

Data can be recorded to a file in a specific location. To do this type in a file name in the '**Capture Text**' window, or use the '**Browse**' option to choose a file.

Clicking '**Start**' will activate the recording procedure and on the lower toolbar the word '**Capture**' will be highlighted.

To stop recording the data, in the upper Tool Bar click on '**Transfer**' and '**Capture Text**' and '**Stop**'.

The file is a standard text file and can be loaded into Excel.



## **Appendix H Conversion from PPM to mg/nm<sup>3</sup> of Hydrogen Fluoride**

(Parts per Million to milligrams per normalised cubic metre)

The molecular weight (mw) of F	=	18.998	g/mol
The molecular weight (mw) of H	=	$\frac{1}{19.998}$	g/mol
The molecular weight (mw) of HF	=	19.998	g/mol
The Universal Gas Constant (R)	=	0.08206	litre /mol.°K
Therefore, at STP, 1m <sup>3</sup> of gas (Standard Temperature and Pressure)	=	44.6229	moles
Standard Atmospheric Pressure (P)	=	101.325	Kpa
Standard temperature (T°K)	=	273.13	°K

$$\begin{aligned}
 1\text{ppm of any gas} &= 1 \times 10^{-6} \\
 &= 44.6229 \times 10^{-6} \frac{\text{mol}}{\text{m}^3} \\
 1\text{ppm HF} &= \frac{19.998 \times 44.6229}{1,000,000} \frac{\text{g} \times \text{mol}}{\text{mol} \times \text{m}^3} \\
 1\text{ppm HF} &= 0.8929 \frac{\text{mg}}{\text{m}^3} \text{ at STP}
 \end{aligned}$$

### **Adjustments for different Temperatures and Pressures.**

$$\text{Actual Concentration} = \frac{\text{New Pressure(Kpa)} \times 273.13}{101.325 \times \text{New Temperature(°K)}} \times \text{STP concentration}$$

eg. At a pressure of 94.34Kpa and a temperature of 20°C.

$$\text{Actual Concentration} = \frac{94.34 \times 273.13}{101.325 \times 293.13} \times 0.8929 \text{ mg/m}^3$$

$$= 0.867 \times 0.8929 \text{ mg/m}^3$$

$$1\text{ppm of HF} = 0.774 \text{ mg/m}^3 \text{ at 94.34Kpa and 20°C.}$$

## **Appendix I Alignment procedures for a moving building.**

All buildings move. Some move more than others depending on the external and internal forces. In most cases, this movement goes unnoticed until cracks form in concrete or a small piece of plaster flakes off. Movement can occur over years as the building foundations settle, or over seconds as wind forces move the structure. Settlement over time is too slow to cause an alignment problem, because any movement is very small, and can be compensated for with periodic adjustments. When the movement is caused by wind, the structure returns to its previous position once the wind has passed. In the same way, the shaking motion produced by the movement of overhead cranes is not usually a problem as the structure quickly returns to its original position when the crane has stopped.

Movement caused by thermal expansion due to solar heating is different. Metal structures are particularly susceptible to deflection when the solar heating produces large differential forces, which result in a twisting or warping motion of the structure. This is seen, especially on sunny days, as a diurnal variation in the **GasFinder** light level. This is caused by the expansion and contraction of the metal structure carrying the laser mount, which twists with respect to the longitudinal axis of the original laser path. This causes the laser beam to move away from the reflectors and results in a drop in the returning light level. The amount of movement will vary considerably with the orientation of the building and the attachment of the mount within the building.

If movement is suspected, it can be verified and measured as follows:

Arrange to have access to the mount where the transmitter and telescope are located, and plan to make observations through the telescope at least four times throughout the day. Movement is usually a maximum on bright, sunny days. At each observation, note the time and the position of the cross hairs in the telescope with respect to a part on the reflector. Shining a flashlight beam on the reflector will make it easy to see at long distances. Do not adjust any alignment screws. At the end of the day, you should have a number of points showing the different positions of the cross hairs. This difference between these positions will indicate the amount and direction of movement of the laser beam. See Fig 1.

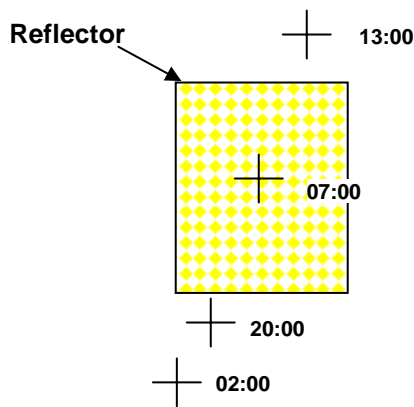


Fig 1.

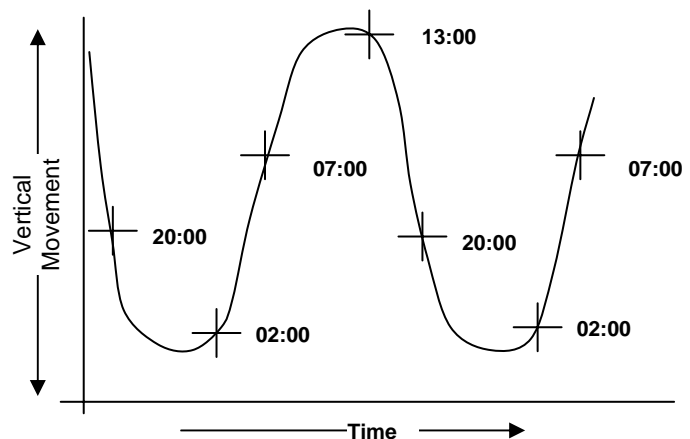


Fig 2.

The observations can be made over a shorter time period, but the results may not give an accurate picture of the movement. A plot of the positions in a continuous time period will yield a graph similar to Fig. 2. This graph can be used to estimate the maximum movement of the beam.

In the preceding example, the final retro array will be similar to the shape shown in Fig 3. The number of reflectors and their spacing may have to be increased. Contact Boreal Laser Inc. for more specific details.

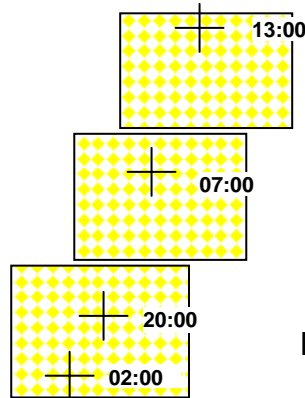


Fig. 3.

### **Centering the cross hairs with the centre of the laser beam.**

At 400m, the diameter of the beam is about 600mm, so the area of the beam may be larger than the enclosure. To find the edges of the beam, the **GasFinder** has to be traversed horizontally and vertically until the light level drops. Note where the cross hairs are in the scope at these positions, (see Fig.4) and position the **GasFinder** or transmitter head, so that the cross hairs are in the centre of the travel. Looking through the telescope, and without adjusting the alignment of the **GasFinder**, adjust the crosshairs to the centre of the reflector. This is done by removing the two cover caps in the centre of the scope and turning the screws underneath so that the cross hairs are centred on the reflector.

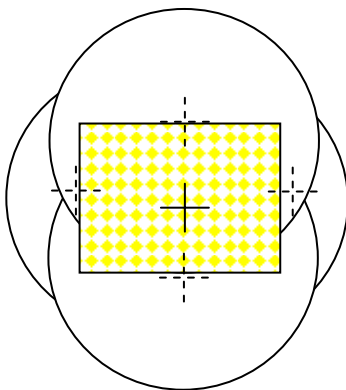
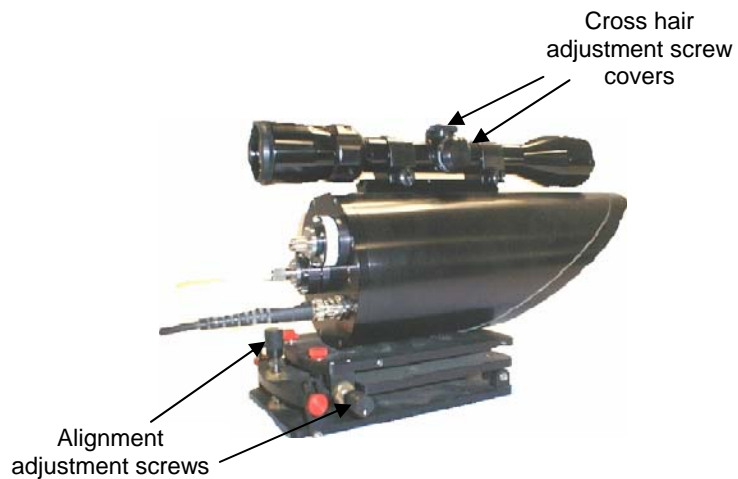


Fig 4.



## **Appendix J Accessories**

<b>GasFinder2.0</b>
Aiming Scope
4 - 20mA Option
GasFinder2.0 Manual
<b>Software</b>
GasView2 Software (version # )
GasView2 Manual
<b>Case</b>
Black Plastic Carrying Case
<b>Mount</b>
Large Boreal Mount
Small Boreal Mount
Rotating Base
Manfrotto Quick Release Assembly
<b>Universal Enclosure</b>
Universal Enclosure Kit
Vortex Cooler Kit
<b>Tripods</b>
Tripod, Large Manfrotto
Tripod, Small Manfrotto
Tripod Head, Manfrotto Pan-Tilt
Tripod Head, Manfrotto Ball
Hex Plate
<b>Battery &amp; Power Supply</b>
Battery
Battery Cable
Battery Charger
Power Supply (Single Channel)
Power Supply (Dual Channel)
Power Cable, 12v Spare
Plug Adapter for Foreign Operation

<b>Retroreflectors</b>
Retro Tape Sheet, Grey
Retro Tape Sheet, Red/White
Retro Tape Roll, Red/White
2½" Opticon retros
2" Opticon retros
Retro Enclosure, Small
Hood for Small Retro Enclosure
Retro Enclosure, Large
Hood for Large Retro Enclosure
Retro Enclosure, 4" Square Box
Retro Enclosure Heater
Solar Panel Kit
<b>Data Cables</b>
Data Cable
Data Cable, with 4-20mA Connection
Data Cable, for Fiberoptic Modem
<b>Modems</b>
Modem, Fiberoptic
Fiberoptic Cable (Multimode)
Modem, Telephone
Modem, Wireless
<b>Consumables</b>
"Novus" Cleaner
Compressed Air Canister
<b>Test Equipment</b>
Infra-red Card
Range-finding Binoculars

## **Appendix K** **Parameter Settings**

## **Appendix B**

### **Path Positions**

#### **Sites 1,2 3**

Data tables and graphs are provided for field tests on the three primary and three supplementary wells. These tests show data for each well and the individual measurement paths for each well.

# Path Positions by Site

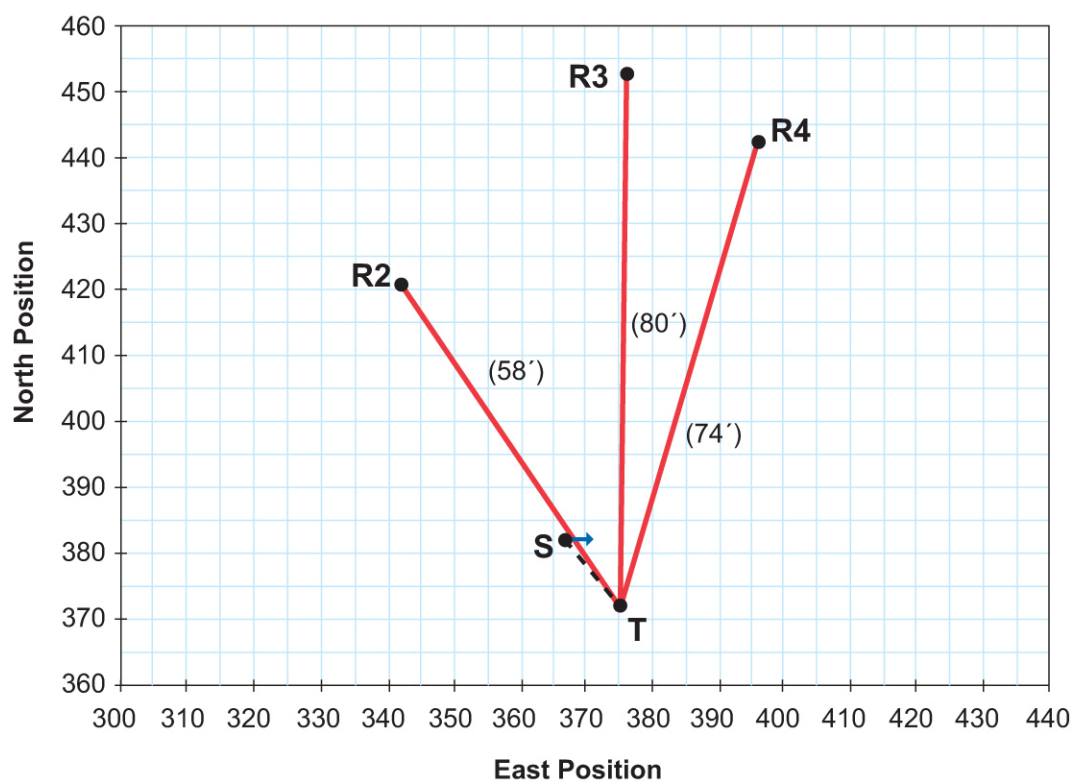


Figure E1. Equipment and Path Positioning for Site 1.

Notes:

T = transceiver. R1, and R2 = Retro-reflectors for corresponding measurement paths.

S = source. Small blue arrow indicates orientation of horizontal vent.

Green arrow indicates approximate average

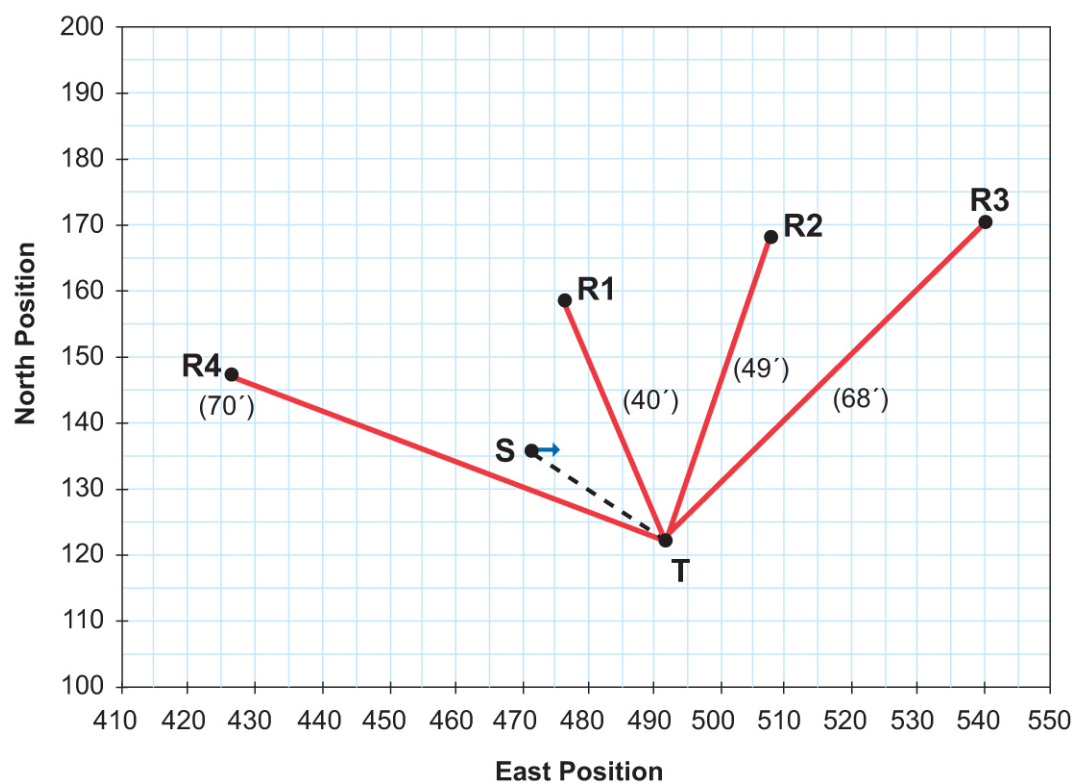


Figure E2. Equipment and Path Positioning for Site 2.

Notes:

T = transceiver. R1, and R2 = Retro-reflectors for corresponding measurement paths.

S = source. Small blue arrow indicates orientation of horizontal vent.

Green arrow indicates approximate average



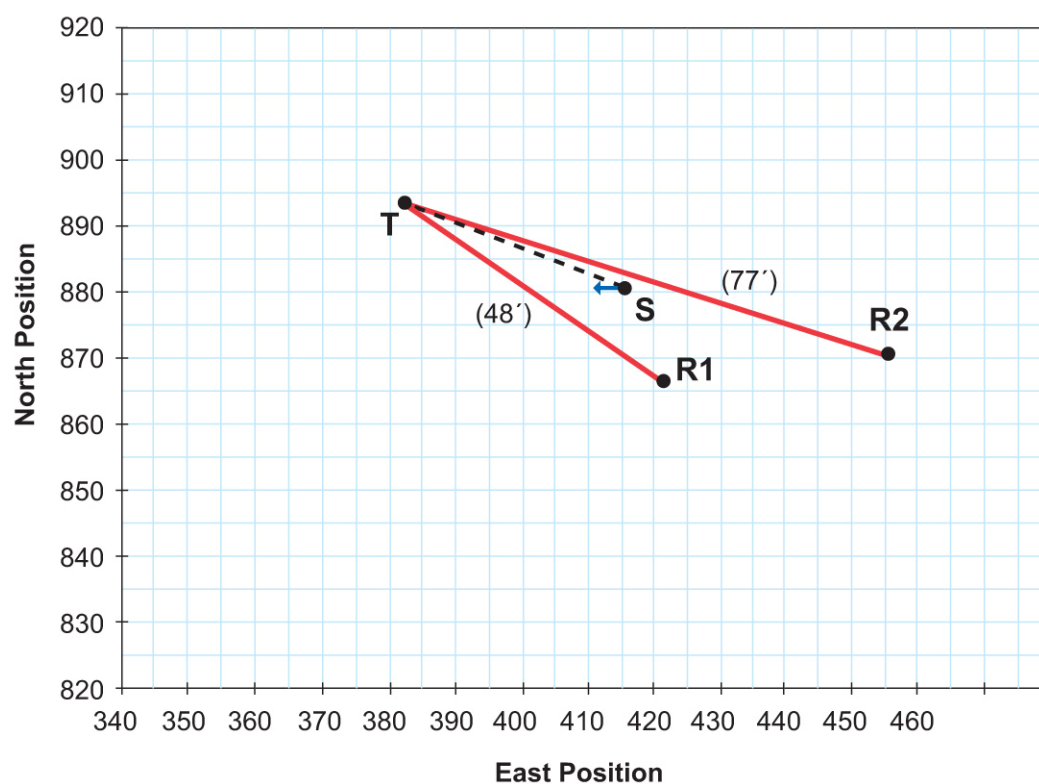


Figure E3. Equipment and Path Positioning for Site 3.

Notes:

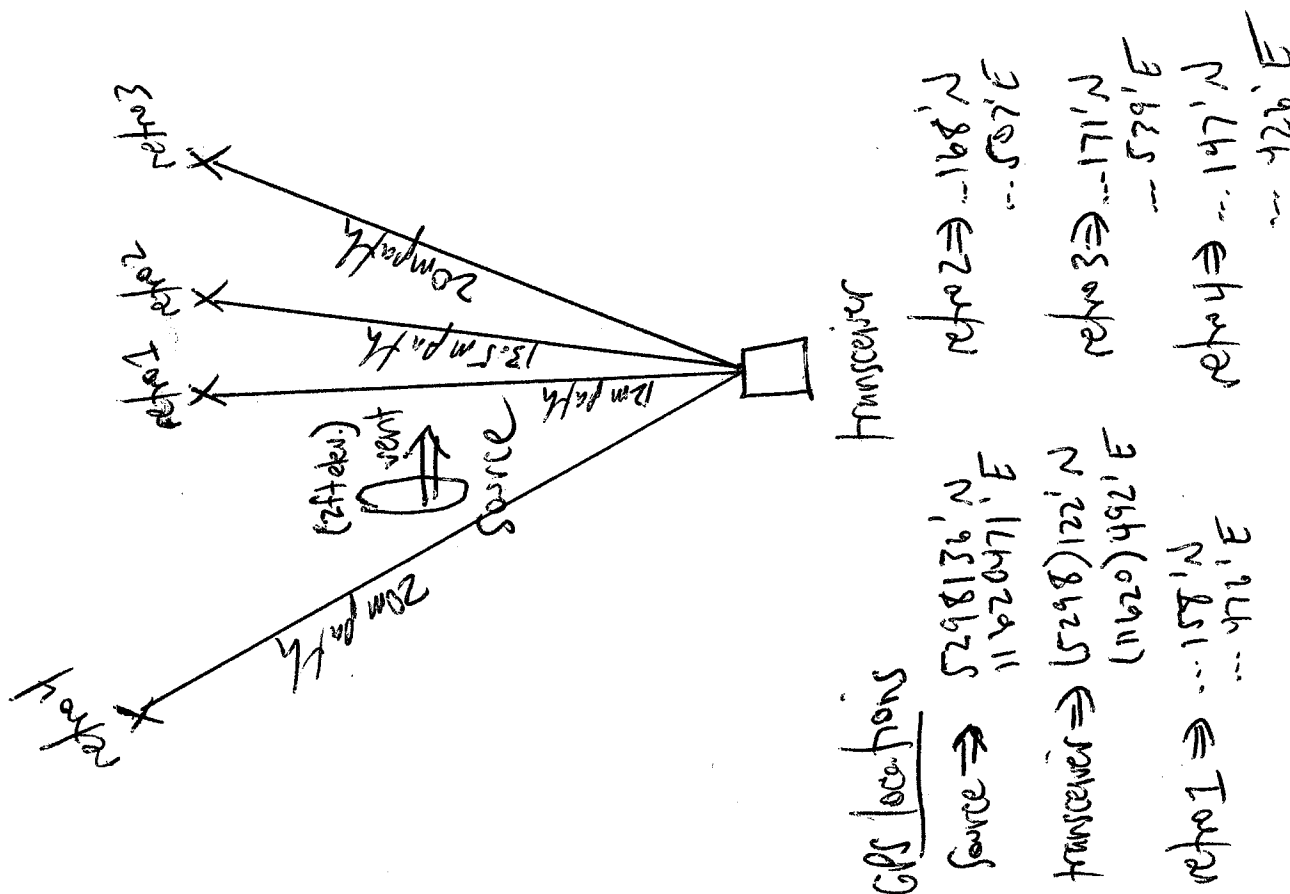
T = transceiver. R1, and R2 = Retro-reflectors for corresponding measurement paths.

S = source. Small blue arrow indicates orientation of horizontal vent.

Green arrow indicates approximate average prevailing wind direction.

Site #1, Hebron

all paths 4/4/2016



GPS locations

Source ⇒  
5295382 ft N  
11617367 ft E

transverse  $\Rightarrow$  52953325  
E, 105L1911

transceiver 2  $\Rightarrow$  5295372' N  
11617375' E

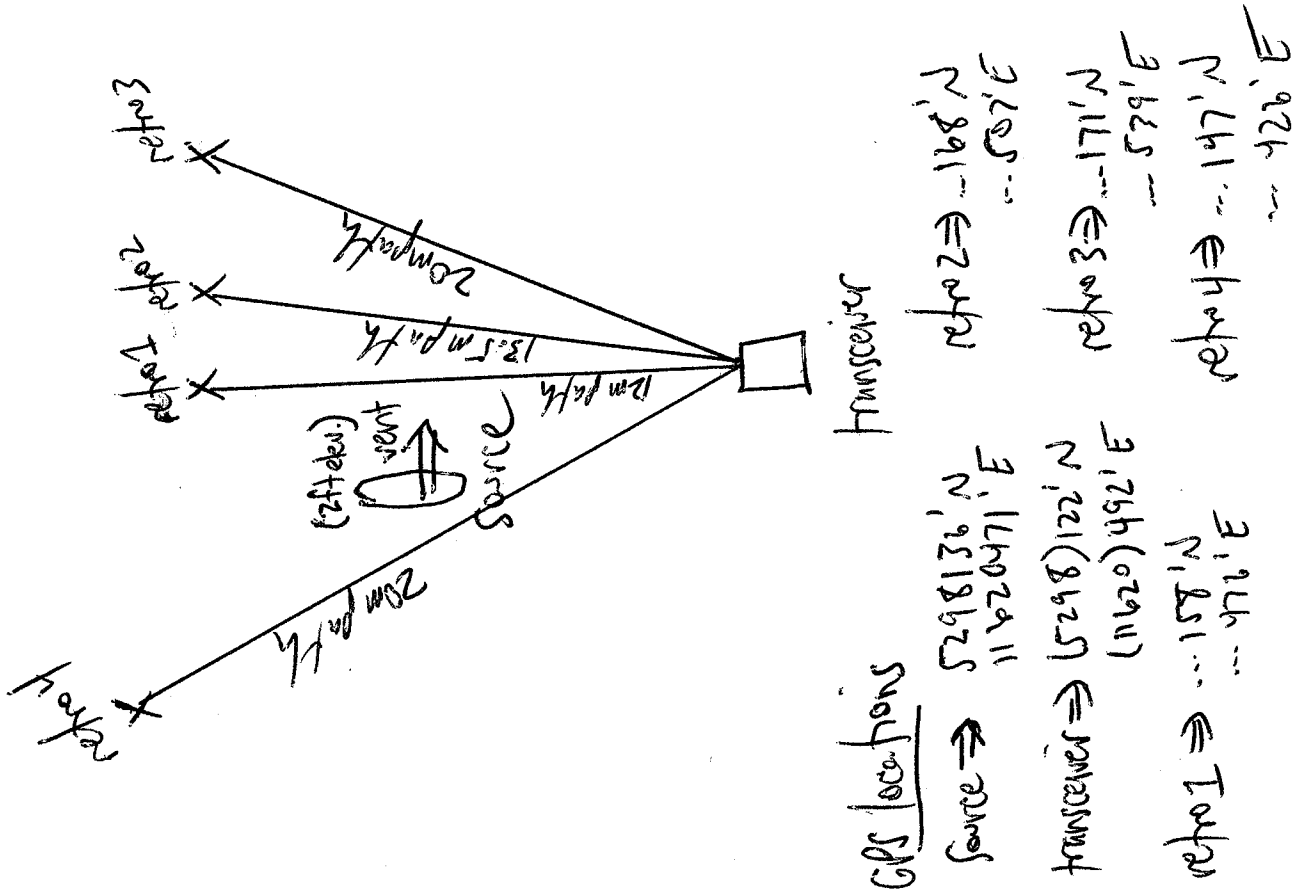
refno 2  $\Rightarrow$  5295420'N  
11607342'E

ref 303 5294521 N  
116173761 E

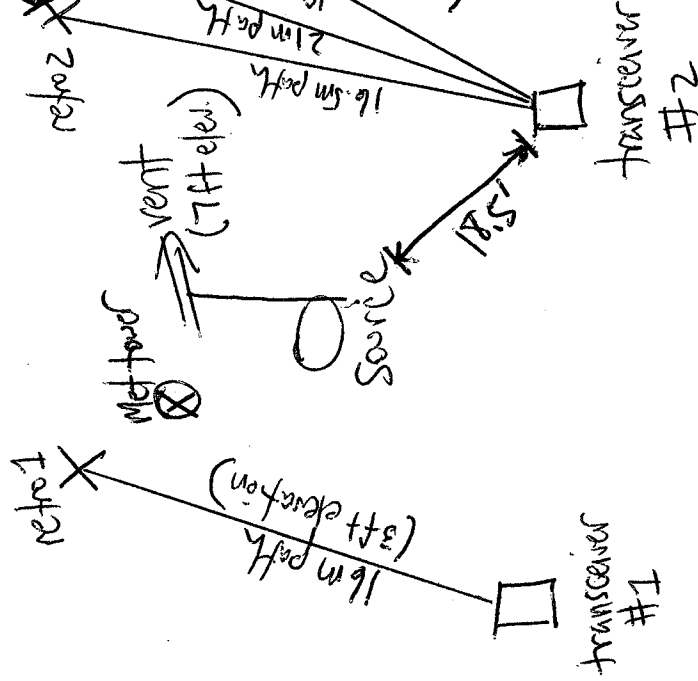
ref 4  $\Rightarrow$  5254325  
116173461E

## Site #2 Hebron

all paths 4 ft elevation

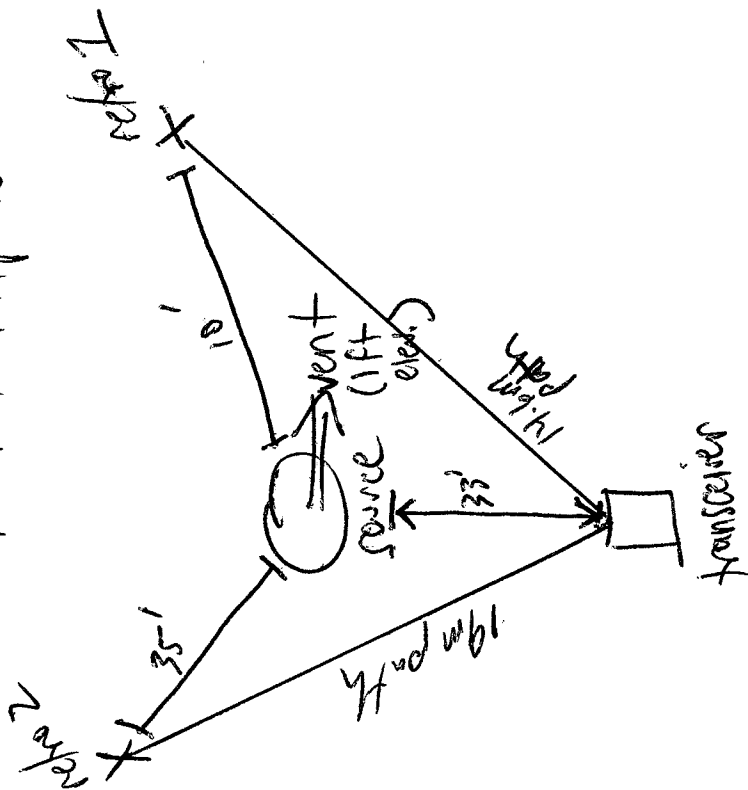


## Site #1, Hebron



# Site #3 Hebron

4.5' elevation all paths



## GPS locations

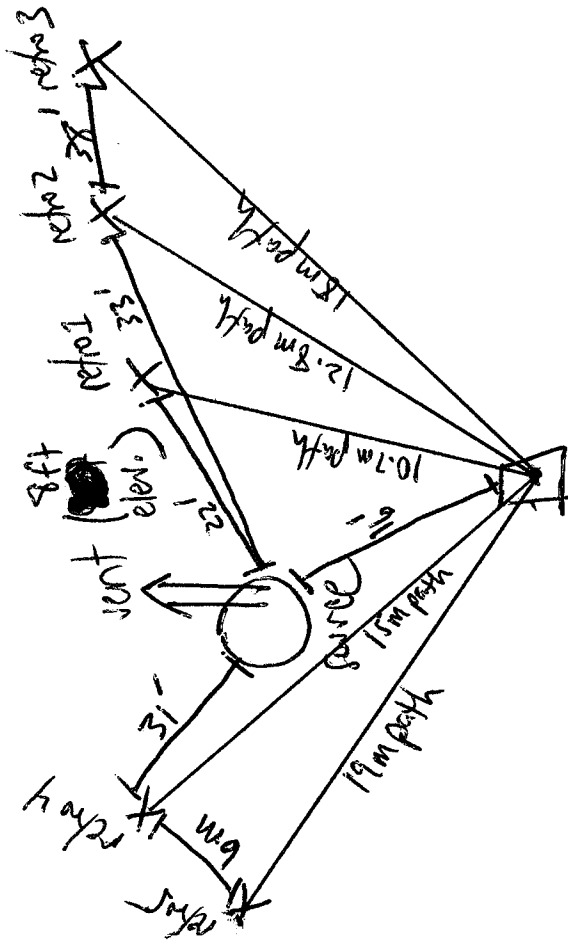
~~transceiver~~  $\Rightarrow$  (5299)893'N 870'N  
transceiver (11022)382'E 455'E

source  $\Rightarrow$  880'N 415'E

refo1  $\Rightarrow$  800'N 421'E

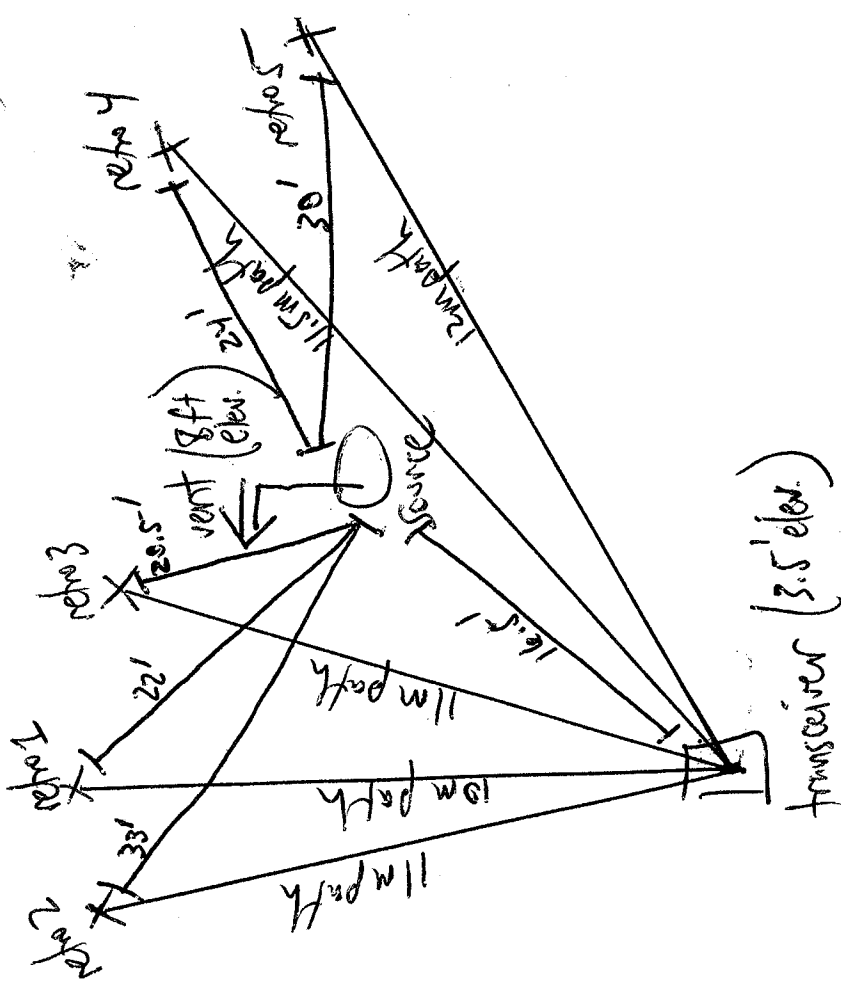
# Site #2 Wharton

4ft elevation all paths



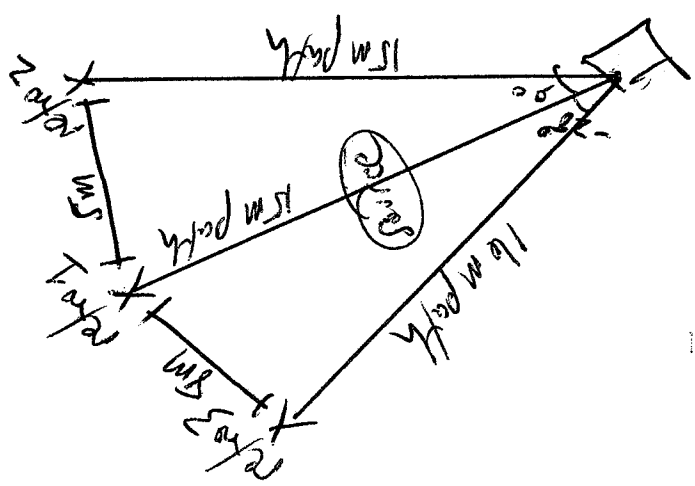
No viable GPS tracking.

# Site #6 State Line



No GPS

# Site #5 Abandoned well



## **Appendix C**

### **Path Measurement Data**

Data tables in this appendix include the following data, grouped by site and TDL measurement path at that site:

- 1) Path Loading – The concentration of methane in parts per million by volume times the path length in meters (ppm\*m).
- 2) Path length in meters (m).
- 3) Time - The “timestamp” as recorded in the datalogger with the date and the time of path-loading data recorded at 2-3 second intervals. The tables in this appendix follow that format. Some of the records say Eastern Time and some say Mountain Time. This was the result of the technician not changing the setting for a particular run at the Eastern Time zone location. It does not affect the technical results. Mountain Time can be converted to the Eastern equivalent by merely adding two hours to the Mountain Time value.

NOTE: The original Excel® field data files were also provided to GSTC.

The data records are for the following sites and corresponding paths.

<u>Sites</u>	<u>Path</u>
1	1, 2, 3, 4
2	1, 2, 3, 4
3	1, 2
4	1, 2, 3, 4, 5
5	1, 2, 3
6	1, 2, 3, 4, 5

In some tables the sequence of path numbers might not follow the time sequence. Path numbers were related to field note locations and not necessarily the sequence of times at which measurements were taken for that path. For example measurement data for Site 1 Path 1 were actually taken at a later time of day then data for Site 1 Part 5.

Path Measurement Data Site 1 Path 1			Path Measurement Data Site 1 Path 2		
ppm*m	pathlength	timestamp	ppm*m	pathlength	timestamp
34	16	9/19/2006 10:40	68.1	16.5	9/19/2006 11:29
34	16	9/19/2006 10:40	72	16.5	9/19/2006 11:29
34.2	16	9/19/2006 10:40	69.9	16.5	9/19/2006 11:29
34.4	16	9/19/2006 10:40	68.5	16.5	9/19/2006 11:29
34.6	16	9/19/2006 10:40	73.6	16.5	9/19/2006 11:29
34.5	16	9/19/2006 10:40	91.9	16.5	9/19/2006 11:29
35.1	16	9/19/2006 10:40	103	16.5	9/19/2006 11:29
35	16	9/19/2006 10:40	168	16.5	9/19/2006 11:29
35.2	16	9/19/2006 10:40	85.7	16.5	9/19/2006 11:29
35.5	16	9/19/2006 10:40	70.9	16.5	9/19/2006 11:29
35.6	16	9/19/2006 10:40	54.1	16.5	9/19/2006 11:29
35.6	16	9/19/2006 10:40	48.8	16.5	9/19/2006 11:29
35.5	16	9/19/2006 10:40	45.3	16.5	9/19/2006 11:29
35.8	16	9/19/2006 10:40	77.5	16.5	9/19/2006 11:29
35.6	16	9/19/2006 10:40	66.9	16.5	9/19/2006 11:29
35.4	16	9/19/2006 10:40	61.1	16.5	9/19/2006 11:29
35.2	16	9/19/2006 10:40	70	16.5	9/19/2006 11:29
34.9	16	9/19/2006 10:40	46.7	16.5	9/19/2006 11:29
35.1	16	9/19/2006 10:40	55	16.5	9/19/2006 11:29
35	16	9/19/2006 10:40	50.2	16.5	9/19/2006 11:29
34.9	16	9/19/2006 10:40	65.1	16.5	9/19/2006 11:29
35.1	16	9/19/2006 10:40	88.6	16.5	9/19/2006 11:29
34.9	16	9/19/2006 10:40	63.7	16.5	9/19/2006 11:29
35	16	9/19/2006 10:40	76.1	16.5	9/19/2006 11:29
34.8	16	9/19/2006 10:40	93	16.5	9/19/2006 11:29
34.8	16	9/19/2006 10:40	66.6	16.5	9/19/2006 11:29
34.6	16	9/19/2006 10:40	64.7	16.5	9/19/2006 11:29
34.7	16	9/19/2006 10:40	73.8	16.5	9/19/2006 11:29
34.3	16	9/19/2006 10:40	57.6	16.5	9/19/2006 11:30
34.1	16	9/19/2006 10:40	71.1	16.5	9/19/2006 11:30
34.4	16	9/19/2006 10:40	59	16.5	9/19/2006 11:30
34.2	16	9/19/2006 10:40	68.4	16.5	9/19/2006 11:30
34.3	16	9/19/2006 10:40	55.6	16.5	9/19/2006 11:30
34.1	16	9/19/2006 10:41	78.5	16.5	9/19/2006 11:30
34.5	16	9/19/2006 10:41	50.3	16.5	9/19/2006 11:30
34	16	9/19/2006 10:41	71.1	16.5	9/19/2006 11:30
34.4	16	9/19/2006 10:41	63.1	16.5	9/19/2006 11:30
34.4	16	9/19/2006 10:41	52	16.5	9/19/2006 11:30
34.4	16	9/19/2006 10:41	53.4	16.5	9/19/2006 11:30
34.4	16	9/19/2006 10:41	45	16.5	9/19/2006 11:30
34.2	16	9/19/2006 10:41	60.9	16.5	9/19/2006 11:30
34.5	16	9/19/2006 10:41	77.3	16.5	9/19/2006 11:30
34.4	16	9/19/2006 10:41	91.8	16.5	9/19/2006 11:30
34.3	16	9/19/2006 10:41	109	16.5	9/19/2006 11:30
34.1	16	9/19/2006 10:41	100	16.5	9/19/2006 11:30
34.5	16	9/19/2006 10:41	79.3	16.5	9/19/2006 11:30
34.4	16	9/19/2006 10:41	81.1	16.5	9/19/2006 11:30
34.4	16	9/19/2006 10:41	74.4	16.5	9/19/2006 11:30
34.5	16	9/19/2006 10:41	51.1	16.5	9/19/2006 11:30
34.4	16	9/19/2006 10:41	50.2	16.5	9/19/2006 11:30
34.5	16	9/19/2006 10:41	48.1	16.5	9/19/2006 11:30
34.2	16	9/19/2006 10:41	73.3	16.5	9/19/2006 11:30
34.5	16	9/19/2006 10:41	69.3	16.5	9/19/2006 11:30
34.6	16	9/19/2006 10:41	62.1	16.5	9/19/2006 11:30
34.6	16	9/19/2006 10:41	60.4	16.5	9/19/2006 11:30
34.3	16	9/19/2006 10:41	61.9	16.5	9/19/2006 11:30
34.3	16	9/19/2006 10:41	77	16.5	9/19/2006 11:30
34.5	16	9/19/2006 10:41	126	16.5	9/19/2006 11:30
34.7	16	9/19/2006 10:41	191	16.5	9/19/2006 11:30
34.6	16	9/19/2006 10:41	375	16.5	9/19/2006 11:30
34.6	16	9/19/2006 10:41	722	16.5	9/19/2006 11:30



Path Measurement Data Site 1 Path 1			Path Measurement Data Site 1 Path 2		
ppm*m	pathlength	timestamp	ppm*m	pathlength	timestamp
34.7	16	9/19/2006 10:41	259	16.5	9/19/2006 11:31
34.3	16	9/19/2006 10:41	430	16.5	9/19/2006 11:31
33.8	16	9/19/2006 10:42	389	16.5	9/19/2006 11:31
33.9	16	9/19/2006 10:42	605	16.5	9/19/2006 11:31
33.9	16	9/19/2006 10:42	395	16.5	9/19/2006 11:31
33.9	16	9/19/2006 10:42	222	16.5	9/19/2006 11:31
33.9	16	9/19/2006 10:42	61.5	16.5	9/19/2006 11:31
34	16	9/19/2006 10:43	34.9	16.5	9/19/2006 11:31
33.9	16	9/19/2006 10:43	34.4	16.5	9/19/2006 11:31
33.8	16	9/19/2006 10:43	34.9	16.5	9/19/2006 11:31
33.5	16	9/19/2006 10:43	34.4	16.5	9/19/2006 11:31
33.5	16	9/19/2006 10:43	34.3	16.5	9/19/2006 11:31
33.5	16	9/19/2006 10:43	34.5	16.5	9/19/2006 11:31
33.6	16	9/19/2006 10:44	34.7	16.5	9/19/2006 11:31
33.5	16	9/19/2006 10:44	34.6	16.5	9/19/2006 11:31
33.5	16	9/19/2006 10:44	34.7	16.5	9/19/2006 11:31
33.8	16	9/19/2006 10:44	34.1	16.5	9/19/2006 11:31
33.7	16	9/19/2006 10:44	34.4	16.5	9/19/2006 11:31
33.9	16	9/19/2006 10:44	34.4	16.5	9/19/2006 11:31
33.6	16	9/19/2006 10:45	34.5	16.5	9/19/2006 11:31
33.5	16	9/19/2006 10:45	34.3	16.5	9/19/2006 11:31
33.6	16	9/19/2006 10:45	34.3	16.5	9/19/2006 11:31
33.7	16	9/19/2006 10:45	34.3	16.5	9/19/2006 11:31
33.7	16	9/19/2006 10:45	34.2	16.5	9/19/2006 11:31
33.7	16	9/19/2006 10:45	34.3	16.5	9/19/2006 11:31
33.9	16	9/19/2006 10:46	34.3	16.5	9/19/2006 11:31
33.8	16	9/19/2006 10:46	34.3	16.5	9/19/2006 11:31
34.2	16	9/19/2006 10:46	34.5	16.5	9/19/2006 11:31
34.4	16	9/19/2006 10:46	34.4	16.5	9/19/2006 11:31
34.3	16	9/19/2006 10:46	34.3	16.5	9/19/2006 11:31
34.3	16	9/19/2006 10:46	34.3	16.5	9/19/2006 11:31
34.2	16	9/19/2006 10:47	34.3	16.5	9/19/2006 11:31
34.2	16	9/19/2006 10:47	34.4	16.5	9/19/2006 11:31
34.3	16	9/19/2006 10:47	34.7	16.5	9/19/2006 11:31
34.1	16	9/19/2006 10:47	34.5	16.5	9/19/2006 11:32
34.2	16	9/19/2006 10:47	35.5	16.5	9/19/2006 11:32
34.5	16	9/19/2006 10:48	36.9	16.5	9/19/2006 11:32
34.5	16	9/19/2006 10:48	40.5	16.5	9/19/2006 11:32
34.4	16	9/19/2006 10:48	38.8	16.5	9/19/2006 11:32
34.4	16	9/19/2006 10:48	38.6	16.5	9/19/2006 11:32
34.5	16	9/19/2006 10:48	43.3	16.5	9/19/2006 11:32
34.5	16	9/19/2006 10:48	37.4	16.5	9/19/2006 11:32
34.5	16	9/19/2006 10:49	36.4	16.5	9/19/2006 11:32
34.6	16	9/19/2006 10:49	36.7	16.5	9/19/2006 11:32
34.8	16	9/19/2006 10:49	36.8	16.5	9/19/2006 11:32
34.9	16	9/19/2006 10:49	43.6	16.5	9/19/2006 11:32
34.8	16	9/19/2006 10:49	38.4	16.5	9/19/2006 11:32
36.5	16	9/19/2006 10:49	37.7	16.5	9/19/2006 11:32
39.4	16	9/19/2006 10:50	41.1	16.5	9/19/2006 11:32
34.8	16	9/19/2006 10:50	56.6	16.5	9/19/2006 11:32
43.6	16	9/19/2006 10:50	35.6	16.5	9/19/2006 11:32
60.1	16	9/19/2006 10:50	35.1	16.5	9/19/2006 11:32
42.6	16	9/19/2006 10:50	34.8	16.5	9/19/2006 11:32
36.7	16	9/19/2006 10:50	34.7	16.5	9/19/2006 11:32
38.8	16	9/19/2006 10:51	34.5	16.5	9/19/2006 11:32
38.4	16	9/19/2006 10:51	34.5	16.5	9/19/2006 11:32
36.3	16	9/19/2006 10:51	34.6	16.5	9/19/2006 11:32
35.2	16	9/19/2006 10:51	34.8	16.5	9/19/2006 11:32
35.1	16	9/19/2006 10:51	34.9	16.5	9/19/2006 11:32
35.1	16	9/19/2006 10:52	34.7	16.5	9/19/2006 11:32
35	16	9/19/2006 10:52	34.7	16.5	9/19/2006 11:32

Path Measurement Data Site 1 Path 1			Path Measurement Data Site 1 Path 2		
ppm*m	pathlength	timestamp	ppm*m	pathlength	timestamp
35.3	16	9/19/2006 10:52	34.7	16.5	9/19/2006 11:32
35.3	16	9/19/2006 10:52	34.9	16.5	9/19/2006 11:32
35.3	16	9/19/2006 10:52	34.8	16.5	9/19/2006 11:32
35.2	16	9/19/2006 10:52	34.8	16.5	9/19/2006 11:32
35.3	16	9/19/2006 10:53	34.8	16.5	9/19/2006 11:32
35.3	16	9/19/2006 10:53	34.8	16.5	9/19/2006 11:32
35.2	16	9/19/2006 10:53	34.8	16.5	9/19/2006 11:32
35.3	16	9/19/2006 10:53	35	16.5	9/19/2006 11:32
35.2	16	9/19/2006 10:53	35.8	16.5	9/19/2006 11:33
35.3	16	9/19/2006 10:53	38.1	16.5	9/19/2006 11:33
35.2	16	9/19/2006 10:54	41.5	16.5	9/19/2006 11:33
35.3	16	9/19/2006 10:54	52.2	16.5	9/19/2006 11:33
35.2	16	9/19/2006 10:54	55	16.5	9/19/2006 11:33
35.1	16	9/19/2006 10:54	65.8	16.5	9/19/2006 11:33
35.1	16	9/19/2006 10:54	65.2	16.5	9/19/2006 11:33
35.1	16	9/19/2006 10:54	59	16.5	9/19/2006 11:33
35.3	16	9/19/2006 10:55	56	16.5	9/19/2006 11:33
35.4	16	9/19/2006 10:55	66.8	16.5	9/19/2006 11:33
35.4	16	9/19/2006 10:55	65.6	16.5	9/19/2006 11:33
35.3	16	9/19/2006 10:55	58.9	16.5	9/19/2006 11:33
35.3	16	9/19/2006 10:55	51.1	16.5	9/19/2006 11:33
35.3	16	9/19/2006 10:56	71.1	16.5	9/19/2006 11:33
35.3	16	9/19/2006 10:56	85.6	16.5	9/19/2006 11:33
35.3	16	9/19/2006 10:56	443	16.5	9/19/2006 11:33
35.2	16	9/19/2006 10:56	230	16.5	9/19/2006 11:33
35.3	16	9/19/2006 10:56	438	16.5	9/19/2006 11:33
35.3	16	9/19/2006 10:56	70.5	16.5	9/19/2006 11:33
35.2	16	9/19/2006 10:57	36.6	16.5	9/19/2006 11:33
35.4	16	9/19/2006 10:57	38.9	16.5	9/19/2006 11:33
35.4	16	9/19/2006 10:57	39.1	16.5	9/19/2006 11:33
35.5	16	9/19/2006 10:57	36.9	16.5	9/19/2006 11:33
35.6	16	9/19/2006 10:57	35.5	16.5	9/19/2006 11:33
37.4	16	9/19/2006 10:57	36.4	16.5	9/19/2006 11:33
48.9	16	9/19/2006 10:58	38.6	16.5	9/19/2006 11:33
58.4	16	9/19/2006 10:58	41.2	16.5	9/19/2006 11:33
42.3	16	9/19/2006 10:58	40.8	16.5	9/19/2006 11:33
35.3	16	9/19/2006 10:58	41.9	16.5	9/19/2006 11:33
35	16	9/19/2006 10:58	47	16.5	9/19/2006 11:33
34.9	16	9/19/2006 10:58	60.5	16.5	9/19/2006 11:33
34.9	16	9/19/2006 10:59	62.8	16.5	9/19/2006 11:33
34.9	16	9/19/2006 10:59	54.6	16.5	9/19/2006 11:33
35.1	16	9/19/2006 10:59	51.3	16.5	9/19/2006 11:33
34.8	16	9/19/2006 10:59	46.6	16.5	9/19/2006 11:34
34.8	16	9/19/2006 10:59	47.9	16.5	9/19/2006 11:34
34.9	16	9/19/2006 11:00	46.7	16.5	9/19/2006 11:34
34.7	16	9/19/2006 11:00	41.9	16.5	9/19/2006 11:34
35	16	9/19/2006 11:00	41.9	16.5	9/19/2006 11:34
34.8	16	9/19/2006 11:00	44.3	16.5	9/19/2006 11:34
34.9	16	9/19/2006 11:00	44.8	16.5	9/19/2006 11:34
35	16	9/19/2006 11:00	213	16.5	9/19/2006 11:34
34.7	16	9/19/2006 11:01	84.1	16.5	9/19/2006 11:34
34.2	16	9/19/2006 11:01	150	16.5	9/19/2006 11:34
34.2	16	9/19/2006 11:01	123	16.5	9/19/2006 11:34
34.2	16	9/19/2006 11:01	91	16.5	9/19/2006 11:34
34.1	16	9/19/2006 11:01	72.1	16.5	9/19/2006 11:34
34.1	16	9/19/2006 11:01	57.1	16.5	9/19/2006 11:34
34.2	16	9/19/2006 11:02	65.6	16.5	9/19/2006 11:34
34.3	16	9/19/2006 11:02	86.1	16.5	9/19/2006 11:34
34.1	16	9/19/2006 11:02	68.2	16.5	9/19/2006 11:34
34.1	16	9/19/2006 11:02	65.1	16.5	9/19/2006 11:34
34.3	16	9/19/2006 11:02	72.3	16.5	9/19/2006 11:34

Path Measurement Data Site 1 Path 1			Path Measurement Data Site 1 Path 2		
ppm*m	pathlength	timestamp	ppm*m	pathlength	timestamp
34.2	16	9/19/2006 11:02	76.2	16.5	9/19/2006 11:34
34.3	16	9/19/2006 11:03	101	16.5	9/19/2006 11:34
34.2	16	9/19/2006 11:03	118	16.5	9/19/2006 11:34
34.2	16	9/19/2006 11:03	106	16.5	9/19/2006 11:34
34.3	16	9/19/2006 11:03	120	16.5	9/19/2006 11:34
34.3	16	9/19/2006 11:03	84.3	16.5	9/19/2006 11:34
34.2	16	9/19/2006 11:04	133	16.5	9/19/2006 11:34
34.3	16	9/19/2006 11:04	123	16.5	9/19/2006 11:34
34.3	16	9/19/2006 11:04	124	16.5	9/19/2006 11:34
34.3	16	9/19/2006 11:04	218	16.5	9/19/2006 11:34
34.4	16	9/19/2006 11:04	79.8	16.5	9/19/2006 11:34
34.4	16	9/19/2006 11:04	146	16.5	9/19/2006 11:34
34.4	16	9/19/2006 11:05	195	16.5	9/19/2006 11:34
34.2	16	9/19/2006 11:05	121	16.5	9/19/2006 11:34
34.4	16	9/19/2006 11:05	131	16.5	9/19/2006 11:35
34.7	16	9/19/2006 11:05	119	16.5	9/19/2006 11:35
34.7	16	9/19/2006 11:05	108	16.5	9/19/2006 11:35
34.9	16	9/19/2006 11:05	108	16.5	9/19/2006 11:35
34.8	16	9/19/2006 11:06	100	16.5	9/19/2006 11:35
			147	16.5	9/19/2006 11:35
			210	16.5	9/19/2006 11:35
			227	16.5	9/19/2006 11:35
			176	16.5	9/19/2006 11:35
			292	16.5	9/19/2006 11:35
			298	16.5	9/19/2006 11:35
			336	16.5	9/19/2006 11:35
			306	16.5	9/19/2006 11:35
			237	16.5	9/19/2006 11:35
			363	16.5	9/19/2006 11:35
			407	16.5	9/19/2006 11:35
			379	16.5	9/19/2006 11:35
			298	16.5	9/19/2006 11:35
			205	16.5	9/19/2006 11:35
			95.3	16.5	9/19/2006 11:35
			84.3	16.5	9/19/2006 11:35
			75.2	16.5	9/19/2006 11:35
			74.6	16.5	9/19/2006 11:35
			49.5	16.5	9/19/2006 11:35
			44.6	16.5	9/19/2006 11:35
			45.9	16.5	9/19/2006 11:35
			53.4	16.5	9/19/2006 11:35
			56.5	16.5	9/19/2006 11:35
			49.7	16.5	9/19/2006 11:35
			46.8	16.5	9/19/2006 11:35
			43.7	16.5	9/19/2006 11:35
			43.2	16.5	9/19/2006 11:35
			41.2	16.5	9/19/2006 11:35
			40.4	16.5	9/19/2006 11:35
			39.7	16.5	9/19/2006 11:36
			142	16.5	9/19/2006 11:36
			141	16.5	9/19/2006 11:36
			58.1	16.5	9/19/2006 11:36
			229	16.5	9/19/2006 11:36
			674	16.5	9/19/2006 11:36
			353	16.5	9/19/2006 11:36
			360	16.5	9/19/2006 11:36
			843	16.5	9/19/2006 11:36
			1220	16.5	9/19/2006 11:36
			1108	16.5	9/19/2006 11:36
			1801	16.5	9/19/2006 11:36
			404	16.5	9/19/2006 11:36

Path Measurement Data Site 1 Path 1			Path Measurement Data Site 1 Path 2		
ppm*m	pathlength	timestamp	ppm*m	pathlength	timestamp
			435	16.5	9/19/2006 11:36
			233	16.5	9/19/2006 11:36
			199	16.5	9/19/2006 11:36
			135	16.5	9/19/2006 11:36
			119	16.5	9/19/2006 11:36
			77.4	16.5	9/19/2006 11:36
			52.3	16.5	9/19/2006 11:36
			55.2	16.5	9/19/2006 11:36
			75	16.5	9/19/2006 11:36
			47.1	16.5	9/19/2006 11:36
			45.9	16.5	9/19/2006 11:36
			44.2	16.5	9/19/2006 11:36
			44.4	16.5	9/19/2006 11:36
			53.8	16.5	9/19/2006 11:36
			50.9	16.5	9/19/2006 11:36
			63.3	16.5	9/19/2006 11:36
			54.9	16.5	9/19/2006 11:36
			87.2	16.5	9/19/2006 11:36
			105	16.5	9/19/2006 11:36
			56	16.5	9/19/2006 11:36
			56.8	16.5	9/19/2006 11:36
			64.4	16.5	9/19/2006 11:37
			47.3	16.5	9/19/2006 11:37
			42.7	16.5	9/19/2006 11:37
			42.3	16.5	9/19/2006 11:37
			42.1	16.5	9/19/2006 11:37
			42.5	16.5	9/19/2006 11:37
			42.3	16.5	9/19/2006 11:37
			42.7	16.5	9/19/2006 11:37
			42.4	16.5	9/19/2006 11:37
			42.5	16.5	9/19/2006 11:37
			43.9	16.5	9/19/2006 11:37
			44.7	16.5	9/19/2006 11:37
			42.6	16.5	9/19/2006 11:37
			42.1	16.5	9/19/2006 11:37
			42.6	16.5	9/19/2006 11:37
			42.5	16.5	9/19/2006 11:37
			42.8	16.5	9/19/2006 11:37
			42	16.5	9/19/2006 11:37
			42.3	16.5	9/19/2006 11:37
			40.6	16.5	9/19/2006 11:37
			40.8	16.5	9/19/2006 11:37
			39.7	16.5	9/19/2006 11:37
			38.4	16.5	9/19/2006 11:37
			37.2	16.5	9/19/2006 11:37
			36.5	16.5	9/19/2006 11:37
			35.6	16.5	9/19/2006 11:37
			35.5	16.5	9/19/2006 11:37
			35.1	16.5	9/19/2006 11:37
			35.1	16.5	9/19/2006 11:37
			34.8	16.5	9/19/2006 11:37
			34.6	16.5	9/19/2006 11:37
			34.7	16.5	9/19/2006 11:37
			34.6	16.5	9/19/2006 11:37
			35	16.5	9/19/2006 11:37
			34.9	16.5	9/19/2006 11:38
			35.6	16.5	9/19/2006 11:38
			36.3	16.5	9/19/2006 11:38
			35.3	16.5	9/19/2006 11:38
			34.6	16.5	9/19/2006 11:38
			34.5	16.5	9/19/2006 11:38

Path Measurement Data Site 1 Path 1			Path Measurement Data Site 1 Path 2		
ppm*m	pathlength	timestamp	ppm*m	pathlength	timestamp
			34.6	16.5	9/19/2006 11:38
			34.8	16.5	9/19/2006 11:38
			34.4	16.5	9/19/2006 11:38
			34.5	16.5	9/19/2006 11:38
			34.4	16.5	9/19/2006 11:38
			34.4	16.5	9/19/2006 11:38
			34.6	16.5	9/19/2006 11:38
			34.5	16.5	9/19/2006 11:38
			34.7	16.5	9/19/2006 11:38
			34.6	16.5	9/19/2006 11:38
			34.7	16.5	9/19/2006 11:38
			34.8	16.5	9/19/2006 11:38
			34.9	16.5	9/19/2006 11:38
			34.8	16.5	9/19/2006 11:38
			34.7	16.5	9/19/2006 11:38
			34.7	16.5	9/19/2006 11:38
			34.8	16.5	9/19/2006 11:38
			34.8	16.5	9/19/2006 11:38
			34.9	16.5	9/19/2006 11:38
			34.7	16.5	9/19/2006 11:38
			34.9	16.5	9/19/2006 11:38
			34.7	16.5	9/19/2006 11:38
			34.6	16.5	9/19/2006 11:38
			34.8	16.5	9/19/2006 11:38
			34.8	16.5	9/19/2006 11:38
			34.7	16.5	9/19/2006 11:38
			34.6	16.5	9/19/2006 11:38
			34.6	16.5	9/19/2006 11:38
			34.7	16.5	9/19/2006 11:39
			34.6	16.5	9/19/2006 11:39
			34.5	16.5	9/19/2006 11:39
			34.7	16.5	9/19/2006 11:39
			34.6	16.5	9/19/2006 11:39
			37.4	16.5	9/19/2006 11:39
			54.1	16.5	9/19/2006 11:39
			88.4	16.5	9/19/2006 11:39
			110	16.5	9/19/2006 11:39
			371	16.5	9/19/2006 11:39
			292	16.5	9/19/2006 11:39
			477	16.5	9/19/2006 11:39
			542	16.5	9/19/2006 11:39
			377	16.5	9/19/2006 11:39
			107	16.5	9/19/2006 11:39
			61.5	16.5	9/19/2006 11:39
			77.8	16.5	9/19/2006 11:39
			76.9	16.5	9/19/2006 11:39
			73	16.5	9/19/2006 11:39
			120	16.5	9/19/2006 11:39
			104	16.5	9/19/2006 11:39
			114	16.5	9/19/2006 11:39
			80.6	16.5	9/19/2006 11:39
			58.2	16.5	9/19/2006 11:39
			85.5	16.5	9/19/2006 11:39
			66.6	16.5	9/19/2006 11:39
			104	16.5	9/19/2006 11:39
			92.8	16.5	9/19/2006 11:39
			70.7	16.5	9/19/2006 11:39
			55.7	16.5	9/19/2006 11:39
			50.3	16.5	9/19/2006 11:39
			64.1	16.5	9/19/2006 11:39
			62.2	16.5	9/19/2006 11:39

Path Measurement Data Site 1 Path 1			Path Measurement Data Site 1 Path 2		
ppm*m	pathlength	timestamp	ppm*m	pathlength	timestamp
			62	16.5	9/19/2006 11:39
			62.4	16.5	9/19/2006 11:40
			53.6	16.5	9/19/2006 11:40
			47.8	16.5	9/19/2006 11:40
			41.7	16.5	9/19/2006 11:40
			46.2	16.5	9/19/2006 11:40
			45.5	16.5	9/19/2006 11:40
			139	16.5	9/19/2006 11:40
			108	16.5	9/19/2006 11:40
			110	16.5	9/19/2006 11:40
			93.7	16.5	9/19/2006 11:40
			84.2	16.5	9/19/2006 11:40
			84.7	16.5	9/19/2006 11:40
			104	16.5	9/19/2006 11:40
			83	16.5	9/19/2006 11:40
			110	16.5	9/19/2006 11:40
			112	16.5	9/19/2006 11:40
			174	16.5	9/19/2006 11:40
			147	16.5	9/19/2006 11:40
			164	16.5	9/19/2006 11:40
			138	16.5	9/19/2006 11:40
			104	16.5	9/19/2006 11:40
			97.7	16.5	9/19/2006 11:40
			546	16.5	9/19/2006 11:40
			376	16.5	9/19/2006 11:40
			304	16.5	9/19/2006 11:40
			280	16.5	9/19/2006 11:40
			83.7	16.5	9/19/2006 11:40
			127	16.5	9/19/2006 11:40
			81	16.5	9/19/2006 11:40
			44	16.5	9/19/2006 11:40
			79.8	16.5	9/19/2006 11:40
			106	16.5	9/19/2006 11:40
			100	16.5	9/19/2006 11:40
			122	16.5	9/19/2006 11:41
			71.8	16.5	9/19/2006 11:41
			115	16.5	9/19/2006 11:41
			95.1	16.5	9/19/2006 11:41
			98	16.5	9/19/2006 11:41
			111	16.5	9/19/2006 11:41
			114	16.5	9/19/2006 11:41
			102	16.5	9/19/2006 11:41
			61.1	16.5	9/19/2006 11:41
			65.9	16.5	9/19/2006 11:41
			75.3	16.5	9/19/2006 11:41
			90.7	16.5	9/19/2006 11:41
			199	16.5	9/19/2006 11:41
			171	16.5	9/19/2006 11:41
			202	16.5	9/19/2006 11:41
			173	16.5	9/19/2006 11:41
			141	16.5	9/19/2006 11:41
			87.8	16.5	9/19/2006 11:41
			76.2	16.5	9/19/2006 11:41
			58.9	16.5	9/19/2006 11:41
			52	16.5	9/19/2006 11:41
			45.5	16.5	9/19/2006 11:41
			37.2	16.5	9/19/2006 11:41
			44.5	16.5	9/19/2006 11:41
			67.5	16.5	9/19/2006 11:41
			93.5	16.5	9/19/2006 11:41
			88.8	16.5	9/19/2006 11:41

Path Measurement Data Site 1 Path 1			Path Measurement Data Site 1 Path 2		
ppm*m	pathlength	timestamp	ppm*m	pathlength	timestamp
			58.6	16.5	9/19/2006 11:41
			86	16.5	9/19/2006 11:41
			156	16.5	9/19/2006 11:41
			98.1	16.5	9/19/2006 11:41
			98.5	16.5	9/19/2006 11:41
			122	16.5	9/19/2006 11:41
			163	16.5	9/19/2006 11:41
			231	16.5	9/19/2006 11:42
			247	16.5	9/19/2006 11:42
			277	16.5	9/19/2006 11:42
			367	16.5	9/19/2006 11:42
			315	16.5	9/19/2006 11:42
			127	16.5	9/19/2006 11:42
			62.7	16.5	9/19/2006 11:42
			87.8	16.5	9/19/2006 11:42
			118	16.5	9/19/2006 11:42
			117	16.5	9/19/2006 11:42
			102	16.5	9/19/2006 11:42
			92.5	16.5	9/19/2006 11:42
			102	16.5	9/19/2006 11:42
			274	16.5	9/19/2006 11:42
			187	16.5	9/19/2006 11:42
			106	16.5	9/19/2006 11:42
			94.9	16.5	9/19/2006 11:42
			111	16.5	9/19/2006 11:42
			300	16.5	9/19/2006 11:42
			92.7	16.5	9/19/2006 11:42
			95.5	16.5	9/19/2006 11:42
			150	16.5	9/19/2006 11:42
			154	16.5	9/19/2006 11:42
			745	16.5	9/19/2006 11:42
			1392	16.5	9/19/2006 11:42
			983	16.5	9/19/2006 11:42
			618	16.5	9/19/2006 11:42
			633	16.5	9/19/2006 11:42
			647	16.5	9/19/2006 11:42
			416	16.5	9/19/2006 11:42
			121	16.5	9/19/2006 11:42
			76.5	16.5	9/19/2006 11:42
			49	16.5	9/19/2006 11:42
			45.3	16.5	9/19/2006 11:43
			47	16.5	9/19/2006 11:43
			71.9	16.5	9/19/2006 11:43
			70.4	16.5	9/19/2006 11:43
			84.5	16.5	9/19/2006 11:43
			117	16.5	9/19/2006 11:43
			101	16.5	9/19/2006 11:43
			105	16.5	9/19/2006 11:43
			100	16.5	9/19/2006 11:43
			166	16.5	9/19/2006 11:43
			96.3	16.5	9/19/2006 11:43
			89	16.5	9/19/2006 11:43
			149	16.5	9/19/2006 11:43
			269	16.5	9/19/2006 11:43
			385	16.5	9/19/2006 11:43
			115	16.5	9/19/2006 11:43
			77.6	16.5	9/19/2006 11:43
			55.6	16.5	9/19/2006 11:43
			42.3	16.5	9/19/2006 11:43
			73.6	16.5	9/19/2006 11:43
			463	16.5	9/19/2006 11:43

Path Measurement Data Site 1 Path 1			Path Measurement Data Site 1 Path 2		
ppm*m	pathlength	timestamp	ppm*m	pathlength	timestamp
			336	16.5	9/19/2006 11:43
			491	16.5	9/19/2006 11:43
			178	16.5	9/19/2006 11:43
			130	16.5	9/19/2006 11:43
			219	16.5	9/19/2006 11:43
			1381	16.5	9/19/2006 11:43
			1003	16.5	9/19/2006 11:43
			85.7	16.5	9/19/2006 11:43
			79.3	16.5	9/19/2006 11:43
			79.3	16.5	9/19/2006 11:43
			98.4	16.5	9/19/2006 11:43
			229	16.5	9/19/2006 11:43
			123	16.5	9/19/2006 11:43
			154	16.5	9/19/2006 11:44
			125	16.5	9/19/2006 11:44
			82.3	16.5	9/19/2006 11:44
			50.5	16.5	9/19/2006 11:44
			56	16.5	9/19/2006 11:44
			53.6	16.5	9/19/2006 11:44
			65.2	16.5	9/19/2006 11:44
			74.1	16.5	9/19/2006 11:44
			139	16.5	9/19/2006 11:44
			147	16.5	9/19/2006 11:44
			605	16.5	9/19/2006 11:44
			276	16.5	9/19/2006 11:44
			139	16.5	9/19/2006 11:44
			120	16.5	9/19/2006 11:44
			216	16.5	9/19/2006 11:44
			144	16.5	9/19/2006 11:44
			102	16.5	9/19/2006 11:44
			71	16.5	9/19/2006 11:44
			103	16.5	9/19/2006 11:44
			105	16.5	9/19/2006 11:44
			121	16.5	9/19/2006 11:44
			75.3	16.5	9/19/2006 11:44
			96.1	16.5	9/19/2006 11:44
			81	16.5	9/19/2006 11:44
			253	16.5	9/19/2006 11:44
			171	16.5	9/19/2006 11:44
			75.6	16.5	9/19/2006 11:44
			87.3	16.5	9/19/2006 11:44
			86.8	16.5	9/19/2006 11:44
			87.9	16.5	9/19/2006 11:44
			95.5	16.5	9/19/2006 11:44
			111	16.5	9/19/2006 11:44
			104	16.5	9/19/2006 11:44
			96.3	16.5	9/19/2006 11:44
			109	16.5	9/19/2006 11:45
			164	16.5	9/19/2006 11:45
			138	16.5	9/19/2006 11:45
			150	16.5	9/19/2006 11:45
			207	16.5	9/19/2006 11:45
			215	16.5	9/19/2006 11:45
			113	16.5	9/19/2006 11:45
			120	16.5	9/19/2006 11:45
			146	16.5	9/19/2006 11:45
			210	16.5	9/19/2006 11:45
			586	16.5	9/19/2006 11:45
			542	16.5	9/19/2006 11:45
			313	16.5	9/19/2006 11:45
			171	16.5	9/19/2006 11:45



Path Measurement Data Site 1 Path 1			Path Measurement Data Site 1 Path 2		
ppm*m	pathlength	timestamp	ppm*m	pathlength	timestamp
			97.8	16.5	9/19/2006 11:45
			71.1	16.5	9/19/2006 11:45
			65.2	16.5	9/19/2006 11:45
			57.7	16.5	9/19/2006 11:45
			54.6	16.5	9/19/2006 11:45
			49.6	16.5	9/19/2006 11:45
			41.8	16.5	9/19/2006 11:45
			39.9	16.5	9/19/2006 11:45
			41.8	16.5	9/19/2006 11:45
			40.8	16.5	9/19/2006 11:45
			40.2	16.5	9/19/2006 11:45
			39.1	16.5	9/19/2006 11:45
			38.7	16.5	9/19/2006 11:45
			37.4	16.5	9/19/2006 11:45
			37.2	16.5	9/19/2006 11:45
			39.5	16.5	9/19/2006 11:45
			38.8	16.5	9/19/2006 11:45
			44.1	16.5	9/19/2006 11:45
			46.7	16.5	9/19/2006 11:45
			60.2	16.5	9/19/2006 11:46
			148	16.5	9/19/2006 11:46
			69.1	16.5	9/19/2006 11:46
			45.4	16.5	9/19/2006 11:46
			54.1	16.5	9/19/2006 11:46
			59.2	16.5	9/19/2006 11:46
			60.3	16.5	9/19/2006 11:46
			56	16.5	9/19/2006 11:46
			192	16.5	9/19/2006 11:46
			529	16.5	9/19/2006 11:46
			570	16.5	9/19/2006 11:46
			121	16.5	9/19/2006 11:46
			44.8	16.5	9/19/2006 11:46
			36.6	16.5	9/19/2006 11:46
			35.4	16.5	9/19/2006 11:46
			34.8	16.5	9/19/2006 11:46
			34.9	16.5	9/19/2006 11:46
			34.9	16.5	9/19/2006 11:46
			34.6	16.5	9/19/2006 11:46
			34.6	16.5	9/19/2006 11:46
			34.6	16.5	9/19/2006 11:46
			34.3	16.5	9/19/2006 11:46
			34.4	16.5	9/19/2006 11:46
			34.2	16.5	9/19/2006 11:46
			34.2	16.5	9/19/2006 11:46
			36.4	16.5	9/19/2006 11:46
			37.7	16.5	9/19/2006 11:46
			41.8	16.5	9/19/2006 11:46
			49.1	16.5	9/19/2006 11:46
			75.1	16.5	9/19/2006 11:46
			59.2	16.5	9/19/2006 11:46
			63.1	16.5	9/19/2006 11:46
			51.5	16.5	9/19/2006 11:46
			100	16.5	9/19/2006 11:46
			88.7	16.5	9/19/2006 11:47
			101	16.5	9/19/2006 11:47
			93.1	16.5	9/19/2006 11:47
			82.9	16.5	9/19/2006 11:47
			87.8	16.5	9/19/2006 11:47
			95.1	16.5	9/19/2006 11:47
			70.9	16.5	9/19/2006 11:47
			64.6	16.5	9/19/2006 11:47

Path Measurement Data Site 1 Path 1			Path Measurement Data Site 1 Path 2		
ppm*m	pathlength	timestamp	ppm*m	pathlength	timestamp
			71.8	16.5	9/19/2006 11:47
			53.9	16.5	9/19/2006 11:47
			63.5	16.5	9/19/2006 11:47
			51.9	16.5	9/19/2006 11:47
			65	16.5	9/19/2006 11:47
			59.5	16.5	9/19/2006 11:47
			72.5	16.5	9/19/2006 11:47
			113	16.5	9/19/2006 11:47
			113	16.5	9/19/2006 11:47
			102	16.5	9/19/2006 11:47
			92.7	16.5	9/19/2006 11:47
			88.4	16.5	9/19/2006 11:47
			54.3	16.5	9/19/2006 11:47
			72.2	16.5	9/19/2006 11:47
			52.9	16.5	9/19/2006 11:47
			43.7	16.5	9/19/2006 11:47
			153	16.5	9/19/2006 11:47
			852	16.5	9/19/2006 11:47
			2333	16.5	9/19/2006 11:47
			2252	16.5	9/19/2006 11:47
			1908	16.5	9/19/2006 11:47
			1170	16.5	9/19/2006 11:47
			484	16.5	9/19/2006 11:47
			166	16.5	9/19/2006 11:47
			195	16.5	9/19/2006 11:47
			121	16.5	9/19/2006 11:47
			80.4	16.5	9/19/2006 11:48
			40.2	16.5	9/19/2006 11:48
			36.5	16.5	9/19/2006 11:48
			35.7	16.5	9/19/2006 11:48
			34.3	16.5	9/19/2006 11:48
			34.2	16.5	9/19/2006 11:48
			36.7	16.5	9/19/2006 11:48
			41.4	16.5	9/19/2006 11:48
			40.6	16.5	9/19/2006 11:48
			46.2	16.5	9/19/2006 11:48
			46.5	16.5	9/19/2006 11:48
			48.2	16.5	9/19/2006 11:48
			43.2	16.5	9/19/2006 11:48
			41	16.5	9/19/2006 11:48
			40	16.5	9/19/2006 11:48
			50.3	16.5	9/19/2006 11:48
			82.2	16.5	9/19/2006 11:48
			210	16.5	9/19/2006 11:48
			407	16.5	9/19/2006 11:48
			729	16.5	9/19/2006 11:48
			891	16.5	9/19/2006 11:48
			815	16.5	9/19/2006 11:48
			553	16.5	9/19/2006 11:48
			88.8	16.5	9/19/2006 11:48
			42.5	16.5	9/19/2006 11:48
			218	16.5	9/19/2006 11:48
			353	16.5	9/19/2006 11:48
			286	16.5	9/19/2006 11:48
			77.5	16.5	9/19/2006 11:48
			99.1	16.5	9/19/2006 11:48
			109	16.5	9/19/2006 11:48
			68.2	16.5	9/19/2006 11:48
			92.2	16.5	9/19/2006 11:48
			89.6	16.5	9/19/2006 11:48
			56	16.5	9/19/2006 11:49

Path Measurement Data Site 1 Path 1			Path Measurement Data Site 1 Path 2		
ppm*m	pathlength	timestamp	ppm*m	pathlength	timestamp
			62.6	16.5	9/19/2006 11:49
			86.2	16.5	9/19/2006 11:49
			114	16.5	9/19/2006 11:49
			96.8	16.5	9/19/2006 11:49
			93	16.5	9/19/2006 11:49
			80.9	16.5	9/19/2006 11:49
			96.4	16.5	9/19/2006 11:49
			103	16.5	9/19/2006 11:49
			79.8	16.5	9/19/2006 11:49
			92.5	16.5	9/19/2006 11:49
			185	16.5	9/19/2006 11:49
			222	16.5	9/19/2006 11:49
			108	16.5	9/19/2006 11:49
			169	16.5	9/19/2006 11:49
			161	16.5	9/19/2006 11:49
			111	16.5	9/19/2006 11:49
			189	16.5	9/19/2006 11:49
			802	16.5	9/19/2006 11:49
			322	16.5	9/19/2006 11:49
			138	16.5	9/19/2006 11:49
			116	16.5	9/19/2006 11:49
			170	16.5	9/19/2006 11:49
			152	16.5	9/19/2006 11:49
			138	16.5	9/19/2006 11:49
			149	16.5	9/19/2006 11:49
			152	16.5	9/19/2006 11:49
			133	16.5	9/19/2006 11:49
			121	16.5	9/19/2006 11:49
			139	16.5	9/19/2006 11:49
			118	16.5	9/19/2006 11:49
			116	16.5	9/19/2006 11:49
			93.8	16.5	9/19/2006 11:49
			67	16.5	9/19/2006 11:50
			62.7	16.5	9/19/2006 11:50
			78.2	16.5	9/19/2006 11:50
			250	16.5	9/19/2006 11:50
			382	16.5	9/19/2006 11:50
			473	16.5	9/19/2006 11:50
			362	16.5	9/19/2006 11:50
			255	16.5	9/19/2006 11:50
			142	16.5	9/19/2006 11:50
			118	16.5	9/19/2006 11:50
			50.3	16.5	9/19/2006 11:50
			69.1	16.5	9/19/2006 11:50
			99.2	16.5	9/19/2006 11:50
			95.4	16.5	9/19/2006 11:50
			98.3	16.5	9/19/2006 11:50
			87.2	16.5	9/19/2006 11:50
			53.3	16.5	9/19/2006 11:50
			64.3	16.5	9/19/2006 11:50
			81	16.5	9/19/2006 11:50
			53.8	16.5	9/19/2006 11:50
			48	16.5	9/19/2006 11:50
			66.5	16.5	9/19/2006 11:50
			56.4	16.5	9/19/2006 11:50
			63.7	16.5	9/19/2006 11:50
			65.1	16.5	9/19/2006 11:50
			58	16.5	9/19/2006 11:50
			47.2	16.5	9/19/2006 11:50
			70.9	16.5	9/19/2006 11:50
			94.9	16.5	9/19/2006 11:50

Path Measurement Data Site 1 Path 1			Path Measurement Data Site 1 Path 2		
ppm*m	pathlength	timestamp	ppm*m	pathlength	timestamp
			86.5	16.5	9/19/2006 11:50
			132	16.5	9/19/2006 11:50
			124	16.5	9/19/2006 11:50
			100	16.5	9/19/2006 11:50
			106	16.5	9/19/2006 11:50
			105	16.5	9/19/2006 11:50
			179	16.5	9/19/2006 11:51
			188	16.5	9/19/2006 11:51
			109	16.5	9/19/2006 11:51
			193	16.5	9/19/2006 11:51
			1153	16.5	9/19/2006 11:51
			2281	16.5	9/19/2006 11:51
			290	16.5	9/19/2006 11:51
			44.1	16.5	9/19/2006 11:51
			47.4	16.5	9/19/2006 11:51
			91.8	16.5	9/19/2006 11:51
			218	16.5	9/19/2006 11:51
			142	16.5	9/19/2006 11:51
			77.2	16.5	9/19/2006 11:51
			148	16.5	9/19/2006 11:51
			650	16.5	9/19/2006 11:51
			1000	16.5	9/19/2006 11:51
			776	16.5	9/19/2006 11:51
			244	16.5	9/19/2006 11:51
			411	16.5	9/19/2006 11:51
			447	16.5	9/19/2006 11:51
			2077	16.5	9/19/2006 11:51
			623	16.5	9/19/2006 11:51
			461	16.5	9/19/2006 11:51
			500	16.5	9/19/2006 11:51
			1195	16.5	9/19/2006 11:51
			443	16.5	9/19/2006 11:51
			315	16.5	9/19/2006 11:51
			250	16.5	9/19/2006 11:51
			259	16.5	9/19/2006 11:51
			316	16.5	9/19/2006 11:51
			330	16.5	9/19/2006 11:51
			336	16.5	9/19/2006 11:51
			198	16.5	9/19/2006 11:51
			237	16.5	9/19/2006 11:52
			206	16.5	9/19/2006 11:52
			268	16.5	9/19/2006 11:52
			274	16.5	9/19/2006 11:52
			164	16.5	9/19/2006 11:52
			97.9	16.5	9/19/2006 11:52
			98.7	16.5	9/19/2006 11:52
			114	16.5	9/19/2006 11:52
			82.9	16.5	9/19/2006 11:52
			93.7	16.5	9/19/2006 11:52
			107	16.5	9/19/2006 11:52
			76.1	16.5	9/19/2006 11:52
			75.7	16.5	9/19/2006 11:52
			64.9	16.5	9/19/2006 11:52
			53	16.5	9/19/2006 11:52
			40.7	16.5	9/19/2006 11:52
			39.9	16.5	9/19/2006 11:52
			41.8	16.5	9/19/2006 11:52
			45.4	16.5	9/19/2006 11:52
			54.5	16.5	9/19/2006 11:52
			53	16.5	9/19/2006 11:52
			73.8	16.5	9/19/2006 11:52

Path Measurement Data Site 1 Path 1			Path Measurement Data Site 1 Path 2		
ppm*m	pathlength	timestamp	ppm*m	pathlength	timestamp
			73.4	16.5	9/19/2006 11:52
			48.3	16.5	9/19/2006 11:52
			48.3	16.5	9/19/2006 11:52
			81.2	16.5	9/19/2006 11:52
			137	16.5	9/19/2006 11:52
			83.7	16.5	9/19/2006 11:52
			68.8	16.5	9/19/2006 11:52
			53.4	16.5	9/19/2006 11:52
			47.8	16.5	9/19/2006 11:52
			38.3	16.5	9/19/2006 11:52
			36.5	16.5	9/19/2006 11:52
			36.3	16.5	9/19/2006 11:52
			35.5	16.5	9/19/2006 11:53
			35.6	16.5	9/19/2006 11:53
			35.4	16.5	9/19/2006 11:53
			35.4	16.5	9/19/2006 11:53
			35.6	16.5	9/19/2006 11:53
			36.6	16.5	9/19/2006 11:53
			39.5	16.5	9/19/2006 11:53
			38.2	16.5	9/19/2006 11:53
			37.4	16.5	9/19/2006 11:53
			37.8	16.5	9/19/2006 11:53
			38.4	16.5	9/19/2006 11:53
			38.5	16.5	9/19/2006 11:53
			39	16.5	9/19/2006 11:53
			41.7	16.5	9/19/2006 11:53
			41	16.5	9/19/2006 11:53
			41.5	16.5	9/19/2006 11:53

Path Measurement Data Site 1 Path 3			Path Measurement Data Site 1 Path 4		
ppm*m	pathlength	timestamp	ppm*m	pathlength	timestamp
1122	21	9/19/2006 12:00	178	19.5	9/19/2006 12:24
751	21	9/19/2006 12:00	209	19.5	9/19/2006 12:24
879	21	9/19/2006 12:00	569	19.5	9/19/2006 12:24
811	21	9/19/2006 12:00	247	19.5	9/19/2006 12:24
836	21	9/19/2006 12:00	162	19.5	9/19/2006 12:24
528	21	9/19/2006 12:00	164	19.5	9/19/2006 12:24
366	21	9/19/2006 12:00	130	19.5	9/19/2006 12:24
990	21	9/19/2006 12:00	152	19.5	9/19/2006 12:24
1345	21	9/19/2006 12:00	181	19.5	9/19/2006 12:24
442	21	9/19/2006 12:00	171	19.5	9/19/2006 12:24
372	21	9/19/2006 12:00	170	19.5	9/19/2006 12:24
338	21	9/19/2006 12:00	168	19.5	9/19/2006 12:24
229	21	9/19/2006 12:00	155	19.5	9/19/2006 12:24
152	21	9/19/2006 12:00	169	19.5	9/19/2006 12:24
77.1	21	9/19/2006 12:00	168	19.5	9/19/2006 12:24
51.3	21	9/19/2006 12:00	204	19.5	9/19/2006 12:24
45.2	21	9/19/2006 12:00	229	19.5	9/19/2006 12:24
44.3	21	9/19/2006 12:01	197	19.5	9/19/2006 12:24
47.7	21	9/19/2006 12:01	181	19.5	9/19/2006 12:24
62.3	21	9/19/2006 12:01	225	19.5	9/19/2006 12:24
49.3	21	9/19/2006 12:01	211	19.5	9/19/2006 12:24
45.1	21	9/19/2006 12:01	179	19.5	9/19/2006 12:24
45.8	21	9/19/2006 12:01	158	19.5	9/19/2006 12:24
47.3	21	9/19/2006 12:01	161	19.5	9/19/2006 12:24
48.5	21	9/19/2006 12:01	127	19.5	9/19/2006 12:24
53.5	21	9/19/2006 12:01	86.2	19.5	9/19/2006 12:25
53.7	21	9/19/2006 12:01	59.5	19.5	9/19/2006 12:25
49.6	21	9/19/2006 12:01	43.2	19.5	9/19/2006 12:25
51.7	21	9/19/2006 12:01	40.2	19.5	9/19/2006 12:25
47.1	21	9/19/2006 12:01	40.6	19.5	9/19/2006 12:25
45.3	21	9/19/2006 12:01	42.1	19.5	9/19/2006 12:25
50.1	21	9/19/2006 12:01	43	19.5	9/19/2006 12:25
53.9	21	9/19/2006 12:01	43.4	19.5	9/19/2006 12:25
57.4	21	9/19/2006 12:01	43.5	19.5	9/19/2006 12:25
57.9	21	9/19/2006 12:01	42.3	19.5	9/19/2006 12:25
50.9	21	9/19/2006 12:01	41.4	19.5	9/19/2006 12:25
52.6	21	9/19/2006 12:01	41.3	19.5	9/19/2006 12:25
51.4	21	9/19/2006 12:01	46.4	19.5	9/19/2006 12:25
47.2	21	9/19/2006 12:01	69.3	19.5	9/19/2006 12:25
49.8	21	9/19/2006 12:01	101	19.5	9/19/2006 12:25
49.3	21	9/19/2006 12:01	117	19.5	9/19/2006 12:25
50.1	21	9/19/2006 12:01	189	19.5	9/19/2006 12:25
50.6	21	9/19/2006 12:01	121	19.5	9/19/2006 12:25
52.5	21	9/19/2006 12:01	56.6	19.5	9/19/2006 12:25
51.5	21	9/19/2006 12:01	42.8	19.5	9/19/2006 12:25
52	21	9/19/2006 12:01	44.2	19.5	9/19/2006 12:25
53.5	21	9/19/2006 12:01	57.8	19.5	9/19/2006 12:25
53.6	21	9/19/2006 12:01	124	19.5	9/19/2006 12:25
53.2	21	9/19/2006 12:01	117	19.5	9/19/2006 12:25
50.9	21	9/19/2006 12:01	518	19.5	9/19/2006 12:25
47.9	21	9/19/2006 12:01	465	19.5	9/19/2006 12:25
47.3	21	9/19/2006 12:02	165	19.5	9/19/2006 12:25
47.5	21	9/19/2006 12:02	76.7	19.5	9/19/2006 12:25
48.8	21	9/19/2006 12:02	52.5	19.5	9/19/2006 12:25
48.8	21	9/19/2006 12:02	54.4	19.5	9/19/2006 12:25
46.9	21	9/19/2006 12:02	45.4	19.5	9/19/2006 12:25
45.9	21	9/19/2006 12:02	62.2	19.5	9/19/2006 12:25
45.2	21	9/19/2006 12:02	77.5	19.5	9/19/2006 12:25

Path Measurement Data Site 1 Path 3			Path Measurement Data Site 1 Path 4		
ppm*m	pathlength	timestamp	ppm*m	pathlength	timestamp
44.8	21	9/19/2006 12:02	83.3	19.5	9/19/2006 12:26
45.4	21	9/19/2006 12:02	154	19.5	9/19/2006 12:26
45.3	21	9/19/2006 12:02	749	19.5	9/19/2006 12:26
45.2	21	9/19/2006 12:02	452	19.5	9/19/2006 12:26
45.3	21	9/19/2006 12:02	365	19.5	9/19/2006 12:26
45.6	21	9/19/2006 12:02	407	19.5	9/19/2006 12:26
45.2	21	9/19/2006 12:02	313	19.5	9/19/2006 12:26
45	21	9/19/2006 12:02	447	19.5	9/19/2006 12:26
44.2	21	9/19/2006 12:02	305	19.5	9/19/2006 12:26
44	21	9/19/2006 12:02	226	19.5	9/19/2006 12:26
44.1	21	9/19/2006 12:02	299	19.5	9/19/2006 12:26
44.6	21	9/19/2006 12:02	130	19.5	9/19/2006 12:26
44.2	21	9/19/2006 12:02	144	19.5	9/19/2006 12:26
44.6	21	9/19/2006 12:02	84.9	19.5	9/19/2006 12:26
44.6	21	9/19/2006 12:02	229	19.5	9/19/2006 12:26
44.4	21	9/19/2006 12:02	82.6	19.5	9/19/2006 12:26
44.8	21	9/19/2006 12:02	60.1	19.5	9/19/2006 12:26
44.4	21	9/19/2006 12:02	56.4	19.5	9/19/2006 12:26
44.2	21	9/19/2006 12:02	50.1	19.5	9/19/2006 12:26
44.2	21	9/19/2006 12:02	47.3	19.5	9/19/2006 12:26
44	21	9/19/2006 12:02	50.1	19.5	9/19/2006 12:26
44.1	21	9/19/2006 12:02	63.2	19.5	9/19/2006 12:26
44	21	9/19/2006 12:02	96.7	19.5	9/19/2006 12:26
43.7	21	9/19/2006 12:02	136	19.5	9/19/2006 12:26
43.7	21	9/19/2006 12:02	85.9	19.5	9/19/2006 12:26
43.7	21	9/19/2006 12:02	65.7	19.5	9/19/2006 12:26
43.4	21	9/19/2006 12:03	50	19.5	9/19/2006 12:26
43.4	21	9/19/2006 12:03	77.1	19.5	9/19/2006 12:26
43.5	21	9/19/2006 12:03	90.6	19.5	9/19/2006 12:26
43.6	21	9/19/2006 12:03	132	19.5	9/19/2006 12:26
43.5	21	9/19/2006 12:03	115	19.5	9/19/2006 12:26
43.6	21	9/19/2006 12:03	120	19.5	9/19/2006 12:26
43.5	21	9/19/2006 12:03	133	19.5	9/19/2006 12:26
43.4	21	9/19/2006 12:03	81.2	19.5	9/19/2006 12:26
43.5	21	9/19/2006 12:03	47.9	19.5	9/19/2006 12:27
43.6	21	9/19/2006 12:03	43.4	19.5	9/19/2006 12:27
43.3	21	9/19/2006 12:03	41.8	19.5	9/19/2006 12:27
43.5	21	9/19/2006 12:03	45.1	19.5	9/19/2006 12:27
43.2	21	9/19/2006 12:03	44.3	19.5	9/19/2006 12:27
43.3	21	9/19/2006 12:03	42.7	19.5	9/19/2006 12:27
43.1	21	9/19/2006 12:03	42.1	19.5	9/19/2006 12:27
43	21	9/19/2006 12:03	41.5	19.5	9/19/2006 12:27
43.4	21	9/19/2006 12:03	42.2	19.5	9/19/2006 12:27
43.5	21	9/19/2006 12:03	42	19.5	9/19/2006 12:27
43.3	21	9/19/2006 12:03	41.7	19.5	9/19/2006 12:27
43.5	21	9/19/2006 12:03	41.2	19.5	9/19/2006 12:27
43.7	21	9/19/2006 12:03	42.2	19.5	9/19/2006 12:27
43.4	21	9/19/2006 12:03	42	19.5	9/19/2006 12:27
43.6	21	9/19/2006 12:03	41.6	19.5	9/19/2006 12:27
43.8	21	9/19/2006 12:03	41.8	19.5	9/19/2006 12:27
43.7	21	9/19/2006 12:03	41.1	19.5	9/19/2006 12:27
44	21	9/19/2006 12:03	40.3	19.5	9/19/2006 12:27
44.2	21	9/19/2006 12:03	40.9	19.5	9/19/2006 12:27
44	21	9/19/2006 12:03	42.2	19.5	9/19/2006 12:27
43.6	21	9/19/2006 12:03	42.2	19.5	9/19/2006 12:27
43.9	21	9/19/2006 12:03	44.1	19.5	9/19/2006 12:27
44	21	9/19/2006 12:03	49.7	19.5	9/19/2006 12:27
43.7	21	9/19/2006 12:03	75.5	19.5	9/19/2006 12:27
43.6	21	9/19/2006 12:03	53.5	19.5	9/19/2006 12:27
43.5	21	9/19/2006 12:03	50	19.5	9/19/2006 12:27
43.3	21	9/19/2006 12:03	47.3	19.5	9/19/2006 12:27

Path Measurement Data Site 1 Path 3			Path Measurement Data Site 1 Path 4		
ppm*m	pathlength	timestamp	ppm*m	pathlength	timestamp
43.6	21	9/19/2006 12:04	48.3	19.5	9/19/2006 12:27
43.5	21	9/19/2006 12:04	48.2	19.5	9/19/2006 12:27
43.4	21	9/19/2006 12:04	50.3	19.5	9/19/2006 12:27
43.3	21	9/19/2006 12:04	53.4	19.5	9/19/2006 12:27
43.4	21	9/19/2006 12:04	56.9	19.5	9/19/2006 12:27
43.2	21	9/19/2006 12:04	57.2	19.5	9/19/2006 12:27
43.2	21	9/19/2006 12:04	54.3	19.5	9/19/2006 12:27
43.2	21	9/19/2006 12:04	54.8	19.5	9/19/2006 12:28
43.6	21	9/19/2006 12:04	59	19.5	9/19/2006 12:28
43.3	21	9/19/2006 12:04	61.1	19.5	9/19/2006 12:28
43.3	21	9/19/2006 12:04	63	19.5	9/19/2006 12:28
43.4	21	9/19/2006 12:04	64.3	19.5	9/19/2006 12:28
43.2	21	9/19/2006 12:04	60.9	19.5	9/19/2006 12:28
44.6	21	9/19/2006 12:04	61	19.5	9/19/2006 12:28
44.8	21	9/19/2006 12:04	59.6	19.5	9/19/2006 12:28
44.8	21	9/19/2006 12:04	57.9	19.5	9/19/2006 12:28
51.1	21	9/19/2006 12:04	56.8	19.5	9/19/2006 12:28
52.4	21	9/19/2006 12:04	60.1	19.5	9/19/2006 12:28
62.3	21	9/19/2006 12:04	63.7	19.5	9/19/2006 12:28
57.6	21	9/19/2006 12:04	64	19.5	9/19/2006 12:28
64.2	21	9/19/2006 12:04	63.7	19.5	9/19/2006 12:28
344	21	9/19/2006 12:04	62.5	19.5	9/19/2006 12:28
709	21	9/19/2006 12:04	59.6	19.5	9/19/2006 12:28
192	21	9/19/2006 12:04	58	19.5	9/19/2006 12:28
57.5	21	9/19/2006 12:04	55.2	19.5	9/19/2006 12:28
47.9	21	9/19/2006 12:04	425	19.5	9/19/2006 12:28
49.7	21	9/19/2006 12:04	373	19.5	9/19/2006 12:28
47.4	21	9/19/2006 12:04	261	19.5	9/19/2006 12:28
62.1	21	9/19/2006 12:04	208	19.5	9/19/2006 12:28
54.7	21	9/19/2006 12:04	184	19.5	9/19/2006 12:28
90.1	21	9/19/2006 12:04	176	19.5	9/19/2006 12:28
80.4	21	9/19/2006 12:04	108	19.5	9/19/2006 12:28
265	21	9/19/2006 12:04	102	19.5	9/19/2006 12:28
82.1	21	9/19/2006 12:04	157	19.5	9/19/2006 12:29
128	21	9/19/2006 12:05	177	19.5	9/19/2006 12:29
304	21	9/19/2006 12:05	128	19.5	9/19/2006 12:29
551	21	9/19/2006 12:05	105	19.5	9/19/2006 12:29
427	21	9/19/2006 12:05	170	19.5	9/19/2006 12:29
209	21	9/19/2006 12:05	136	19.5	9/19/2006 12:29
145	21	9/19/2006 12:05	289	19.5	9/19/2006 12:29
156	21	9/19/2006 12:05	704	19.5	9/19/2006 12:29
160	21	9/19/2006 12:05	175	19.5	9/19/2006 12:29
135	21	9/19/2006 12:05	137	19.5	9/19/2006 12:29
92.8	21	9/19/2006 12:05	162	19.5	9/19/2006 12:29
68.3	21	9/19/2006 12:05	228	19.5	9/19/2006 12:29
57.8	21	9/19/2006 12:05	798	19.5	9/19/2006 12:29
51.7	21	9/19/2006 12:05	688	19.5	9/19/2006 12:29
51.1	21	9/19/2006 12:05	594	19.5	9/19/2006 12:29
56.5	21	9/19/2006 12:05	453	19.5	9/19/2006 12:29
63.7	21	9/19/2006 12:05	86.5	19.5	9/19/2006 12:29
51.8	21	9/19/2006 12:05	49.7	19.5	9/19/2006 12:29
48.7	21	9/19/2006 12:05	67.8	19.5	9/19/2006 12:29
47.3	21	9/19/2006 12:05	133	19.5	9/19/2006 12:29
52.4	21	9/19/2006 12:05	1064	19.5	9/19/2006 12:29
51.3	21	9/19/2006 12:05	393	19.5	9/19/2006 12:29
52	21	9/19/2006 12:05	277	19.5	9/19/2006 12:29
51.9	21	9/19/2006 12:05	235	19.5	9/19/2006 12:29
50	21	9/19/2006 12:05	159	19.5	9/19/2006 12:29
49.2	21	9/19/2006 12:05	109	19.5	9/19/2006 12:29
48.6	21	9/19/2006 12:05	113	19.5	9/19/2006 12:29
48.5	21	9/19/2006 12:05	63.1	19.5	9/19/2006 12:29



Path Measurement Data Site 1 Path 3			Path Measurement Data Site 1 Path 4		
ppm*m	pathlength	timestamp	ppm*m	pathlength	timestamp
47.3	21	9/19/2006 12:05	41.4	19.5	9/19/2006 12:29
47.3	21	9/19/2006 12:05	40.8	19.5	9/19/2006 12:29
47.6	21	9/19/2006 12:05	40.5	19.5	9/19/2006 12:29
48	21	9/19/2006 12:05	40.4	19.5	9/19/2006 12:29
48.5	21	9/19/2006 12:05	42.8	19.5	9/19/2006 12:29
50.1	21	9/19/2006 12:05	51	19.5	9/19/2006 12:30
50.4	21	9/19/2006 12:06	50.5	19.5	9/19/2006 12:30
51	21	9/19/2006 12:06	45.1	19.5	9/19/2006 12:30
50.9	21	9/19/2006 12:06	42.4	19.5	9/19/2006 12:30
51.3	21	9/19/2006 12:06	41.2	19.5	9/19/2006 12:30
51.9	21	9/19/2006 12:06	41.1	19.5	9/19/2006 12:30
53.7	21	9/19/2006 12:06	40.5	19.5	9/19/2006 12:30
54.7	21	9/19/2006 12:06	39.7	19.5	9/19/2006 12:30
53.3	21	9/19/2006 12:06	39.7	19.5	9/19/2006 12:30
53.6	21	9/19/2006 12:06	39.8	19.5	9/19/2006 12:30
52.7	21	9/19/2006 12:06	39.8	19.5	9/19/2006 12:30
51.9	21	9/19/2006 12:06	39.3	19.5	9/19/2006 12:30
53.1	21	9/19/2006 12:06	39.6	19.5	9/19/2006 12:30
52.1	21	9/19/2006 12:06	39.6	19.5	9/19/2006 12:30
52.5	21	9/19/2006 12:06	39.7	19.5	9/19/2006 12:30
56.4	21	9/19/2006 12:06	40	19.5	9/19/2006 12:30
55.8	21	9/19/2006 12:06	40	19.5	9/19/2006 12:30
55	21	9/19/2006 12:06	39.8	19.5	9/19/2006 12:30
55.4	21	9/19/2006 12:06	40	19.5	9/19/2006 12:30
54.7	21	9/19/2006 12:06	39.8	19.5	9/19/2006 12:30
52.1	21	9/19/2006 12:06	39.8	19.5	9/19/2006 12:30
51.6	21	9/19/2006 12:06	39.9	19.5	9/19/2006 12:30
53.8	21	9/19/2006 12:06	39.7	19.5	9/19/2006 12:30
69.2	21	9/19/2006 12:06	39.9	19.5	9/19/2006 12:30
100	21	9/19/2006 12:06	39.8	19.5	9/19/2006 12:30
84.2	21	9/19/2006 12:06	39.6	19.5	9/19/2006 12:30
81	21	9/19/2006 12:06	39.7	19.5	9/19/2006 12:30
91.6	21	9/19/2006 12:06	39.7	19.5	9/19/2006 12:31
158	21	9/19/2006 12:06	41.4	19.5	9/19/2006 12:31
158	21	9/19/2006 12:06	41.6	19.5	9/19/2006 12:31
208	21	9/19/2006 12:06	41.3	19.5	9/19/2006 12:31
145	21	9/19/2006 12:06	41.2	19.5	9/19/2006 12:31
87.5	21	9/19/2006 12:06	41.8	19.5	9/19/2006 12:31
95.9	21	9/19/2006 12:06	42.3	19.5	9/19/2006 12:32
74.3	21	9/19/2006 12:06	42.3	19.5	9/19/2006 12:32
49.4	21	9/19/2006 12:06	42.3	19.5	9/19/2006 12:32
47.8	21	9/19/2006 12:07	42.6	19.5	9/19/2006 12:32
47.2	21	9/19/2006 12:07	43.2	19.5	9/19/2006 12:32
47.1	21	9/19/2006 12:07	44	19.5	9/19/2006 12:32
46.9	21	9/19/2006 12:07	43.7	19.5	9/19/2006 12:32
46.3	21	9/19/2006 12:07	44	19.5	9/19/2006 12:32
46.7	21	9/19/2006 12:07	43.8	19.5	9/19/2006 12:32
46.6	21	9/19/2006 12:07	43.5	19.5	9/19/2006 12:32
45.4	21	9/19/2006 12:07	44.3	19.5	9/19/2006 12:32
44.8	21	9/19/2006 12:07	44.3	19.5	9/19/2006 12:32
45.1	21	9/19/2006 12:07	44.2	19.5	9/19/2006 12:32
45	21	9/19/2006 12:07	44.2	19.5	9/19/2006 12:32
44.8	21	9/19/2006 12:07	44.9	19.5	9/19/2006 12:32
44.2	21	9/19/2006 12:07	46.1	19.5	9/19/2006 12:32
44.1	21	9/19/2006 12:07			
43.9	21	9/19/2006 12:07			
44.3	21	9/19/2006 12:07			
44.2	21	9/19/2006 12:07			
44.5	21	9/19/2006 12:07			
44	21	9/19/2006 12:07			
44.1	21	9/19/2006 12:07			

Path Measurement Data Site 1 Path 3			Path Measurement Data Site 1 Path 4		
ppm*m	pathlength	timestamp	ppm*m	pathlength	timestamp
43.9	21	9/19/2006 12:07			
43.9	21	9/19/2006 12:07			
44	21	9/19/2006 12:07			
44.3	21	9/19/2006 12:07			
44.1	21	9/19/2006 12:07			
44.2	21	9/19/2006 12:07			
44.7	21	9/19/2006 12:07			
44.6	21	9/19/2006 12:07			
44.3	21	9/19/2006 12:07			
44.3	21	9/19/2006 12:07			
44	21	9/19/2006 12:07			
44.4	21	9/19/2006 12:07			
44.4	21	9/19/2006 12:07			
44.4	21	9/19/2006 12:08			
44.3	21	9/19/2006 12:08			
44.2	21	9/19/2006 12:08			
44.3	21	9/19/2006 12:08			
44.1	21	9/19/2006 12:08			
44.3	21	9/19/2006 12:08			
43.9	21	9/19/2006 12:08			
44	21	9/19/2006 12:08			
44.4	21	9/19/2006 12:08			
44.3	21	9/19/2006 12:08			
44.2	21	9/19/2006 12:08			
44.8	21	9/19/2006 12:08			
44.9	21	9/19/2006 12:08			
44.7	21	9/19/2006 12:08			
44.7	21	9/19/2006 12:08			
55.3	21	9/19/2006 12:08			
124	21	9/19/2006 12:08			
203	21	9/19/2006 12:08			
212	21	9/19/2006 12:08			
253	21	9/19/2006 12:08			
186	21	9/19/2006 12:08			
161	21	9/19/2006 12:08			
184	21	9/19/2006 12:08			
114	21	9/19/2006 12:08			
68.5	21	9/19/2006 12:08			
66.5	21	9/19/2006 12:08			
84.4	21	9/19/2006 12:08			
78.3	21	9/19/2006 12:08			
57.9	21	9/19/2006 12:08			
53.8	21	9/19/2006 12:08			
46	21	9/19/2006 12:08			
45	21	9/19/2006 12:08			
44.7	21	9/19/2006 12:08			
43.7	21	9/19/2006 12:08			
43.4	21	9/19/2006 12:09			
43.3	21	9/19/2006 12:09			
43.6	21	9/19/2006 12:09			
43.4	21	9/19/2006 12:09			
43.6	21	9/19/2006 12:09			
43.4	21	9/19/2006 12:09			
43.9	21	9/19/2006 12:09			
46	21	9/19/2006 12:09			
49.6	21	9/19/2006 12:09			
48.5	21	9/19/2006 12:09			
47	21	9/19/2006 12:09			
50.1	21	9/19/2006 12:09			
58.8	21	9/19/2006 12:09			
58.1	21	9/19/2006 12:09			

Path Measurement Data Site 1 Path 3			Path Measurement Data Site 1 Path 4		
ppm*m	pathlength	timestamp	ppm*m	pathlength	timestamp
50.7	21	9/19/2006 12:09			
50.8	21	9/19/2006 12:09			
50.1	21	9/19/2006 12:09			
46.4	21	9/19/2006 12:09			
45.5	21	9/19/2006 12:09			
45.2	21	9/19/2006 12:09			
55.8	21	9/19/2006 12:09			
46.6	21	9/19/2006 12:09			
52.8	21	9/19/2006 12:09			
63.5	21	9/19/2006 12:09			
82.2	21	9/19/2006 12:09			
253	21	9/19/2006 12:09			
176	21	9/19/2006 12:09			
135	21	9/19/2006 12:09			
48.7	21	9/19/2006 12:09			
45.4	21	9/19/2006 12:09			
44.6	21	9/19/2006 12:09			
44.5	21	9/19/2006 12:09			
49.5	21	9/19/2006 12:09			
51.1	21	9/19/2006 12:09			
60.1	21	9/19/2006 12:10			
56.9	21	9/19/2006 12:10			
51.2	21	9/19/2006 12:10			
58.2	21	9/19/2006 12:10			
141	21	9/19/2006 12:10			
191	21	9/19/2006 12:10			
229	21	9/19/2006 12:10			
97.5	21	9/19/2006 12:10			
66.5	21	9/19/2006 12:10			
355	21	9/19/2006 12:10			
61	21	9/19/2006 12:10			
61.8	21	9/19/2006 12:10			
59.1	21	9/19/2006 12:10			
51.2	21	9/19/2006 12:10			
48.5	21	9/19/2006 12:10			
46.9	21	9/19/2006 12:10			
47.6	21	9/19/2006 12:10			
45.2	21	9/19/2006 12:10			
46.1	21	9/19/2006 12:10			
45.6	21	9/19/2006 12:10			
46.2	21	9/19/2006 12:10			
45.1	21	9/19/2006 12:10			
45.7	21	9/19/2006 12:10			
43.9	21	9/19/2006 12:10			
44	21	9/19/2006 12:10			
44.2	21	9/19/2006 12:10			
43.8	21	9/19/2006 12:10			
43.8	21	9/19/2006 12:10			
47.5	21	9/19/2006 12:10			
56.7	21	9/19/2006 12:10			
54.5	21	9/19/2006 12:10			
50.8	21	9/19/2006 12:10			
50	21	9/19/2006 12:10			
49.1	21	9/19/2006 12:10			
48.2	21	9/19/2006 12:11			
49	21	9/19/2006 12:11			
49.6	21	9/19/2006 12:11			
47.9	21	9/19/2006 12:11			
45.9	21	9/19/2006 12:11			
44.4	21	9/19/2006 12:11			
43.7	21	9/19/2006 12:11			

Path Measurement Data Site 1 Path 3			Path Measurement Data Site 1 Path 4		
ppm*m	pathlength	timestamp	ppm*m	pathlength	timestamp
44.2	21	9/19/2006 12:11			
54.4	21	9/19/2006 12:11			
49.2	21	9/19/2006 12:11			
50.1	21	9/19/2006 12:11			
58.6	21	9/19/2006 12:11			
73.1	21	9/19/2006 12:11			
91.3	21	9/19/2006 12:11			
67.6	21	9/19/2006 12:11			
58.3	21	9/19/2006 12:11			
65.6	21	9/19/2006 12:11			
51.3	21	9/19/2006 12:11			
45.7	21	9/19/2006 12:11			
46.4	21	9/19/2006 12:11			
59.9	21	9/19/2006 12:11			
131	21	9/19/2006 12:11			
189	21	9/19/2006 12:11			
333	21	9/19/2006 12:11			
78.3	21	9/19/2006 12:11			
45.9	21	9/19/2006 12:11			
49.8	21	9/19/2006 12:11			
44.6	21	9/19/2006 12:11			
44.1	21	9/19/2006 12:11			
44.1	21	9/19/2006 12:11			
54.9	21	9/19/2006 12:11			
51.4	21	9/19/2006 12:11			
43.7	21	9/19/2006 12:11			
305	21	9/19/2006 12:12			
203	21	9/19/2006 12:12			
43.7	21	9/19/2006 12:12			
43.6	21	9/19/2006 12:12			
43.7	21	9/19/2006 12:12			
43.5	21	9/19/2006 12:12			
43.4	21	9/19/2006 12:12			
43.6	21	9/19/2006 12:12			
43.5	21	9/19/2006 12:12			
43.6	21	9/19/2006 12:12			
43.6	21	9/19/2006 12:12			
43.7	21	9/19/2006 12:12			
43.9	21	9/19/2006 12:12			
43.6	21	9/19/2006 12:12			
43.6	21	9/19/2006 12:12			
43.4	21	9/19/2006 12:12			
43.7	21	9/19/2006 12:12			
43.5	21	9/19/2006 12:12			
43.5	21	9/19/2006 12:12			
43.5	21	9/19/2006 12:12			
43.6	21	9/19/2006 12:12			
43.3	21	9/19/2006 12:12			
43.7	21	9/19/2006 12:12			
43.5	21	9/19/2006 12:12			
43.8	21	9/19/2006 12:12			
43.7	21	9/19/2006 12:12			
43.7	21	9/19/2006 12:12			
43.7	21	9/19/2006 12:12			
43.6	21	9/19/2006 12:12			
43.9	21	9/19/2006 12:12			
43.8	21	9/19/2006 12:12			
43.6	21	9/19/2006 12:12			
43.5	21	9/19/2006 12:12			
44	21	9/19/2006 12:12			
44	21	9/19/2006 12:12			
44.2	21	9/19/2006 12:12			

Path Measurement Data Site 1 Path 3			Path Measurement Data Site 1 Path 4		
ppm*m	pathlength	timestamp	ppm*m	pathlength	timestamp
44.1	21	9/19/2006 12:13			
43.7	21	9/19/2006 12:13			
44	21	9/19/2006 12:13			
43.7	21	9/19/2006 12:13			
44.2	21	9/19/2006 12:13			
44.4	21	9/19/2006 12:13			
45.1	21	9/19/2006 12:13			
45.7	21	9/19/2006 12:13			
45.4	21	9/19/2006 12:13			
46.1	21	9/19/2006 12:13			
47.3	21	9/19/2006 12:13			
47.1	21	9/19/2006 12:13			
46.8	21	9/19/2006 12:13			
46.4	21	9/19/2006 12:13			
46.1	21	9/19/2006 12:13			
46.7	21	9/19/2006 12:13			
46.1	21	9/19/2006 12:13			
46	21	9/19/2006 12:13			
45.9	21	9/19/2006 12:13			
45.4	21	9/19/2006 12:13			
45.4	21	9/19/2006 12:13			
45.4	21	9/19/2006 12:13			
45.4	21	9/19/2006 12:13			
45.1	21	9/19/2006 12:13			
45.2	21	9/19/2006 12:13			
45.1	21	9/19/2006 12:13			
45.2	21	9/19/2006 12:13			
45.3	21	9/19/2006 12:13			
45.4	21	9/19/2006 12:13			
45.6	21	9/19/2006 12:13			
45.6	21	9/19/2006 12:13			
45.7	21	9/19/2006 12:13			
46.1	21	9/19/2006 12:13			
45.7	21	9/19/2006 12:14			
45.6	21	9/19/2006 12:14			
45.8	21	9/19/2006 12:14			
46.2	21	9/19/2006 12:14			
46	21	9/19/2006 12:14			
46.1	21	9/19/2006 12:14			
46.2	21	9/19/2006 12:14			
46.1	21	9/19/2006 12:14			
46.1	21	9/19/2006 12:14			
46	21	9/19/2006 12:14			
45.6	21	9/19/2006 12:14			
46	21	9/19/2006 12:14			
47.6	21	9/19/2006 12:14			
47.2	21	9/19/2006 12:14			
46	21	9/19/2006 12:14			
46.1	21	9/19/2006 12:14			
45.7	21	9/19/2006 12:14			
45.6	21	9/19/2006 12:14			
45.6	21	9/19/2006 12:14			
45.7	21	9/19/2006 12:14			
45.3	21	9/19/2006 12:14			
44.8	21	9/19/2006 12:14			
44.7	21	9/19/2006 12:14			
44.7	21	9/19/2006 12:14			
44.5	21	9/19/2006 12:14			
44	21	9/19/2006 12:14			
43.5	21	9/19/2006 12:14			
43.5	21	9/19/2006 12:14			

Path Measurement Data Site 1 Path 3			Path Measurement Data Site 1 Path 4		
ppm*m	pathlength	timestamp	ppm*m	pathlength	timestamp
43.7	21	9/19/2006 12:14			
43.4	21	9/19/2006 12:14			
43.3	21	9/19/2006 12:14			
43.1	21	9/19/2006 12:14			
43.4	21	9/19/2006 12:14			
43	21	9/19/2006 12:15			
43.2	21	9/19/2006 12:15			
43.4	21	9/19/2006 12:15			
43.4	21	9/19/2006 12:15			
95.1	21	9/19/2006 12:15			
137	21	9/19/2006 12:15			
78.2	21	9/19/2006 12:15			
243	21	9/19/2006 12:15			
247	21	9/19/2006 12:15			
154	21	9/19/2006 12:15			
125	21	9/19/2006 12:15			
98.2	21	9/19/2006 12:15			
88.4	21	9/19/2006 12:15			
82.9	21	9/19/2006 12:15			
84.5	21	9/19/2006 12:15			
65.4	21	9/19/2006 12:15			
61.3	21	9/19/2006 12:15			
60.1	21	9/19/2006 12:15			
60	21	9/19/2006 12:15			
64.7	21	9/19/2006 12:15			
68.2	21	9/19/2006 12:15			
65.5	21	9/19/2006 12:15			
50.8	21	9/19/2006 12:15			
55.8	21	9/19/2006 12:15			
79.5	21	9/19/2006 12:15			
100	21	9/19/2006 12:15			
250	21	9/19/2006 12:15			
274	21	9/19/2006 12:15			
268	21	9/19/2006 12:15			
308	21	9/19/2006 12:15			
49.3	21	9/19/2006 12:15			
44.9	21	9/19/2006 12:15			
44.3	21	9/19/2006 12:15			
43.8	21	9/19/2006 12:15			
43.9	21	9/19/2006 12:16			
44	21	9/19/2006 12:16			
44.1	21	9/19/2006 12:16			
44.5	21	9/19/2006 12:16			
44.2	21	9/19/2006 12:16			
44	21	9/19/2006 12:16			
44	21	9/19/2006 12:16			
44.2	21	9/19/2006 12:16			
44.4	21	9/19/2006 12:16			
44.4	21	9/19/2006 12:16			
45.4	21	9/19/2006 12:16			
55.7	21	9/19/2006 12:16			
71.5	21	9/19/2006 12:16			
81.5	21	9/19/2006 12:16			
78.5	21	9/19/2006 12:16			
51.1	21	9/19/2006 12:16			
59.5	21	9/19/2006 12:16			
61.8	21	9/19/2006 12:16			
62.4	21	9/19/2006 12:16			
82	21	9/19/2006 12:16			
72.3	21	9/19/2006 12:16			
70.9	21	9/19/2006 12:16			

Path Measurement Data Site 1 Path 3			Path Measurement Data Site 1 Path 4		
ppm*m	pathlength	timestamp	ppm*m	pathlength	timestamp
69.7	21	9/19/2006 12:16			
54.5	21	9/19/2006 12:16			
49.2	21	9/19/2006 12:16			
46.6	21	9/19/2006 12:16			
46.2	21	9/19/2006 12:16			
45.3	21	9/19/2006 12:16			
45.8	21	9/19/2006 12:16			
48.8	21	9/19/2006 12:16			
48.5	21	9/19/2006 12:16			
49.6	21	9/19/2006 12:16			
49.2	21	9/19/2006 12:16			
47.7	21	9/19/2006 12:16			
48.4	21	9/19/2006 12:17			
48.2	21	9/19/2006 12:17			
48.7	21	9/19/2006 12:17			
47.7	21	9/19/2006 12:17			
47.4	21	9/19/2006 12:17			
47.7	21	9/19/2006 12:17			
45	21	9/19/2006 12:17			
44.5	21	9/19/2006 12:17			
44.6	21	9/19/2006 12:17			
44.5	21	9/19/2006 12:17			
44.7	21	9/19/2006 12:17			
44.7	21	9/19/2006 12:17			
44.5	21	9/19/2006 12:17			
59.5	21	9/19/2006 12:17			
58	21	9/19/2006 12:17			
46.2	21	9/19/2006 12:17			
51.2	21	9/19/2006 12:17			
50.6	21	9/19/2006 12:17			
61.2	21	9/19/2006 12:17			
65.1	21	9/19/2006 12:17			
71	21	9/19/2006 12:17			
64.1	21	9/19/2006 12:17			
125	21	9/19/2006 12:17			
198	21	9/19/2006 12:17			
259	21	9/19/2006 12:17			
119	21	9/19/2006 12:17			
252	21	9/19/2006 12:17			
676	21	9/19/2006 12:17			
233	21	9/19/2006 12:17			
249	21	9/19/2006 12:17			
192	21	9/19/2006 12:17			
129	21	9/19/2006 12:17			
68.5	21	9/19/2006 12:17			
89.6	21	9/19/2006 12:18			
67.4	21	9/19/2006 12:18			
65.8	21	9/19/2006 12:18			
56.8	21	9/19/2006 12:18			
59.5	21	9/19/2006 12:18			
47.3	21	9/19/2006 12:18			
44.2	21	9/19/2006 12:18			
44.3	21	9/19/2006 12:18			
44.2	21	9/19/2006 12:18			
47	21	9/19/2006 12:18			
44.9	21	9/19/2006 12:18			
45.4	21	9/19/2006 12:18			
44.3	21	9/19/2006 12:18			
45.2	21	9/19/2006 12:18			
47.3	21	9/19/2006 12:18			
48.6	21	9/19/2006 12:18			

Path Measurement Data Site 1 Path 3			Path Measurement Data Site 1 Path 4		
ppm*m	pathlength	timestamp	ppm*m	pathlength	timestamp
47.8	21	9/19/2006 12:18			
48.6	21	9/19/2006 12:18			
48	21	9/19/2006 12:18			
47.8	21	9/19/2006 12:18			
47.2	21	9/19/2006 12:18			
46.8	21	9/19/2006 12:18			
47.1	21	9/19/2006 12:18			
46.7	21	9/19/2006 12:18			
46.9	21	9/19/2006 12:18			
46.3	21	9/19/2006 12:18			
46.3	21	9/19/2006 12:18			
46	21	9/19/2006 12:18			
45.7	21	9/19/2006 12:18			
45.5	21	9/19/2006 12:18			
45.2	21	9/19/2006 12:18			
44.6	21	9/19/2006 12:18			
44.6	21	9/19/2006 12:18			
44.7	21	9/19/2006 12:18			
44.1	21	9/19/2006 12:18			
44.2	21	9/19/2006 12:19			
44	21	9/19/2006 12:19			
46	21	9/19/2006 12:19			
47.6	21	9/19/2006 12:19			
49.1	21	9/19/2006 12:19			
48.8	21	9/19/2006 12:19			
48.2	21	9/19/2006 12:19			
47.7	21	9/19/2006 12:19			
47.7	21	9/19/2006 12:19			
47.5	21	9/19/2006 12:19			
47.8	21	9/19/2006 12:19			
48.6	21	9/19/2006 12:19			
54.6	21	9/19/2006 12:19			
67.8	21	9/19/2006 12:19			
96.6	21	9/19/2006 12:19			
142	21	9/19/2006 12:19			
131	21	9/19/2006 12:19			
189	21	9/19/2006 12:19			
151	21	9/19/2006 12:19			
127	21	9/19/2006 12:19			
121	21	9/19/2006 12:19			
216	21	9/19/2006 12:19			
641	21	9/19/2006 12:19			
220	21	9/19/2006 12:19			
105	21	9/19/2006 12:19			
98.7	21	9/19/2006 12:19			
115	21	9/19/2006 12:19			
126	21	9/19/2006 12:19			
103	21	9/19/2006 12:19			
90.8	21	9/19/2006 12:19			
75.3	21	9/19/2006 12:19			
51.2	21	9/19/2006 12:19			
45.2	21	9/19/2006 12:19			
45	21	9/19/2006 12:20			
44.8	21	9/19/2006 12:20			
44.8	21	9/19/2006 12:20			
44.7	21	9/19/2006 12:20			
44	21	9/19/2006 12:20			



Path Measurement Data Site 2 Path 1			Path Measurement Data Site 2 Path 2		
ppm*m	pathlength	Timestamp (Eastern time)	ppm*m	pathlength	Timestamp (Eastern time)
1531	12	9/19/2006 15:29	535	13.5	9/19/2006 15:59
1362	12	9/19/2006 15:29	280	13.5	9/19/2006 15:59
979	12	9/19/2006 15:29	249	13.5	9/19/2006 15:59
575	12	9/19/2006 15:29	347	13.5	9/19/2006 15:59
474	12	9/19/2006 15:29	270	13.5	9/19/2006 15:59
1946	12	9/19/2006 15:29	209	13.5	9/19/2006 15:59
2397	12	9/19/2006 15:29	179	13.5	9/19/2006 15:59
1652	12	9/19/2006 15:29	155	13.5	9/19/2006 15:59
428	12	9/19/2006 15:29	188	13.5	9/19/2006 15:59
337	12	9/19/2006 15:29	103	13.5	9/19/2006 15:59
385	12	9/19/2006 15:29	56.3	13.5	9/19/2006 15:59
806	12	9/19/2006 15:29	44.4	13.5	9/19/2006 15:59
266	12	9/19/2006 15:29	38.2	13.5	9/19/2006 15:59
1120	12	9/19/2006 15:29	35.7	13.5	9/19/2006 15:59
2096	12	9/19/2006 15:29	32.3	13.5	9/19/2006 15:59
1880	12	9/19/2006 15:29	32.5	13.5	9/19/2006 15:59
890	12	9/19/2006 15:29	33	13.5	9/19/2006 15:59
176	12	9/19/2006 15:29	32.5	13.5	9/19/2006 15:59
84.9	12	9/19/2006 15:29	32.8	13.5	9/19/2006 15:59
487	12	9/19/2006 15:29	33.3	13.5	9/19/2006 15:59
470	12	9/19/2006 15:29	33.7	13.5	9/19/2006 15:59
306	12	9/19/2006 15:29	37.3	13.5	9/19/2006 15:59
930	12	9/19/2006 15:29	173	13.5	9/19/2006 16:00
1129	12	9/19/2006 15:29	460	13.5	9/19/2006 16:00
1192	12	9/19/2006 15:29	312	13.5	9/19/2006 16:00
671	12	9/19/2006 15:29	121	13.5	9/19/2006 16:00
656	12	9/19/2006 15:29	175	13.5	9/19/2006 16:00
875	12	9/19/2006 15:29	283	13.5	9/19/2006 16:00
1605	12	9/19/2006 15:30	64.3	13.5	9/19/2006 16:00
1396	12	9/19/2006 15:30	41.4	13.5	9/19/2006 16:00
1569	12	9/19/2006 15:30	38	13.5	9/19/2006 16:00
1716	12	9/19/2006 15:30	36.2	13.5	9/19/2006 16:00
1752	12	9/19/2006 15:30	34	13.5	9/19/2006 16:00
1292	12	9/19/2006 15:30	31.9	13.5	9/19/2006 16:00
1352	12	9/19/2006 15:30	32	13.5	9/19/2006 16:00
1703	12	9/19/2006 15:30	32.2	13.5	9/19/2006 16:00
1096	12	9/19/2006 15:30	49.9	13.5	9/19/2006 16:00
867	12	9/19/2006 15:30	72.6	13.5	9/19/2006 16:00
1598	12	9/19/2006 15:30	132	13.5	9/19/2006 16:00
1024	12	9/19/2006 15:30	239	13.5	9/19/2006 16:00
1002	12	9/19/2006 15:30	207	13.5	9/19/2006 16:00
221	12	9/19/2006 15:30	117	13.5	9/19/2006 16:00
625	12	9/19/2006 15:30	301	13.5	9/19/2006 16:00
430	12	9/19/2006 15:30	230	13.5	9/19/2006 16:00
237	12	9/19/2006 15:30	279	13.5	9/19/2006 16:00
199	12	9/19/2006 15:30	254	13.5	9/19/2006 16:00
433	12	9/19/2006 15:30	353	13.5	9/19/2006 16:00
154	12	9/19/2006 15:30	282	13.5	9/19/2006 16:00
517	12	9/19/2006 15:30	180	13.5	9/19/2006 16:00
248	12	9/19/2006 15:31	130	13.5	9/19/2006 16:00
209	12	9/19/2006 15:31	91.5	13.5	9/19/2006 16:00
135	12	9/19/2006 15:31	82.3	13.5	9/19/2006 16:00
613	12	9/19/2006 15:31	43.4	13.5	9/19/2006 16:00
646	12	9/19/2006 15:31	43.1	13.5	9/19/2006 16:00
168	12	9/19/2006 15:31	38.9	13.5	9/19/2006 16:00
158	12	9/19/2006 15:31	37.2	13.5	9/19/2006 16:01
133	12	9/19/2006 15:31	37.4	13.5	9/19/2006 16:01
62.9	12	9/19/2006 15:31	37.8	13.5	9/19/2006 16:01
75.6	12	9/19/2006 15:31	35.3	13.5	9/19/2006 16:01
638	12	9/19/2006 15:31	34.5	13.5	9/19/2006 16:01

Path Measurement Data Site 2 Path 1			Path Measurement Data Site 2 Path 2		
ppm*m	pathlength	Timestamp (Eastern time)	ppm*m	pathlength	Timestamp (Eastern time)
409	12	9/19/2006 15:31	33.7	13.5	9/19/2006 16:01
289	12	9/19/2006 15:31	34.4	13.5	9/19/2006 16:01
142	12	9/19/2006 15:32	34.6	13.5	9/19/2006 16:01
100	12	9/19/2006 15:32	33.5	13.5	9/19/2006 16:01
93.1	12	9/19/2006 15:32	32.1	13.5	9/19/2006 16:01
323	12	9/19/2006 15:32	31.6	13.5	9/19/2006 16:01
98.9	12	9/19/2006 15:32	31.8	13.5	9/19/2006 16:01
683	12	9/19/2006 15:32	31.7	13.5	9/19/2006 16:01
1255	12	9/19/2006 15:32	31.8	13.5	9/19/2006 16:01
991	12	9/19/2006 15:32	32.1	13.5	9/19/2006 16:01
583	12	9/19/2006 15:32	32	13.5	9/19/2006 16:01
883	12	9/19/2006 15:32	119	13.5	9/19/2006 16:01
990	12	9/19/2006 15:32	474	13.5	9/19/2006 16:01
199	12	9/19/2006 15:32	564	13.5	9/19/2006 16:01
678	12	9/19/2006 15:32	582	13.5	9/19/2006 16:01
565	12	9/19/2006 15:32	313	13.5	9/19/2006 16:01
759	12	9/19/2006 15:32	296	13.5	9/19/2006 16:01
950	12	9/19/2006 15:32	208	13.5	9/19/2006 16:01
1167	12	9/19/2006 15:32	82.6	13.5	9/19/2006 16:01
2431	12	9/19/2006 15:32	63.6	13.5	9/19/2006 16:01
1009	12	9/19/2006 15:32	52.5	13.5	9/19/2006 16:01
1810	12	9/19/2006 15:32	43.8	13.5	9/19/2006 16:01
1571	12	9/19/2006 15:32	41.3	13.5	9/19/2006 16:01
1286	12	9/19/2006 15:32	50.7	13.5	9/19/2006 16:01
1416	12	9/19/2006 15:32	52	13.5	9/19/2006 16:01
2080	12	9/19/2006 15:32	52.5	13.5	9/19/2006 16:01
1157	12	9/19/2006 15:32	53.2	13.5	9/19/2006 16:01
1665	12	9/19/2006 15:32	50.2	13.5	9/19/2006 16:01
2319	12	9/19/2006 15:32	52.3	13.5	9/19/2006 16:01
1304	12	9/19/2006 15:32	52.5	13.5	9/19/2006 16:02
1227	12	9/19/2006 15:32	62	13.5	9/19/2006 16:02
1242	12	9/19/2006 15:32	79.3	13.5	9/19/2006 16:02
586	12	9/19/2006 15:32	165	13.5	9/19/2006 16:02
1191	12	9/19/2006 15:32	392	13.5	9/19/2006 16:02
2017	12	9/19/2006 15:32	289	13.5	9/19/2006 16:02
1209	12	9/19/2006 15:33	184	13.5	9/19/2006 16:02
959	12	9/19/2006 15:33	143	13.5	9/19/2006 16:02
2229	12	9/19/2006 15:33	584	13.5	9/19/2006 16:02
1113	12	9/19/2006 15:33	477	13.5	9/19/2006 16:02
1617	12	9/19/2006 15:33	376	13.5	9/19/2006 16:02
1470	12	9/19/2006 15:33	76.7	13.5	9/19/2006 16:02
1561	12	9/19/2006 15:33	127	13.5	9/19/2006 16:02
1472	12	9/19/2006 15:33	751	13.5	9/19/2006 16:02
2376	12	9/19/2006 15:33	223	13.5	9/19/2006 16:02
1158	12	9/19/2006 15:33	550	13.5	9/19/2006 16:02
874	12	9/19/2006 15:33	422	13.5	9/19/2006 16:02
1392	12	9/19/2006 15:33	359	13.5	9/19/2006 16:02
1625	12	9/19/2006 15:33	278	13.5	9/19/2006 16:02
1646	12	9/19/2006 15:33	265	13.5	9/19/2006 16:02
2199	12	9/19/2006 15:33	283	13.5	9/19/2006 16:02
2136	12	9/19/2006 15:33	372	13.5	9/19/2006 16:02
1234	12	9/19/2006 15:33	320	13.5	9/19/2006 16:02
944	12	9/19/2006 15:33	174	13.5	9/19/2006 16:02
1495	12	9/19/2006 15:33	106	13.5	9/19/2006 16:02
1035	12	9/19/2006 15:33	104	13.5	9/19/2006 16:02
1634	12	9/19/2006 15:33	148	13.5	9/19/2006 16:02
1121	12	9/19/2006 15:33	140	13.5	9/19/2006 16:02
907	12	9/19/2006 15:33	39.1	13.5	9/19/2006 16:02
516	12	9/19/2006 15:33	146	13.5	9/19/2006 16:02
426	12	9/19/2006 15:33	247	13.5	9/19/2006 16:02

Path Measurement Data Site 2 Path 1			Path Measurement Data Site 2 Path 2		
ppm*m	pathlength	Timestamp (Eastern time)	ppm*m	pathlength	Timestamp (Eastern time)
1164	12	9/19/2006 15:33	177	13.5	9/19/2006 16:02
485	12	9/19/2006 15:33	83.8	13.5	9/19/2006 16:02
258	12	9/19/2006 15:33	113	13.5	9/19/2006 16:03
68	12	9/19/2006 15:33	92.5	13.5	9/19/2006 16:03
388	12	9/19/2006 15:33	109	13.5	9/19/2006 16:03
1018	12	9/19/2006 15:33	115	13.5	9/19/2006 16:03
1669	12	9/19/2006 15:33	111	13.5	9/19/2006 16:03
803	12	9/19/2006 15:33	128	13.5	9/19/2006 16:03
564	12	9/19/2006 15:33	110	13.5	9/19/2006 16:03
791	12	9/19/2006 15:34	74.4	13.5	9/19/2006 16:03
396	12	9/19/2006 15:34	66.5	13.5	9/19/2006 16:03
770	12	9/19/2006 15:34	83.8	13.5	9/19/2006 16:03
1133	12	9/19/2006 15:34	68.5	13.5	9/19/2006 16:03
1797	12	9/19/2006 15:34	80.5	13.5	9/19/2006 16:03
1831	12	9/19/2006 15:34	71.2	13.5	9/19/2006 16:03
1605	12	9/19/2006 15:34	1331	13.5	9/19/2006 16:03
1042	12	9/19/2006 15:34	1053	13.5	9/19/2006 16:03
1399	12	9/19/2006 15:34	444	13.5	9/19/2006 16:03
892	12	9/19/2006 15:34	550	13.5	9/19/2006 16:03
854	12	9/19/2006 15:34	282	13.5	9/19/2006 16:03
1239	12	9/19/2006 15:34	131	13.5	9/19/2006 16:03
1074	12	9/19/2006 15:34	42.4	13.5	9/19/2006 16:03
834	12	9/19/2006 15:34	38.6	13.5	9/19/2006 16:03
1198	12	9/19/2006 15:34	39.4	13.5	9/19/2006 16:03
1066	12	9/19/2006 15:34	42.5	13.5	9/19/2006 16:03
907	12	9/19/2006 15:34	42.6	13.5	9/19/2006 16:03
325	12	9/19/2006 15:34	40.9	13.5	9/19/2006 16:03
276	12	9/19/2006 15:34	42.1	13.5	9/19/2006 16:03
486	12	9/19/2006 15:34	40.3	13.5	9/19/2006 16:03
371	12	9/19/2006 15:34	35.7	13.5	9/19/2006 16:03
272	12	9/19/2006 15:34	34.8	13.5	9/19/2006 16:03
249	12	9/19/2006 15:34	34.6	13.5	9/19/2006 16:03
100	12	9/19/2006 15:34	35.1	13.5	9/19/2006 16:03
244	12	9/19/2006 15:34	36	13.5	9/19/2006 16:03
392	12	9/19/2006 15:34	155	13.5	9/19/2006 16:03
1735	12	9/19/2006 15:34	900	13.5	9/19/2006 16:04
158	12	9/19/2006 15:34	492	13.5	9/19/2006 16:04
115	12	9/19/2006 15:34	190	13.5	9/19/2006 16:04
534	12	9/19/2006 15:34	454	13.5	9/19/2006 16:04
797	12	9/19/2006 15:34	260	13.5	9/19/2006 16:04
690	12	9/19/2006 15:34	227	13.5	9/19/2006 16:04
305	12	9/19/2006 15:34	112	13.5	9/19/2006 16:04
87.6	12	9/19/2006 15:35	77.8	13.5	9/19/2006 16:04
67.8	12	9/19/2006 15:35	99.8	13.5	9/19/2006 16:04
56.7	12	9/19/2006 15:35	46.4	13.5	9/19/2006 16:04
46.1	12	9/19/2006 15:35	42.5	13.5	9/19/2006 16:04
38.8	12	9/19/2006 15:35	37.9	13.5	9/19/2006 16:04
43.2	12	9/19/2006 15:35	33.7	13.5	9/19/2006 16:04
101	12	9/19/2006 15:35	32.5	13.5	9/19/2006 16:04
281	12	9/19/2006 15:35	31.6	13.5	9/19/2006 16:04
155	12	9/19/2006 15:35	31.2	13.5	9/19/2006 16:04
155	12	9/19/2006 15:35	30.7	13.5	9/19/2006 16:04
162	12	9/19/2006 15:35	30.6	13.5	9/19/2006 16:04
133	12	9/19/2006 15:35	30.8	13.5	9/19/2006 16:04
1884	12	9/19/2006 15:35	30.6	13.5	9/19/2006 16:04
2360	12	9/19/2006 15:35	31	13.5	9/19/2006 16:04
986	12	9/19/2006 15:35	38.8	13.5	9/19/2006 16:04
594	12	9/19/2006 15:35	88.9	13.5	9/19/2006 16:04
1239	12	9/19/2006 15:35	393	13.5	9/19/2006 16:04
1123	12	9/19/2006 15:35	334	13.5	9/19/2006 16:04

Path Measurement Data Site 2 Path 1			Path Measurement Data Site 2 Path 2		
ppm*m	pathlength	Timestamp (Eastern time)	ppm*m	pathlength	Timestamp (Eastern time)
706	12	9/19/2006 15:35	158	13.5	9/19/2006 16:04
312	12	9/19/2006 15:35	37.3	13.5	9/19/2006 16:04
252	12	9/19/2006 15:35	34	13.5	9/19/2006 16:04
438	12	9/19/2006 15:35	34.1	13.5	9/19/2006 16:04
1136	12	9/19/2006 15:35	33.3	13.5	9/19/2006 16:04
633	12	9/19/2006 15:35	32.9	13.5	9/19/2006 16:04
1223	12	9/19/2006 15:35	32.9	13.5	9/19/2006 16:04
2114	12	9/19/2006 15:35	33.1	13.5	9/19/2006 16:04
1332	12	9/19/2006 15:35	32.5	13.5	9/19/2006 16:04
104	12	9/19/2006 15:35	31.7	13.5	9/19/2006 16:05
26.4	12	9/19/2006 15:35	31.6	13.5	9/19/2006 16:05
26.3	12	9/19/2006 15:35	31.3	13.5	9/19/2006 16:05
26.3	12	9/19/2006 15:35	31.3	13.5	9/19/2006 16:05
26.3	12	9/19/2006 15:35	30.7	13.5	9/19/2006 16:05
26.4	12	9/19/2006 15:35	30.6	13.5	9/19/2006 16:05
29.3	12	9/19/2006 15:36	30.4	13.5	9/19/2006 16:05
448	12	9/19/2006 15:36	30.1	13.5	9/19/2006 16:05
618	12	9/19/2006 15:36	30.2	13.5	9/19/2006 16:05
104	12	9/19/2006 15:36	30.1	13.5	9/19/2006 16:05
573	12	9/19/2006 15:36	30.1	13.5	9/19/2006 16:05
634	12	9/19/2006 15:36	30.2	13.5	9/19/2006 16:05
117	12	9/19/2006 15:36	30.2	13.5	9/19/2006 16:05
38.9	12	9/19/2006 15:36	30.4	13.5	9/19/2006 16:05
29.4	12	9/19/2006 15:36	30.2	13.5	9/19/2006 16:05
26.9	12	9/19/2006 15:36	31.7	13.5	9/19/2006 16:05
26.2	12	9/19/2006 15:36	208	13.5	9/19/2006 16:05
26.4	12	9/19/2006 15:36	753	13.5	9/19/2006 16:05
26.3	12	9/19/2006 15:36	202	13.5	9/19/2006 16:05
26.8	12	9/19/2006 15:36	223	13.5	9/19/2006 16:05
26.7	12	9/19/2006 15:36	167	13.5	9/19/2006 16:05
27	12	9/19/2006 15:36	197	13.5	9/19/2006 16:05
27.6	12	9/19/2006 15:36	77.3	13.5	9/19/2006 16:05
27.3	12	9/19/2006 15:36	80.5	13.5	9/19/2006 16:05
27.2	12	9/19/2006 15:36	90.8	13.5	9/19/2006 16:05
28.2	12	9/19/2006 15:36	79.3	13.5	9/19/2006 16:05
29	12	9/19/2006 15:36	56.4	13.5	9/19/2006 16:05
30	12	9/19/2006 15:36	36.8	13.5	9/19/2006 16:05
30.3	12	9/19/2006 15:36	33.1	13.5	9/19/2006 16:05
134	12	9/19/2006 15:36	34.6	13.5	9/19/2006 16:05
482	12	9/19/2006 15:36	60.2	13.5	9/19/2006 16:05
93	12	9/19/2006 15:36	66.4	13.5	9/19/2006 16:05
52.1	12	9/19/2006 15:36	67.1	13.5	9/19/2006 16:05
69.5	12	9/19/2006 15:36	58.4	13.5	9/19/2006 16:06
101	12	9/19/2006 15:36	44.8	13.5	9/19/2006 16:06
110	12	9/19/2006 15:36	38	13.5	9/19/2006 16:06
134	12	9/19/2006 15:36	32.9	13.5	9/19/2006 16:06
124	12	9/19/2006 15:36	36.8	13.5	9/19/2006 16:06
125	12	9/19/2006 15:36	42.9	13.5	9/19/2006 16:06
85.9	12	9/19/2006 15:37	40.5	13.5	9/19/2006 16:06
100	12	9/19/2006 15:37	44.6	13.5	9/19/2006 16:06
1872	12	9/19/2006 15:37	47	13.5	9/19/2006 16:06
487	12	9/19/2006 15:37	43.3	13.5	9/19/2006 16:06
2299	12	9/19/2006 15:37	41.2	13.5	9/19/2006 16:06
1056	12	9/19/2006 15:37	36.5	13.5	9/19/2006 16:06
1016	12	9/19/2006 15:37	35.7	13.5	9/19/2006 16:06
1069	12	9/19/2006 15:37	36.8	13.5	9/19/2006 16:06
831	12	9/19/2006 15:37	36.5	13.5	9/19/2006 16:06
593	12	9/19/2006 15:37	35.5	13.5	9/19/2006 16:06
149	12	9/19/2006 15:37	34.9	13.5	9/19/2006 16:06
932	12	9/19/2006 15:37	35	13.5	9/19/2006 16:06

Path Measurement Data Site 2 Path 1			Path Measurement Data Site 2 Path 2		
ppm*m	pathlength	Timestamp (Eastern time)	ppm*m	pathlength	Timestamp (Eastern time)
764	12	9/19/2006 15:37	34.2	13.5	9/19/2006 16:06
1888	12	9/19/2006 15:37	34	13.5	9/19/2006 16:06
2023	12	9/19/2006 15:37	34.6	13.5	9/19/2006 16:06
1184	12	9/19/2006 15:37	35.8	13.5	9/19/2006 16:06
1683	12	9/19/2006 15:37	35	13.5	9/19/2006 16:06
486	12	9/19/2006 15:37	35.3	13.5	9/19/2006 16:06
1276	12	9/19/2006 15:37	36.7	13.5	9/19/2006 16:06
1587	12	9/19/2006 15:37	36.8	13.5	9/19/2006 16:06
365	12	9/19/2006 15:37	35.7	13.5	9/19/2006 16:06
341	12	9/19/2006 15:37	36.9	13.5	9/19/2006 16:06
1492	12	9/19/2006 15:37	37.8	13.5	9/19/2006 16:06
962	12	9/19/2006 15:37	39.4	13.5	9/19/2006 16:06
628	12	9/19/2006 15:37	39.7	13.5	9/19/2006 16:06
141	12	9/19/2006 15:37	38.7	13.5	9/19/2006 16:06
99.4	12	9/19/2006 15:37	36.5	13.5	9/19/2006 16:06
139	12	9/19/2006 15:37	35.9	13.5	9/19/2006 16:06
145	12	9/19/2006 15:37	35.8	13.5	9/19/2006 16:07
694	12	9/19/2006 15:37	35.8	13.5	9/19/2006 16:07
994	12	9/19/2006 15:38	35.6	13.5	9/19/2006 16:07
73.7	12	9/19/2006 15:38	35.1	13.5	9/19/2006 16:07
70	12	9/19/2006 15:38	35.3	13.5	9/19/2006 16:07
349	12	9/19/2006 15:38	35.3	13.5	9/19/2006 16:07
278	12	9/19/2006 15:38	35	13.5	9/19/2006 16:07
323	12	9/19/2006 15:38	35.5	13.5	9/19/2006 16:07
1797	12	9/19/2006 15:38	35.5	13.5	9/19/2006 16:07
694	12	9/19/2006 15:38	35.3	13.5	9/19/2006 16:07
283	12	9/19/2006 15:38	35.8	13.5	9/19/2006 16:07
679	12	9/19/2006 15:38	36	13.5	9/19/2006 16:07
1730	12	9/19/2006 15:38	35.4	13.5	9/19/2006 16:07
119	12	9/19/2006 15:38	35.8	13.5	9/19/2006 16:07
429	12	9/19/2006 15:38	40	13.5	9/19/2006 16:07
1197	12	9/19/2006 15:38	42	13.5	9/19/2006 16:07
1171	12	9/19/2006 15:38	43.3	13.5	9/19/2006 16:07
946	12	9/19/2006 15:38	41	13.5	9/19/2006 16:07
730	12	9/19/2006 15:38	174	13.5	9/19/2006 16:07
414	12	9/19/2006 15:38	516	13.5	9/19/2006 16:07
298	12	9/19/2006 15:38	391	13.5	9/19/2006 16:07
452	12	9/19/2006 15:38	705	13.5	9/19/2006 16:07
256	12	9/19/2006 15:38	496	13.5	9/19/2006 16:07
1846	12	9/19/2006 15:38	275	13.5	9/19/2006 16:07
1586	12	9/19/2006 15:38	89.3	13.5	9/19/2006 16:07
2047	12	9/19/2006 15:38	454	13.5	9/19/2006 16:07
2438	12	9/19/2006 15:38	473	13.5	9/19/2006 16:07
619	12	9/19/2006 15:38	289	13.5	9/19/2006 16:07
181	12	9/19/2006 15:38	513	13.5	9/19/2006 16:07
137	12	9/19/2006 15:38	675	13.5	9/19/2006 16:07
237	12	9/19/2006 15:38	434	13.5	9/19/2006 16:07
133	12	9/19/2006 15:38	328	13.5	9/19/2006 16:07
134	12	9/19/2006 15:38	371	13.5	9/19/2006 16:07
396	12	9/19/2006 15:38	296	13.5	9/19/2006 16:07
746	12	9/19/2006 15:38	346	13.5	9/19/2006 16:08
724	12	9/19/2006 15:39	394	13.5	9/19/2006 16:08
716	12	9/19/2006 15:39	411	13.5	9/19/2006 16:08
248	12	9/19/2006 15:39	582	13.5	9/19/2006 16:08
737	12	9/19/2006 15:39	833	13.5	9/19/2006 16:08
1563	12	9/19/2006 15:39	313	13.5	9/19/2006 16:08
827	12	9/19/2006 15:39	453	13.5	9/19/2006 16:08
499	12	9/19/2006 15:39	1073	13.5	9/19/2006 16:08
658	12	9/19/2006 15:39	551	13.5	9/19/2006 16:08
482	12	9/19/2006 15:39	199	13.5	9/19/2006 16:08

Path Measurement Data Site 2 Path 1			Path Measurement Data Site 2 Path 2		
ppm*m	pathlength	Timestamp (Eastern time)	ppm*m	pathlength	Timestamp (Eastern time)
880	12	9/19/2006 15:39	591	13.5	9/19/2006 16:08
698	12	9/19/2006 15:39	1168	13.5	9/19/2006 16:08
242	12	9/19/2006 15:39	772	13.5	9/19/2006 16:08
108	12	9/19/2006 15:39	102	13.5	9/19/2006 16:08
58.1	12	9/19/2006 15:39	106	13.5	9/19/2006 16:08
84.5	12	9/19/2006 15:39	234	13.5	9/19/2006 16:08
554	12	9/19/2006 15:39	134	13.5	9/19/2006 16:08
1161	12	9/19/2006 15:39	152	13.5	9/19/2006 16:08
949	12	9/19/2006 15:39	245	13.5	9/19/2006 16:08
1280	12	9/19/2006 15:39	258	13.5	9/19/2006 16:08
1271	12	9/19/2006 15:39	336	13.5	9/19/2006 16:08
400	12	9/19/2006 15:39	631	13.5	9/19/2006 16:08
592	12	9/19/2006 15:39	472	13.5	9/19/2006 16:08
509	12	9/19/2006 15:39	224	13.5	9/19/2006 16:08
1213	12	9/19/2006 15:39	157	13.5	9/19/2006 16:08
680	12	9/19/2006 15:39	140	13.5	9/19/2006 16:08
931	12	9/19/2006 15:39	75.6	13.5	9/19/2006 16:08
465	12	9/19/2006 15:39	76.7	13.5	9/19/2006 16:08
213	12	9/19/2006 15:39	61.5	13.5	9/19/2006 16:08
434	12	9/19/2006 15:39	75.2	13.5	9/19/2006 16:08
1071	12	9/19/2006 15:39	62	13.5	9/19/2006 16:08
1335	12	9/19/2006 15:39	57.4	13.5	9/19/2006 16:08
1533	12	9/19/2006 15:39	51.5	13.5	9/19/2006 16:08
1018	12	9/19/2006 15:40	41.3	13.5	9/19/2006 16:09
2071	12	9/19/2006 15:40	33.5	13.5	9/19/2006 16:09
1494	12	9/19/2006 15:40	32.2	13.5	9/19/2006 16:09
1125	12	9/19/2006 15:40	35.9	13.5	9/19/2006 16:09
2021	12	9/19/2006 15:40	34.1	13.5	9/19/2006 16:09
1225	12	9/19/2006 15:40	33.9	13.5	9/19/2006 16:09
1258	12	9/19/2006 15:40	34.5	13.5	9/19/2006 16:09
666	12	9/19/2006 15:40	68.4	13.5	9/19/2006 16:09
179	12	9/19/2006 15:40	156	13.5	9/19/2006 16:09
531	12	9/19/2006 15:40	230	13.5	9/19/2006 16:09
1109	12	9/19/2006 15:40	233	13.5	9/19/2006 16:09
772	12	9/19/2006 15:40	572	13.5	9/19/2006 16:09
1818	12	9/19/2006 15:40	373	13.5	9/19/2006 16:09
1614	12	9/19/2006 15:40	589	13.5	9/19/2006 16:09
1103	12	9/19/2006 15:40	1061	13.5	9/19/2006 16:09
256	12	9/19/2006 15:40	1143	13.5	9/19/2006 16:09
726	12	9/19/2006 15:40	1619	13.5	9/19/2006 16:09
809	12	9/19/2006 15:40	531	13.5	9/19/2006 16:09
2368	12	9/19/2006 15:40	100	13.5	9/19/2006 16:09
1709	12	9/19/2006 15:40	31.1	13.5	9/19/2006 16:09
816	12	9/19/2006 15:40	30.7	13.5	9/19/2006 16:09
845	12	9/19/2006 15:40	40.4	13.5	9/19/2006 16:09
814	12	9/19/2006 15:40	114	13.5	9/19/2006 16:09
489	12	9/19/2006 15:40	667	13.5	9/19/2006 16:09
399	12	9/19/2006 15:40	524	13.5	9/19/2006 16:09
1089	12	9/19/2006 15:40	370	13.5	9/19/2006 16:09
1616	12	9/19/2006 15:40	522	13.5	9/19/2006 16:09
2006	12	9/19/2006 15:40	445	13.5	9/19/2006 16:09
1618	12	9/19/2006 15:40	282	13.5	9/19/2006 16:09
2324	12	9/19/2006 15:40	247	13.5	9/19/2006 16:09
1451	12	9/19/2006 15:41	109	13.5	9/19/2006 16:09
1501	12	9/19/2006 15:41	62	13.5	9/19/2006 16:09
1981	12	9/19/2006 15:41	66.1	13.5	9/19/2006 16:09
2508	12	9/19/2006 15:41	55.1	13.5	9/19/2006 16:10
1579	12	9/19/2006 15:41	42.4	13.5	9/19/2006 16:10
1040	12	9/19/2006 15:41	42.7	13.5	9/19/2006 16:10
1095	12	9/19/2006 15:41	51.6	13.5	9/19/2006 16:10

Path Measurement Data Site 2 Path 1			Path Measurement Data Site 2 Path 2		
ppm*m	pathlength	Timestamp (Eastern time)	ppm*m	pathlength	Timestamp (Eastern time)
923	12	9/19/2006 15:41	66.1	13.5	9/19/2006 16:10
2236	12	9/19/2006 15:41	114	13.5	9/19/2006 16:10
1525	12	9/19/2006 15:41	635	13.5	9/19/2006 16:10
675	12	9/19/2006 15:41	1182	13.5	9/19/2006 16:10
187	12	9/19/2006 15:41	801	13.5	9/19/2006 16:10
115	12	9/19/2006 15:41	221	13.5	9/19/2006 16:10
499	12	9/19/2006 15:41	506	13.5	9/19/2006 16:10
923	12	9/19/2006 15:41	563	13.5	9/19/2006 16:10
1036	12	9/19/2006 15:41	501	13.5	9/19/2006 16:10
695	12	9/19/2006 15:41	401	13.5	9/19/2006 16:10
820	12	9/19/2006 15:41	398	13.5	9/19/2006 16:10
258	12	9/19/2006 15:41	208	13.5	9/19/2006 16:10
331	12	9/19/2006 15:41	174	13.5	9/19/2006 16:10
200	12	9/19/2006 15:41	278	13.5	9/19/2006 16:10
969	12	9/19/2006 15:41	316	13.5	9/19/2006 16:10
902	12	9/19/2006 15:41	200	13.5	9/19/2006 16:10
186	12	9/19/2006 15:41	199	13.5	9/19/2006 16:10
155	12	9/19/2006 15:41	532	13.5	9/19/2006 16:10
360	12	9/19/2006 15:41	332	13.5	9/19/2006 16:10
695	12	9/19/2006 15:41	162	13.5	9/19/2006 16:10
735	12	9/19/2006 15:41	67.3	13.5	9/19/2006 16:10
99.2	12	9/19/2006 15:41	153	13.5	9/19/2006 16:10
1120	12	9/19/2006 15:41	1416	13.5	9/19/2006 16:10
741	12	9/19/2006 15:41	413	13.5	9/19/2006 16:10
633	12	9/19/2006 15:41	193	13.5	9/19/2006 16:10
771	12	9/19/2006 15:41	1008	13.5	9/19/2006 16:10
147	12	9/19/2006 15:42	1688	13.5	9/19/2006 16:10
702	12	9/19/2006 15:42	1843	13.5	9/19/2006 16:10
616	12	9/19/2006 15:42	992	13.5	9/19/2006 16:10
568	12	9/19/2006 15:42	504	13.5	9/19/2006 16:10
564	12	9/19/2006 15:42	399	13.5	9/19/2006 16:11
887	12	9/19/2006 15:42	447	13.5	9/19/2006 16:11
872	12	9/19/2006 15:42	411	13.5	9/19/2006 16:11
738	12	9/19/2006 15:42	513	13.5	9/19/2006 16:11
1000	12	9/19/2006 15:42	670	13.5	9/19/2006 16:11
875	12	9/19/2006 15:42	403	13.5	9/19/2006 16:11
1755	12	9/19/2006 15:42	135	13.5	9/19/2006 16:11
569	12	9/19/2006 15:42	84.6	13.5	9/19/2006 16:11
233	12	9/19/2006 15:42	71.5	13.5	9/19/2006 16:11
156	12	9/19/2006 15:42	75.7	13.5	9/19/2006 16:11
474	12	9/19/2006 15:42	71.3	13.5	9/19/2006 16:11
919	12	9/19/2006 15:42	72.4	13.5	9/19/2006 16:11
792	12	9/19/2006 15:42	70.7	13.5	9/19/2006 16:11
1037	12	9/19/2006 15:42	65.8	13.5	9/19/2006 16:11
1938	12	9/19/2006 15:42	52.9	13.5	9/19/2006 16:11
2602	12	9/19/2006 15:42	50.3	13.5	9/19/2006 16:11
2077	12	9/19/2006 15:42	57.2	13.5	9/19/2006 16:11
167	12	9/19/2006 15:42	81.9	13.5	9/19/2006 16:11
1932	12	9/19/2006 15:42	66.5	13.5	9/19/2006 16:11
2450	12	9/19/2006 15:42	55.3	13.5	9/19/2006 16:11
701	12	9/19/2006 15:42	68.5	13.5	9/19/2006 16:11
872	12	9/19/2006 15:42	95.9	13.5	9/19/2006 16:11
1581	12	9/19/2006 15:42	93.8	13.5	9/19/2006 16:11
1102	12	9/19/2006 15:42	97.6	13.5	9/19/2006 16:11
600	12	9/19/2006 15:42	80.8	13.5	9/19/2006 16:11
496	12	9/19/2006 15:42	75.8	13.5	9/19/2006 16:11
364	12	9/19/2006 15:42	64.8	13.5	9/19/2006 16:11
169	12	9/19/2006 15:43	53.9	13.5	9/19/2006 16:11
71.4	12	9/19/2006 15:43	56.1	13.5	9/19/2006 16:11
39.1	12	9/19/2006 15:43	42.1	13.5	9/19/2006 16:11

Path Measurement Data Site 2 Path 1			Path Measurement Data Site 2 Path 2		
ppm*m	pathlength	Timestamp (Eastern time)	ppm*m	pathlength	Timestamp (Eastern time)
40.3	12	9/19/2006 15:43	38.7	13.5	9/19/2006 16:11
123	12	9/19/2006 15:43	35.1	13.5	9/19/2006 16:11
984	12	9/19/2006 15:43	33.7	13.5	9/19/2006 16:11
1389	12	9/19/2006 15:43	33.1	13.5	9/19/2006 16:12
854	12	9/19/2006 15:43	39.3	13.5	9/19/2006 16:12
970	12	9/19/2006 15:43	484	13.5	9/19/2006 16:12
1171	12	9/19/2006 15:43	1513	13.5	9/19/2006 16:12
1545	12	9/19/2006 15:43	1132	13.5	9/19/2006 16:12
1152	12	9/19/2006 15:43	2390	13.5	9/19/2006 16:12
754	12	9/19/2006 15:43	893	13.5	9/19/2006 16:12
1144	12	9/19/2006 15:43	1012	13.5	9/19/2006 16:12
757	12	9/19/2006 15:43	1680	13.5	9/19/2006 16:12
893	12	9/19/2006 15:43	596	13.5	9/19/2006 16:12
1059	12	9/19/2006 15:43	260	13.5	9/19/2006 16:12
1123	12	9/19/2006 15:43	818	13.5	9/19/2006 16:12
1676	12	9/19/2006 15:43	1170	13.5	9/19/2006 16:12
1429	12	9/19/2006 15:43	733	13.5	9/19/2006 16:12
1929	12	9/19/2006 15:43	306	13.5	9/19/2006 16:12
2842	12	9/19/2006 15:43	196	13.5	9/19/2006 16:12
2255	12	9/19/2006 15:43	283	13.5	9/19/2006 16:12
1233	12	9/19/2006 15:43	328	13.5	9/19/2006 16:12
769	12	9/19/2006 15:43	352	13.5	9/19/2006 16:12
464	12	9/19/2006 15:43	225	13.5	9/19/2006 16:12
165	12	9/19/2006 15:43	249	13.5	9/19/2006 16:12
302	12	9/19/2006 15:43	236	13.5	9/19/2006 16:12
137	12	9/19/2006 15:43	193	13.5	9/19/2006 16:12
90.1	12	9/19/2006 15:43	341	13.5	9/19/2006 16:12
78.2	12	9/19/2006 15:43	279	13.5	9/19/2006 16:12
75.7	12	9/19/2006 15:44	268	13.5	9/19/2006 16:12
70.3	12	9/19/2006 15:44	131	13.5	9/19/2006 16:12
449	12	9/19/2006 15:44	68.1	13.5	9/19/2006 16:12
282	12	9/19/2006 15:44	43.1	13.5	9/19/2006 16:12
1745	12	9/19/2006 15:44	31.6	13.5	9/19/2006 16:12
783	12	9/19/2006 15:44	667	13.5	9/19/2006 16:12
1176	12	9/19/2006 15:44	733	13.5	9/19/2006 16:12
1682	12	9/19/2006 15:44	550	13.5	9/19/2006 16:12
2587	12	9/19/2006 15:44	673	13.5	9/19/2006 16:13
1661	12	9/19/2006 15:44	678	13.5	9/19/2006 16:13
735	12	9/19/2006 15:44	385	13.5	9/19/2006 16:13
282	12	9/19/2006 15:44	438	13.5	9/19/2006 16:13
103	12	9/19/2006 15:44	593	13.5	9/19/2006 16:13
64.5	12	9/19/2006 15:44	141	13.5	9/19/2006 16:13
103	12	9/19/2006 15:44	380	13.5	9/19/2006 16:13
724	12	9/19/2006 15:44	509	13.5	9/19/2006 16:13
1664	12	9/19/2006 15:44	417	13.5	9/19/2006 16:13
499	12	9/19/2006 15:44	1067	13.5	9/19/2006 16:13
175	12	9/19/2006 15:44	796	13.5	9/19/2006 16:13
1054	12	9/19/2006 15:44	620	13.5	9/19/2006 16:13
856	12	9/19/2006 15:44	519	13.5	9/19/2006 16:13
1876	12	9/19/2006 15:44	725	13.5	9/19/2006 16:13
2243	12	9/19/2006 15:44	450	13.5	9/19/2006 16:13
964	12	9/19/2006 15:44	237	13.5	9/19/2006 16:13
1101	12	9/19/2006 15:44	92.4	13.5	9/19/2006 16:13
1634	12	9/19/2006 15:44	79.8	13.5	9/19/2006 16:13
703	12	9/19/2006 15:44	34.6	13.5	9/19/2006 16:13
600	12	9/19/2006 15:44	31.2	13.5	9/19/2006 16:13
724	12	9/19/2006 15:44	31.1	13.5	9/19/2006 16:13
983	12	9/19/2006 15:44	31.3	13.5	9/19/2006 16:13
684	12	9/19/2006 15:44	32.5	13.5	9/19/2006 16:13
1361	12	9/19/2006 15:45	40.3	13.5	9/19/2006 16:13



Path Measurement Data Site 2 Path 1			Path Measurement Data Site 2 Path 2		
ppm*m	pathlength	Timestamp (Eastern time)	ppm*m	pathlength	Timestamp (Eastern time)
1054	12	9/19/2006 15:45	110	13.5	9/19/2006 16:13
554	12	9/19/2006 15:45	152	13.5	9/19/2006 16:13
465	12	9/19/2006 15:45	542	13.5	9/19/2006 16:13
281	12	9/19/2006 15:45	503	13.5	9/19/2006 16:13
1986	12	9/19/2006 15:45	185	13.5	9/19/2006 16:13
1205	12	9/19/2006 15:45	92.3	13.5	9/19/2006 16:13
295	12	9/19/2006 15:45	436	13.5	9/19/2006 16:13
36	12	9/19/2006 15:45	339	13.5	9/19/2006 16:13
49.7	12	9/19/2006 15:45	122	13.5	9/19/2006 16:13
113	12	9/19/2006 15:45	95.5	13.5	9/19/2006 16:13
1832	12	9/19/2006 15:45	62.1	13.5	9/19/2006 16:14
972	12	9/19/2006 15:45	60.4	13.5	9/19/2006 16:14
348	12	9/19/2006 15:45	64.9	13.5	9/19/2006 16:14
455	12	9/19/2006 15:45	73.2	13.5	9/19/2006 16:14
415	12	9/19/2006 15:45	76.8	13.5	9/19/2006 16:14
43.1	12	9/19/2006 15:45	81.6	13.5	9/19/2006 16:14
51.2	12	9/19/2006 15:45	44.7	13.5	9/19/2006 16:14
42.2	12	9/19/2006 15:45	36.5	13.5	9/19/2006 16:14
35.8	12	9/19/2006 15:45	32.4	13.5	9/19/2006 16:14
34.4	12	9/19/2006 15:45	32.1	13.5	9/19/2006 16:14
31.4	12	9/19/2006 15:45	31.8	13.5	9/19/2006 16:14
34.4	12	9/19/2006 15:45	31.1	13.5	9/19/2006 16:14
1441	12	9/19/2006 15:45	30.8	13.5	9/19/2006 16:14
1742	12	9/19/2006 15:45	30.8	13.5	9/19/2006 16:14
1109	12	9/19/2006 15:45	30.9	13.5	9/19/2006 16:14
1733	12	9/19/2006 15:45	30.6	13.5	9/19/2006 16:14
2247	12	9/19/2006 15:45	30.7	13.5	9/19/2006 16:14
601	12	9/19/2006 15:45	30.8	13.5	9/19/2006 16:14
997	12	9/19/2006 15:45	30.8	13.5	9/19/2006 16:14
1337	12	9/19/2006 15:45	30.7	13.5	9/19/2006 16:14
1404	12	9/19/2006 15:46	30.7	13.5	9/19/2006 16:14
1584	12	9/19/2006 15:46	30.8	13.5	9/19/2006 16:14
2122	12	9/19/2006 15:46	30.9	13.5	9/19/2006 16:14
1908	12	9/19/2006 15:46	30.9	13.5	9/19/2006 16:14
1222	12	9/19/2006 15:46	30.9	13.5	9/19/2006 16:14
2051	12	9/19/2006 15:46	31	13.5	9/19/2006 16:14
1110	12	9/19/2006 15:46	30.8	13.5	9/19/2006 16:14
1664	12	9/19/2006 15:46	30.8	13.5	9/19/2006 16:14
1928	12	9/19/2006 15:46	30.8	13.5	9/19/2006 16:14
2074	12	9/19/2006 15:46	30.8	13.5	9/19/2006 16:14
1852	12	9/19/2006 15:46	30.9	13.5	9/19/2006 16:14
1175	12	9/19/2006 15:46	30.8	13.5	9/19/2006 16:14
1346	12	9/19/2006 15:46	30.8	13.5	9/19/2006 16:14
1649	12	9/19/2006 15:46	112	13.5	9/19/2006 16:15
1550	12	9/19/2006 15:46	154	13.5	9/19/2006 16:15
2121	12	9/19/2006 15:46	120	13.5	9/19/2006 16:15
1458	12	9/19/2006 15:46	101	13.5	9/19/2006 16:15
1386	12	9/19/2006 15:46	92.5	13.5	9/19/2006 16:15
1086	12	9/19/2006 15:46	78.4	13.5	9/19/2006 16:15
837	12	9/19/2006 15:46	73.5	13.5	9/19/2006 16:15
1687	12	9/19/2006 15:46	52.8	13.5	9/19/2006 16:15
1464	12	9/19/2006 15:46	45.5	13.5	9/19/2006 16:15
899	12	9/19/2006 15:46	43.2	13.5	9/19/2006 16:15
1272	12	9/19/2006 15:46	43.9	13.5	9/19/2006 16:15
1350	12	9/19/2006 15:46	38.7	13.5	9/19/2006 16:15
1275	12	9/19/2006 15:46	36.8	13.5	9/19/2006 16:15
238	12	9/19/2006 15:46	37.6	13.5	9/19/2006 16:15
88.1	12	9/19/2006 15:46	66.2	13.5	9/19/2006 16:15
41.5	12	9/19/2006 15:46	69.3	13.5	9/19/2006 16:15
48.4	12	9/19/2006 15:46	69.2	13.5	9/19/2006 16:15

Path Measurement Data Site 2 Path 1			Path Measurement Data Site 2 Path 2		
ppm*m	pathlength	Timestamp (Eastern time)	ppm*m	pathlength	Timestamp (Eastern time)
1199	12	9/19/2006 15:46	78.5	13.5	9/19/2006 16:15
172	12	9/19/2006 15:47	63.5	13.5	9/19/2006 16:15
94.4	12	9/19/2006 15:47	40.7	13.5	9/19/2006 16:15
113	12	9/19/2006 15:47	35.4	13.5	9/19/2006 16:15
1323	12	9/19/2006 15:47	32.8	13.5	9/19/2006 16:15
2443	12	9/19/2006 15:47	31.7	13.5	9/19/2006 16:15
605	12	9/19/2006 15:47	31.1	13.5	9/19/2006 16:15
322	12	9/19/2006 15:47	30.8	13.5	9/19/2006 16:15
476	12	9/19/2006 15:47	30.5	13.5	9/19/2006 16:15
650	12	9/19/2006 15:47	30.6	13.5	9/19/2006 16:15
664	12	9/19/2006 15:47	56.2	13.5	9/19/2006 16:15
638	12	9/19/2006 15:47	113	13.5	9/19/2006 16:15
1390	12	9/19/2006 15:47	124	13.5	9/19/2006 16:15
940	12	9/19/2006 15:47	68.1	13.5	9/19/2006 16:15
929	12	9/19/2006 15:47	62.5	13.5	9/19/2006 16:15
1211	12	9/19/2006 15:47	57.6	13.5	9/19/2006 16:15
579	12	9/19/2006 15:47	59.3	13.5	9/19/2006 16:15
776	12	9/19/2006 15:47	56.5	13.5	9/19/2006 16:16
309	12	9/19/2006 15:47	44.7	13.5	9/19/2006 16:16
668	12	9/19/2006 15:47	33.6	13.5	9/19/2006 16:16
571	12	9/19/2006 15:47	30.9	13.5	9/19/2006 16:16
491	12	9/19/2006 15:47	30.7	13.5	9/19/2006 16:16
542	12	9/19/2006 15:47	31	13.5	9/19/2006 16:16
306	12	9/19/2006 15:47	32.6	13.5	9/19/2006 16:16
51.4	12	9/19/2006 15:47	34.8	13.5	9/19/2006 16:16
49.4	12	9/19/2006 15:47	43.3	13.5	9/19/2006 16:16
52.8	12	9/19/2006 15:47	53	13.5	9/19/2006 16:16
33.7	12	9/19/2006 15:48	55.1	13.5	9/19/2006 16:16
38.5	12	9/19/2006 15:48	81.9	13.5	9/19/2006 16:16
78.6	12	9/19/2006 15:48	109	13.5	9/19/2006 16:16
201	12	9/19/2006 15:48	79.7	13.5	9/19/2006 16:16
665	12	9/19/2006 15:48	105	13.5	9/19/2006 16:16
534	12	9/19/2006 15:48	118	13.5	9/19/2006 16:16
386	12	9/19/2006 15:48	103	13.5	9/19/2006 16:16
391	12	9/19/2006 15:48	197	13.5	9/19/2006 16:16
676	12	9/19/2006 15:48	468	13.5	9/19/2006 16:16
466	12	9/19/2006 15:48	534	13.5	9/19/2006 16:16
119	12	9/19/2006 15:48	316	13.5	9/19/2006 16:16
131	12	9/19/2006 15:48	237	13.5	9/19/2006 16:16
188	12	9/19/2006 15:48	136	13.5	9/19/2006 16:16
87.3	12	9/19/2006 15:48	283	13.5	9/19/2006 16:16
42.3	12	9/19/2006 15:48	479	13.5	9/19/2006 16:16
29.8	12	9/19/2006 15:48	600	13.5	9/19/2006 16:16
27.4	12	9/19/2006 15:48	469	13.5	9/19/2006 16:16
27.4	12	9/19/2006 15:48	744	13.5	9/19/2006 16:16
71.3	12	9/19/2006 15:48	290	13.5	9/19/2006 16:16
328	12	9/19/2006 15:48	807	13.5	9/19/2006 16:16
444	12	9/19/2006 15:48	537	13.5	9/19/2006 16:16
1087	12	9/19/2006 15:48	431	13.5	9/19/2006 16:16
1121	12	9/19/2006 15:48	1204	13.5	9/19/2006 16:16
360	12	9/19/2006 15:48	784	13.5	9/19/2006 16:16
358	12	9/19/2006 15:48	505	13.5	9/19/2006 16:17
834	12	9/19/2006 15:48	947	13.5	9/19/2006 16:17
977	12	9/19/2006 15:48	875	13.5	9/19/2006 16:17
1239	12	9/19/2006 15:48	650	13.5	9/19/2006 16:17
2176	12	9/19/2006 15:48	550	13.5	9/19/2006 16:17
1940	12	9/19/2006 15:48	120	13.5	9/19/2006 16:17
1576	12	9/19/2006 15:48	138	13.5	9/19/2006 16:17
1184	12	9/19/2006 15:49	74.3	13.5	9/19/2006 16:17
1314	12	9/19/2006 15:49	48.7	13.5	9/19/2006 16:17

Path Measurement Data Site 2 Path 1			Path Measurement Data Site 2 Path 2		
ppm*m	pathlength	Timestamp (Eastern time)	ppm*m	pathlength	Timestamp (Eastern time)
974	12	9/19/2006 15:49	34.5	13.5	9/19/2006 16:17
529	12	9/19/2006 15:49	33.9	13.5	9/19/2006 16:17
339	12	9/19/2006 15:49	31.8	13.5	9/19/2006 16:17
216	12	9/19/2006 15:49	34.4	13.5	9/19/2006 16:17
133	12	9/19/2006 15:49	33.9	13.5	9/19/2006 16:17
39.8	12	9/19/2006 15:49	85.9	13.5	9/19/2006 16:17
34.6	12	9/19/2006 15:49	60	13.5	9/19/2006 16:17
32.3	12	9/19/2006 15:49	34.4	13.5	9/19/2006 16:17
42.2	12	9/19/2006 15:49	38.3	13.5	9/19/2006 16:17
159	12	9/19/2006 15:49	46.9	13.5	9/19/2006 16:17
486	12	9/19/2006 15:49	40.8	13.5	9/19/2006 16:17
540	12	9/19/2006 15:49	38.2	13.5	9/19/2006 16:17
421	12	9/19/2006 15:49	34.7	13.5	9/19/2006 16:17
1776	12	9/19/2006 15:49	36.3	13.5	9/19/2006 16:17
1038	12	9/19/2006 15:49	35	13.5	9/19/2006 16:17
2460	12	9/19/2006 15:49	34.1	13.5	9/19/2006 16:17
1259	12	9/19/2006 15:49	33	13.5	9/19/2006 16:17
740	12	9/19/2006 15:49	65.4	13.5	9/19/2006 16:17
463	12	9/19/2006 15:49	677	13.5	9/19/2006 16:17
572	12	9/19/2006 15:49	700	13.5	9/19/2006 16:17
622	12	9/19/2006 15:49	181	13.5	9/19/2006 16:17
668	12	9/19/2006 15:49	213	13.5	9/19/2006 16:17
341	12	9/19/2006 15:49	140	13.5	9/19/2006 16:17
1208	12	9/19/2006 15:49	558	13.5	9/19/2006 16:17
444	12	9/19/2006 15:49	291	13.5	9/19/2006 16:18
340	12	9/19/2006 15:49	331	13.5	9/19/2006 16:18
738	12	9/19/2006 15:49	357	13.5	9/19/2006 16:18
1237	12	9/19/2006 15:49	351	13.5	9/19/2006 16:18
1197	12	9/19/2006 15:49	524	13.5	9/19/2006 16:18
787	12	9/19/2006 15:49	1129	13.5	9/19/2006 16:18
2133	12	9/19/2006 15:50	689	13.5	9/19/2006 16:18
924	12	9/19/2006 15:50	396	13.5	9/19/2006 16:18
926	12	9/19/2006 15:50	335	13.5	9/19/2006 16:18
1178	12	9/19/2006 15:50	402	13.5	9/19/2006 16:18
593	12	9/19/2006 15:50	416	13.5	9/19/2006 16:18
466	12	9/19/2006 15:50	541	13.5	9/19/2006 16:18
776	12	9/19/2006 15:50	618	13.5	9/19/2006 16:18
907	12	9/19/2006 15:50	601	13.5	9/19/2006 16:18
1188	12	9/19/2006 15:50	141	13.5	9/19/2006 16:18
1889	12	9/19/2006 15:50	77.9	13.5	9/19/2006 16:18
1643	12	9/19/2006 15:50	143	13.5	9/19/2006 16:18
1274	12	9/19/2006 15:50	289	13.5	9/19/2006 16:18
2515	12	9/19/2006 15:50	310	13.5	9/19/2006 16:18
2325	12	9/19/2006 15:50	100	13.5	9/19/2006 16:18
419	12	9/19/2006 15:50	47.1	13.5	9/19/2006 16:18
871	12	9/19/2006 15:50	51.3	13.5	9/19/2006 16:18
1510	12	9/19/2006 15:50	60.6	13.5	9/19/2006 16:18
1979	12	9/19/2006 15:50	53.3	13.5	9/19/2006 16:18
1780	12	9/19/2006 15:50	47.1	13.5	9/19/2006 16:18
1495	12	9/19/2006 15:50	45	13.5	9/19/2006 16:18
1752	12	9/19/2006 15:50	40.9	13.5	9/19/2006 16:18
2411	12	9/19/2006 15:50	42.2	13.5	9/19/2006 16:18
1759	12	9/19/2006 15:50	30.8	13.5	9/19/2006 16:18
1291	12	9/19/2006 15:50	30.8	13.5	9/19/2006 16:18
1183	12	9/19/2006 15:50	30.6	13.5	9/19/2006 16:18
1435	12	9/19/2006 15:50	30.8	13.5	9/19/2006 16:18
1916	12	9/19/2006 15:50	30.6	13.5	9/19/2006 16:18
896	12	9/19/2006 15:50	30.7	13.5	9/19/2006 16:18
479	12	9/19/2006 15:50	30.8	13.5	9/19/2006 16:19
451	12	9/19/2006 15:50	30.9	13.5	9/19/2006 16:19

Path Measurement Data Site 2 Path 1			Path Measurement Data Site 2 Path 2		
ppm*m	pathlength	Timestamp (Eastern time)	ppm*m	pathlength	Timestamp (Eastern time)
559	12	9/19/2006 15:50	31	13.5	9/19/2006 16:19
1381	12	9/19/2006 15:50	30.8	13.5	9/19/2006 16:19
967	12	9/19/2006 15:51	31	13.5	9/19/2006 16:19
1356	12	9/19/2006 15:51	30.7	13.5	9/19/2006 16:19
1790	12	9/19/2006 15:51			
2540	12	9/19/2006 15:51			
1216	12	9/19/2006 15:51			
1837	12	9/19/2006 15:51			
1603	12	9/19/2006 15:51			
1347	12	9/19/2006 15:51			
2251	12	9/19/2006 15:51			
1870	12	9/19/2006 15:51			
1070	12	9/19/2006 15:51			
2572	12	9/19/2006 15:51			
2384	12	9/19/2006 15:51			
1524	12	9/19/2006 15:51			
818	12	9/19/2006 15:51			
386	12	9/19/2006 15:51			
160	12	9/19/2006 15:51			
89.3	12	9/19/2006 15:51			
648	12	9/19/2006 15:51			
476	12	9/19/2006 15:51			
947	12	9/19/2006 15:51			
445	12	9/19/2006 15:51			
533	12	9/19/2006 15:51			
472	12	9/19/2006 15:51			
1247	12	9/19/2006 15:51			
1116	12	9/19/2006 15:51			
1017	12	9/19/2006 15:51			
1089	12	9/19/2006 15:51			
1260	12	9/19/2006 15:51			
547	12	9/19/2006 15:51			
1318	12	9/19/2006 15:51			
1243	12	9/19/2006 15:52			
1892	12	9/19/2006 15:52			
1835	12	9/19/2006 15:52			
1640	12	9/19/2006 15:52			
2184	12	9/19/2006 15:52			
1343	12	9/19/2006 15:52			
217	12	9/19/2006 15:52			
151	12	9/19/2006 15:52			
149	12	9/19/2006 15:52			
337	12	9/19/2006 15:52			
1133	12	9/19/2006 15:52			
226	12	9/19/2006 15:52			
56.6	12	9/19/2006 15:52			
2516	12	9/19/2006 15:52			
1628	12	9/19/2006 15:52			
1203	12	9/19/2006 15:52			
1814	12	9/19/2006 15:52			
1795	12	9/19/2006 15:52			
1505	12	9/19/2006 15:52			
1604	12	9/19/2006 15:52			
1426	12	9/19/2006 15:52			
486	12	9/19/2006 15:52			
506	12	9/19/2006 15:52			
763	12	9/19/2006 15:52			
605	12	9/19/2006 15:52			
1574	12	9/19/2006 15:52			
1038	12	9/19/2006 15:52			

Path Measurement Data Site 2 Path 1			Path Measurement Data Site 2 Path 2		
ppm*m	pathlength	Timestamp (Eastern time)	ppm*m	pathlength	Timestamp (Eastern time)
782	12	9/19/2006 15:53			
531	12	9/19/2006 15:53			
589	12	9/19/2006 15:53			
409	12	9/19/2006 15:53			
1304	12	9/19/2006 15:53			
1039	12	9/19/2006 15:53			
2557	12	9/19/2006 15:53			
2340	12	9/19/2006 15:53			
379	12	9/19/2006 15:53			
2238	12	9/19/2006 15:53			
866	12	9/19/2006 15:53			
250	12	9/19/2006 15:53			
254	12	9/19/2006 15:53			
51.9	12	9/19/2006 15:53			
1770	12	9/19/2006 15:53			
2147	12	9/19/2006 15:53			
1146	12	9/19/2006 15:53			
2157	12	9/19/2006 15:53			

Path Measurement Data Site 2 Path 3			Path Measurement Data Site 2 Path 4		
ppm*m	pathlength	Timestamp (Mountain time)	ppm*m	pathlength	Timestamp (Mountain time)
150	20	9/19/2006 14:33	42.9	20	9/19/2006 15:01
171	20	9/19/2006 14:33	43	20	9/19/2006 15:01
97	20	9/19/2006 14:33	43.2	20	9/19/2006 15:01
60.3	20	9/19/2006 14:33	42.9	20	9/19/2006 15:01
69.3	20	9/19/2006 14:34	42.9	20	9/19/2006 15:01
67.7	20	9/19/2006 14:34	42.9	20	9/19/2006 15:01
64.3	20	9/19/2006 14:34	42.9	20	9/19/2006 15:01
81.4	20	9/19/2006 14:34	43.1	20	9/19/2006 15:01
107	20	9/19/2006 14:34	43.1	20	9/19/2006 15:01
115	20	9/19/2006 14:34	42.8	20	9/19/2006 15:01
178	20	9/19/2006 14:34	43.1	20	9/19/2006 15:01
182	20	9/19/2006 14:34	42.9	20	9/19/2006 15:01
281	20	9/19/2006 14:34	42.8	20	9/19/2006 15:01
533	20	9/19/2006 14:34	42.9	20	9/19/2006 15:02
628	20	9/19/2006 14:34	42.9	20	9/19/2006 15:02
328	20	9/19/2006 14:34	42.8	20	9/19/2006 15:02
446	20	9/19/2006 14:34	43	20	9/19/2006 15:02
496	20	9/19/2006 14:34	42.7	20	9/19/2006 15:02
384	20	9/19/2006 14:34	43.3	20	9/19/2006 15:02
225	20	9/19/2006 14:34	42.9	20	9/19/2006 15:02
170	20	9/19/2006 14:34	42.8	20	9/19/2006 15:02
95.3	20	9/19/2006 14:34	42.7	20	9/19/2006 15:02
113	20	9/19/2006 14:34	42.5	20	9/19/2006 15:02
225	20	9/19/2006 14:34	43.1	20	9/19/2006 15:02
162	20	9/19/2006 14:34	42.7	20	9/19/2006 15:02
175	20	9/19/2006 14:34	42.7	20	9/19/2006 15:02
221	20	9/19/2006 14:34	42.8	20	9/19/2006 15:02
272	20	9/19/2006 14:34	43	20	9/19/2006 15:02
220	20	9/19/2006 14:34	42.7	20	9/19/2006 15:02
471	20	9/19/2006 14:34	42.9	20	9/19/2006 15:02
637	20	9/19/2006 14:34	42.7	20	9/19/2006 15:02
611	20	9/19/2006 14:34	42.8	20	9/19/2006 15:02
536	20	9/19/2006 14:34	42.7	20	9/19/2006 15:02
444	20	9/19/2006 14:34	42.8	20	9/19/2006 15:02
385	20	9/19/2006 14:34	42.8	20	9/19/2006 15:02
322	20	9/19/2006 14:34	42.6	20	9/19/2006 15:02
237	20	9/19/2006 14:34	47.1	20	9/19/2006 15:02
167	20	9/19/2006 14:34	45.7	20	9/19/2006 15:02
156	20	9/19/2006 14:35	44.2	20	9/19/2006 15:02
157	20	9/19/2006 14:35	45.2	20	9/19/2006 15:02
151	20	9/19/2006 14:35	44.4	20	9/19/2006 15:02
126	20	9/19/2006 14:35	43.3	20	9/19/2006 15:02
166	20	9/19/2006 14:35	43	20	9/19/2006 15:02
158	20	9/19/2006 14:35	42.7	20	9/19/2006 15:02
195	20	9/19/2006 14:35	43	20	9/19/2006 15:02
175	20	9/19/2006 14:35	42.9	20	9/19/2006 15:02
124	20	9/19/2006 14:35	43	20	9/19/2006 15:02
178	20	9/19/2006 14:35	42.7	20	9/19/2006 15:03
163	20	9/19/2006 14:35	42.9	20	9/19/2006 15:03
399	20	9/19/2006 14:35	42.5	20	9/19/2006 15:03
557	20	9/19/2006 14:35	42.9	20	9/19/2006 15:03
656	20	9/19/2006 14:35	42.6	20	9/19/2006 15:03
420	20	9/19/2006 14:35	43	20	9/19/2006 15:03
649	20	9/19/2006 14:35	43	20	9/19/2006 15:03
468	20	9/19/2006 14:35	43	20	9/19/2006 15:03
362	20	9/19/2006 14:35	43	20	9/19/2006 15:03
320	20	9/19/2006 14:35	43.1	20	9/19/2006 15:03
274	20	9/19/2006 14:35	42.9	20	9/19/2006 15:03
252	20	9/19/2006 14:35	43.1	20	9/19/2006 15:03

Path Measurement Data Site 2 Path 3			Path Measurement Data Site 2 Path 4		
ppm*m	pathlength	Timestamp (Mountain time)	ppm*m	pathlength	Timestamp (Mountain time)
248	20	9/19/2006 14:35	43.6	20	9/19/2006 15:03
192	20	9/19/2006 14:35	43.1	20	9/19/2006 15:03
204	20	9/19/2006 14:35	43.1	20	9/19/2006 15:03
253	20	9/19/2006 14:35	42.9	20	9/19/2006 15:03
224	20	9/19/2006 14:35	43	20	9/19/2006 15:03
269	20	9/19/2006 14:35	43.1	20	9/19/2006 15:03
252	20	9/19/2006 14:35	43.1	20	9/19/2006 15:03
253	20	9/19/2006 14:35	43	20	9/19/2006 15:03
283	20	9/19/2006 14:35	43.4	20	9/19/2006 15:03
275	20	9/19/2006 14:35	44.4	20	9/19/2006 15:03
222	20	9/19/2006 14:35	56.7	20	9/19/2006 15:03
160	20	9/19/2006 14:35	91.2	20	9/19/2006 15:03
138	20	9/19/2006 14:35	155	20	9/19/2006 15:03
116	20	9/19/2006 14:36	207	20	9/19/2006 15:03
75.9	20	9/19/2006 14:36	202	20	9/19/2006 15:03
244	20	9/19/2006 14:36	217	20	9/19/2006 15:03
168	20	9/19/2006 14:36	224	20	9/19/2006 15:03
85.7	20	9/19/2006 14:36	217	20	9/19/2006 15:03
50.8	20	9/19/2006 14:36	198	20	9/19/2006 15:03
52.9	20	9/19/2006 14:36	181	20	9/19/2006 15:03
53.6	20	9/19/2006 14:36	142	20	9/19/2006 15:03
49.3	20	9/19/2006 14:36	134	20	9/19/2006 15:03
44.8	20	9/19/2006 14:36	116	20	9/19/2006 15:04
44.2	20	9/19/2006 14:36	102	20	9/19/2006 15:04
49.9	20	9/19/2006 14:36	95.2	20	9/19/2006 15:04
56.7	20	9/19/2006 14:36	85.4	20	9/19/2006 15:04
75.3	20	9/19/2006 14:36	240	20	9/19/2006 15:04
115	20	9/19/2006 14:36	336	20	9/19/2006 15:04
298	20	9/19/2006 14:36	1205	20	9/19/2006 15:04
341	20	9/19/2006 14:36	1117	20	9/19/2006 15:04
343	20	9/19/2006 14:36	1041	20	9/19/2006 15:04
336	20	9/19/2006 14:36	527	20	9/19/2006 15:04
366	20	9/19/2006 14:36	390	20	9/19/2006 15:04
367	20	9/19/2006 14:36	707	20	9/19/2006 15:04
262	20	9/19/2006 14:36	807	20	9/19/2006 15:04
249	20	9/19/2006 14:36	861	20	9/19/2006 15:04
225	20	9/19/2006 14:36	1142	20	9/19/2006 15:04
197	20	9/19/2006 14:36	762	20	9/19/2006 15:04
177	20	9/19/2006 14:36	700	20	9/19/2006 15:04
152	20	9/19/2006 14:36	442	20	9/19/2006 15:04
144	20	9/19/2006 14:36	287	20	9/19/2006 15:04
118	20	9/19/2006 14:36	212	20	9/19/2006 15:04
110	20	9/19/2006 14:36	121	20	9/19/2006 15:04
100	20	9/19/2006 14:36	66.8	20	9/19/2006 15:04
101	20	9/19/2006 14:36	57.8	20	9/19/2006 15:04
137	20	9/19/2006 14:36	84.5	20	9/19/2006 15:04
157	20	9/19/2006 14:37	110	20	9/19/2006 15:04
150	20	9/19/2006 14:37	95.2	20	9/19/2006 15:04
390	20	9/19/2006 14:37	72.8	20	9/19/2006 15:04
452	20	9/19/2006 14:37	68.1	20	9/19/2006 15:04
364	20	9/19/2006 14:37	54.1	20	9/19/2006 15:04
367	20	9/19/2006 14:37	50.9	20	9/19/2006 15:04
366	20	9/19/2006 14:37	49	20	9/19/2006 15:04
633	20	9/19/2006 14:37	45.6	20	9/19/2006 15:04
1057	20	9/19/2006 14:37	44	20	9/19/2006 15:04
638	20	9/19/2006 14:37	43.6	20	9/19/2006 15:05
559	20	9/19/2006 14:37	43.3	20	9/19/2006 15:05
803	20	9/19/2006 14:37	43.8	20	9/19/2006 15:05
967	20	9/19/2006 14:37	43.1	20	9/19/2006 15:05
572	20	9/19/2006 14:37	42.6	20	9/19/2006 15:05

Path Measurement Data Site 2 Path 3			Path Measurement Data Site 2 Path 4		
ppm*m	pathlength	Timestamp (Mountain time)	ppm*m	pathlength	Timestamp (Mountain time)
399	20	9/19/2006 14:37	42.6	20	9/19/2006 15:05
172	20	9/19/2006 14:37	42.5	20	9/19/2006 15:05
60	20	9/19/2006 14:37	42.5	20	9/19/2006 15:05
75.5	20	9/19/2006 14:37	42.6	20	9/19/2006 15:05
83.7	20	9/19/2006 14:37	42.2	20	9/19/2006 15:05
88.1	20	9/19/2006 14:37	41.8	20	9/19/2006 15:05
106	20	9/19/2006 14:37	42.4	20	9/19/2006 15:05
95.3	20	9/19/2006 14:37	42.2	20	9/19/2006 15:05
90.2	20	9/19/2006 14:37	42.4	20	9/19/2006 15:05
91.4	20	9/19/2006 14:37	42.5	20	9/19/2006 15:05
90.4	20	9/19/2006 14:37	42.4	20	9/19/2006 15:05
94.5	20	9/19/2006 14:37	42.2	20	9/19/2006 15:05
103	20	9/19/2006 14:37	42.1	20	9/19/2006 15:05
110	20	9/19/2006 14:37	42.3	20	9/19/2006 15:05
106	20	9/19/2006 14:37	42.1	20	9/19/2006 15:05
88.3	20	9/19/2006 14:37	42.3	20	9/19/2006 15:05
50.8	20	9/19/2006 14:37	42.3	20	9/19/2006 15:05
93.4	20	9/19/2006 14:37	42.3	20	9/19/2006 15:05
122	20	9/19/2006 14:37	42	20	9/19/2006 15:05
204	20	9/19/2006 14:37	42.2	20	9/19/2006 15:05
188	20	9/19/2006 14:38	42.1	20	9/19/2006 15:05
145	20	9/19/2006 14:38	42.3	20	9/19/2006 15:05
127	20	9/19/2006 14:38	42.2	20	9/19/2006 15:05
108	20	9/19/2006 14:38	42.4	20	9/19/2006 15:05
102	20	9/19/2006 14:38	42.4	20	9/19/2006 15:05
108	20	9/19/2006 14:38	42.2	20	9/19/2006 15:05
97	20	9/19/2006 14:38	42.7	20	9/19/2006 15:05
102	20	9/19/2006 14:38	42.6	20	9/19/2006 15:05
207	20	9/19/2006 14:38	42.1	20	9/19/2006 15:05
256	20	9/19/2006 14:38	42.3	20	9/19/2006 15:05
220	20	9/19/2006 14:38	42.4	20	9/19/2006 15:06
147	20	9/19/2006 14:38	41.4	20	9/19/2006 15:06
156	20	9/19/2006 14:38	41.8	20	9/19/2006 15:06
116	20	9/19/2006 14:38	41.6	20	9/19/2006 15:06
70.9	20	9/19/2006 14:38	41.6	20	9/19/2006 15:06
52.4	20	9/19/2006 14:38	41.6	20	9/19/2006 15:06
48.1	20	9/19/2006 14:38	42	20	9/19/2006 15:06
47.6	20	9/19/2006 14:38	41.7	20	9/19/2006 15:06
44.7	20	9/19/2006 14:38	42.5	20	9/19/2006 15:06
42.8	20	9/19/2006 14:38	375	20	9/19/2006 15:06
41.2	20	9/19/2006 14:38	819	20	9/19/2006 15:06
41.5	20	9/19/2006 14:38	273	20	9/19/2006 15:06
41.4	20	9/19/2006 14:38	137	20	9/19/2006 15:06
42.2	20	9/19/2006 14:38	171	20	9/19/2006 15:06
41.9	20	9/19/2006 14:38	61.6	20	9/19/2006 15:06
42.4	20	9/19/2006 14:38	51.7	20	9/19/2006 15:06
42.9	20	9/19/2006 14:38	53.8	20	9/19/2006 15:06
42.6	20	9/19/2006 14:38	41.9	20	9/19/2006 15:06
41.6	20	9/19/2006 14:38	41.9	20	9/19/2006 15:06
41.8	20	9/19/2006 14:38	42.1	20	9/19/2006 15:06
41.6	20	9/19/2006 14:38	58.8	20	9/19/2006 15:06
41.8	20	9/19/2006 14:38	77.2	20	9/19/2006 15:06
41.4	20	9/19/2006 14:38	63.5	20	9/19/2006 15:06
41.4	20	9/19/2006 14:38	56.8	20	9/19/2006 15:06
41.5	20	9/19/2006 14:39	58.8	20	9/19/2006 15:06
41.1	20	9/19/2006 14:39	52.2	20	9/19/2006 15:06
41.2	20	9/19/2006 14:39	49.4	20	9/19/2006 15:06
41.1	20	9/19/2006 14:39	45.4	20	9/19/2006 15:06
46.5	20	9/19/2006 14:39	47.6	20	9/19/2006 15:06
236	20	9/19/2006 14:39	41.9	20	9/19/2006 15:06



Path Measurement Data Site 2 Path 3			Path Measurement Data Site 2 Path 4		
ppm*m	pathlength	Timestamp (Mountain time)	ppm*m	pathlength	Timestamp (Mountain time)
288	20	9/19/2006 14:39	41.5	20	9/19/2006 15:06
135	20	9/19/2006 14:39	41.9	20	9/19/2006 15:06
108	20	9/19/2006 14:39	41.8	20	9/19/2006 15:06
98.2	20	9/19/2006 14:39	41.8	20	9/19/2006 15:07
111	20	9/19/2006 14:39	41.9	20	9/19/2006 15:07
241	20	9/19/2006 14:39	41.7	20	9/19/2006 15:07
211	20	9/19/2006 14:39	41.5	20	9/19/2006 15:07
149	20	9/19/2006 14:39	41.7	20	9/19/2006 15:07
92.5	20	9/19/2006 14:39	41.8	20	9/19/2006 15:07
71.5	20	9/19/2006 14:39	42	20	9/19/2006 15:07
70.5	20	9/19/2006 14:39	41.5	20	9/19/2006 15:07
64.9	20	9/19/2006 14:39	41.4	20	9/19/2006 15:07
99.7	20	9/19/2006 14:39	41.7	20	9/19/2006 15:07
154	20	9/19/2006 14:39	41.9	20	9/19/2006 15:07
163	20	9/19/2006 14:39	41.9	20	9/19/2006 15:07
160	20	9/19/2006 14:39	41.7	20	9/19/2006 15:07
126	20	9/19/2006 14:39	41.8	20	9/19/2006 15:07
112	20	9/19/2006 14:39	42.1	20	9/19/2006 15:07
91.2	20	9/19/2006 14:39	42.1	20	9/19/2006 15:07
70	20	9/19/2006 14:39	42	20	9/19/2006 15:07
75.5	20	9/19/2006 14:39	41.7	20	9/19/2006 15:07
68.1	20	9/19/2006 14:39	41.6	20	9/19/2006 15:07
84.2	20	9/19/2006 14:39	41.4	20	9/19/2006 15:07
59.5	20	9/19/2006 14:39	41.5	20	9/19/2006 15:07
41.6	20	9/19/2006 14:39	41.7	20	9/19/2006 15:07
40.5	20	9/19/2006 14:39	41.5	20	9/19/2006 15:07
40.9	20	9/19/2006 14:39	41.8	20	9/19/2006 15:07
41.1	20	9/19/2006 14:39	41.5	20	9/19/2006 15:07
40.9	20	9/19/2006 14:40	41.3	20	9/19/2006 15:07
41.1	20	9/19/2006 14:40	41.4	20	9/19/2006 15:07
41.2	20	9/19/2006 14:40	41.6	20	9/19/2006 15:07
41	20	9/19/2006 14:40	41.5	20	9/19/2006 15:07
40.9	20	9/19/2006 14:40	41.5	20	9/19/2006 15:07
40.9	20	9/19/2006 14:40	41.9	20	9/19/2006 15:07
41.3	20	9/19/2006 14:40	41.8	20	9/19/2006 15:07
41.1	20	9/19/2006 14:40	41.9	20	9/19/2006 15:07
41	20	9/19/2006 14:40	41.7	20	9/19/2006 15:07
40.8	20	9/19/2006 14:40	41.6	20	9/19/2006 15:08
40.8	20	9/19/2006 14:40	41.6	20	9/19/2006 15:08
41.1	20	9/19/2006 14:40	41.4	20	9/19/2006 15:08
41.1	20	9/19/2006 14:40	41.7	20	9/19/2006 15:08
41	20	9/19/2006 14:40	41.6	20	9/19/2006 15:08
41.7	20	9/19/2006 14:40	41.5	20	9/19/2006 15:08
43	20	9/19/2006 14:40	41.5	20	9/19/2006 15:08
42.9	20	9/19/2006 14:40	41.7	20	9/19/2006 15:08
82.2	20	9/19/2006 14:40	41.8	20	9/19/2006 15:08
79.2	20	9/19/2006 14:40	41.8	20	9/19/2006 15:08
70.1	20	9/19/2006 14:40	41.4	20	9/19/2006 15:08
49.9	20	9/19/2006 14:40	41.7	20	9/19/2006 15:08
44.7	20	9/19/2006 14:40	41.4	20	9/19/2006 15:08
40.9	20	9/19/2006 14:40	41.6	20	9/19/2006 15:08
41	20	9/19/2006 14:40	41.7	20	9/19/2006 15:08
41.1	20	9/19/2006 14:40	41.7	20	9/19/2006 15:08
41	20	9/19/2006 14:40	41.6	20	9/19/2006 15:08
41	20	9/19/2006 14:40	41.4	20	9/19/2006 15:08
41	20	9/19/2006 14:40	41.6	20	9/19/2006 15:08
40.9	20	9/19/2006 14:40	41.4	20	9/19/2006 15:08
40.9	20	9/19/2006 14:40	41.2	20	9/19/2006 15:08
41.5	20	9/19/2006 14:40	41.5	20	9/19/2006 15:08
41.4	20	9/19/2006 14:40	41.9	20	9/19/2006 15:08

Path Measurement Data Site 2 Path 3			Path Measurement Data Site 2 Path 4		
ppm*m	pathlength	Timestamp (Mountain time)	ppm*m	pathlength	Timestamp (Mountain time)
41	20	9/19/2006 14:40	41.7	20	9/19/2006 15:08
40.8	20	9/19/2006 14:40	41.7	20	9/19/2006 15:08
40.8	20	9/19/2006 14:41	41.5	20	9/19/2006 15:08
41.1	20	9/19/2006 14:41	41.6	20	9/19/2006 15:08
48.5	20	9/19/2006 14:41	41.6	20	9/19/2006 15:08
43.5	20	9/19/2006 14:41	41.4	20	9/19/2006 15:08
43.5	20	9/19/2006 14:41	41.4	20	9/19/2006 15:08
41	20	9/19/2006 14:41	41.6	20	9/19/2006 15:08
40.8	20	9/19/2006 14:41	41.3	20	9/19/2006 15:08
41.1	20	9/19/2006 14:41	41.6	20	9/19/2006 15:08
41	20	9/19/2006 14:41	41.7	20	9/19/2006 15:08
41	20	9/19/2006 14:41	41.6	20	9/19/2006 15:09
41	20	9/19/2006 14:41	41.6	20	9/19/2006 15:09
40.9	20	9/19/2006 14:41	41.5	20	9/19/2006 15:09
41	20	9/19/2006 14:41	41.5	20	9/19/2006 15:09
40.8	20	9/19/2006 14:41	41.7	20	9/19/2006 15:09
40.8	20	9/19/2006 14:41	42	20	9/19/2006 15:09
40.6	20	9/19/2006 14:41	41.5	20	9/19/2006 15:09
41	20	9/19/2006 14:41	41.8	20	9/19/2006 15:09
41	20	9/19/2006 14:41	41.7	20	9/19/2006 15:09
40.9	20	9/19/2006 14:41	42	20	9/19/2006 15:09
40.7	20	9/19/2006 14:41	41.6	20	9/19/2006 15:09
40.7	20	9/19/2006 14:41	41.9	20	9/19/2006 15:09
41	20	9/19/2006 14:41	41.6	20	9/19/2006 15:09
40.7	20	9/19/2006 14:41	41.8	20	9/19/2006 15:09
40.9	20	9/19/2006 14:41	41.8	20	9/19/2006 15:09
40.6	20	9/19/2006 14:41	41.7	20	9/19/2006 15:09
40.9	20	9/19/2006 14:41	41.6	20	9/19/2006 15:09
41.2	20	9/19/2006 14:41	41.6	20	9/19/2006 15:09
40.7	20	9/19/2006 14:41	41.8	20	9/19/2006 15:09
40.8	20	9/19/2006 14:41	41.8	20	9/19/2006 15:09
40.9	20	9/19/2006 14:41	41.5	20	9/19/2006 15:09
41	20	9/19/2006 14:41	41.7	20	9/19/2006 15:09
41.1	20	9/19/2006 14:41	41.8	20	9/19/2006 15:09
41.3	20	9/19/2006 14:41	41.7	20	9/19/2006 15:09
43.4	20	9/19/2006 14:41	44.1	20	9/19/2006 15:09
50.7	20	9/19/2006 14:42	50.9	20	9/19/2006 15:09
69.3	20	9/19/2006 14:42	55.3	20	9/19/2006 15:09
56.4	20	9/19/2006 14:42	63.1	20	9/19/2006 15:09
44.1	20	9/19/2006 14:42	47.9	20	9/19/2006 15:09
50.4	20	9/19/2006 14:42	44.1	20	9/19/2006 15:09
126	20	9/19/2006 14:42	66.5	20	9/19/2006 15:09
202	20	9/19/2006 14:42	82.4	20	9/19/2006 15:09
88.7	20	9/19/2006 14:42	87.6	20	9/19/2006 15:09
42	20	9/19/2006 14:42	71.9	20	9/19/2006 15:09
40.9	20	9/19/2006 14:42	48.9	20	9/19/2006 15:10
40.9	20	9/19/2006 14:42	42.9	20	9/19/2006 15:10
41.1	20	9/19/2006 14:42	43.8	20	9/19/2006 15:10
41	20	9/19/2006 14:42	46.5	20	9/19/2006 15:10
40.8	20	9/19/2006 14:42	42.3	20	9/19/2006 15:10
41	20	9/19/2006 14:42	42	20	9/19/2006 15:10
41	20	9/19/2006 14:42	42	20	9/19/2006 15:10
41.5	20	9/19/2006 14:42	41.7	20	9/19/2006 15:10
42.7	20	9/19/2006 14:42	41.9	20	9/19/2006 15:10
42	20	9/19/2006 14:42	41.9	20	9/19/2006 15:10
41.4	20	9/19/2006 14:42	41.8	20	9/19/2006 15:10
40.9	20	9/19/2006 14:42	41.8	20	9/19/2006 15:10
41.7	20	9/19/2006 14:42	41.6	20	9/19/2006 15:10
41.6	20	9/19/2006 14:42	41.6	20	9/19/2006 15:10
40.9	20	9/19/2006 14:42	41.7	20	9/19/2006 15:10

Path Measurement Data Site 2 Path 3			Path Measurement Data Site 2 Path 4		
ppm*m	pathlength	Timestamp (Mountain time)	ppm*m	pathlength	Timestamp (Mountain time)
41.1	20	9/19/2006 14:42	41.7	20	9/19/2006 15:10
41.1	20	9/19/2006 14:42	42	20	9/19/2006 15:10
41	20	9/19/2006 14:42	75	20	9/19/2006 15:10
40.8	20	9/19/2006 14:42	400	20	9/19/2006 15:10
40.8	20	9/19/2006 14:42	1201	20	9/19/2006 15:10
41.1	20	9/19/2006 14:42	373	20	9/19/2006 15:10
41.2	20	9/19/2006 14:42	729	20	9/19/2006 15:10
41.3	20	9/19/2006 14:42	836	20	9/19/2006 15:10
41.2	20	9/19/2006 14:42	851	20	9/19/2006 15:10
41	20	9/19/2006 14:42	506	20	9/19/2006 15:10
41.4	20	9/19/2006 14:43	531	20	9/19/2006 15:10
41	20	9/19/2006 14:43	416	20	9/19/2006 15:10
41	20	9/19/2006 14:43	491	20	9/19/2006 15:10
41.1	20	9/19/2006 14:43	446	20	9/19/2006 15:10
40.8	20	9/19/2006 14:43	510	20	9/19/2006 15:10
40.7	20	9/19/2006 14:43	471	20	9/19/2006 15:10
40.9	20	9/19/2006 14:43	341	20	9/19/2006 15:10
40.9	20	9/19/2006 14:43	266	20	9/19/2006 15:10
41.1	20	9/19/2006 14:43	250	20	9/19/2006 15:10
41.1	20	9/19/2006 14:43	180	20	9/19/2006 15:11
40.9	20	9/19/2006 14:43	173	20	9/19/2006 15:11
41	20	9/19/2006 14:43	112	20	9/19/2006 15:11
41	20	9/19/2006 14:43	120	20	9/19/2006 15:11
41.2	20	9/19/2006 14:43	105	20	9/19/2006 15:11
41	20	9/19/2006 14:43	84.3	20	9/19/2006 15:11
40.8	20	9/19/2006 14:43	80.5	20	9/19/2006 15:11
40.8	20	9/19/2006 14:43	62.7	20	9/19/2006 15:11
40.6	20	9/19/2006 14:43	59.1	20	9/19/2006 15:11
40.9	20	9/19/2006 14:43	58.5	20	9/19/2006 15:11
41	20	9/19/2006 14:43	43.8	20	9/19/2006 15:11
41	20	9/19/2006 14:43	42.6	20	9/19/2006 15:11
40.9	20	9/19/2006 14:43	42.2	20	9/19/2006 15:11
40.8	20	9/19/2006 14:43	42.6	20	9/19/2006 15:11
41.2	20	9/19/2006 14:43	42.1	20	9/19/2006 15:11
41	20	9/19/2006 14:43	42.5	20	9/19/2006 15:11
40.9	20	9/19/2006 14:43	42.2	20	9/19/2006 15:11
41	20	9/19/2006 14:43	42.4	20	9/19/2006 15:11
41	20	9/19/2006 14:43	43.1	20	9/19/2006 15:11
41	20	9/19/2006 14:43	43	20	9/19/2006 15:11
40.9	20	9/19/2006 14:43	42.8	20	9/19/2006 15:11
40.9	20	9/19/2006 14:43	43.3	20	9/19/2006 15:11
41	20	9/19/2006 14:43	45	20	9/19/2006 15:11
41.1	20	9/19/2006 14:43	55.7	20	9/19/2006 15:11
41.1	20	9/19/2006 14:43	258	20	9/19/2006 15:11
41.3	20	9/19/2006 14:44	576	20	9/19/2006 15:11
41.2	20	9/19/2006 14:44	444	20	9/19/2006 15:11
41	20	9/19/2006 14:44	319	20	9/19/2006 15:11
41.1	20	9/19/2006 14:44	309	20	9/19/2006 15:11
40.9	20	9/19/2006 14:44	289	20	9/19/2006 15:11
40.9	20	9/19/2006 14:44	225	20	9/19/2006 15:11
41	20	9/19/2006 14:44	207	20	9/19/2006 15:11
41	20	9/19/2006 14:44	154	20	9/19/2006 15:11
40.9	20	9/19/2006 14:44	133	20	9/19/2006 15:11
41.1	20	9/19/2006 14:44	141	20	9/19/2006 15:12
41.2	20	9/19/2006 14:44	63.6	20	9/19/2006 15:12
40.9	20	9/19/2006 14:44	49.1	20	9/19/2006 15:12
41.9	20	9/19/2006 14:44	42.9	20	9/19/2006 15:12
45.5	20	9/19/2006 14:44	42.7	20	9/19/2006 15:12
46.5	20	9/19/2006 14:44	42.4	20	9/19/2006 15:12
47.6	20	9/19/2006 14:44	42.3	20	9/19/2006 15:12

Path Measurement Data Site 2 Path 3			Path Measurement Data Site 2 Path 4		
ppm*m	pathlength	Timestamp (Mountain time)	ppm*m	pathlength	Timestamp (Mountain time)
46.8	20	9/19/2006 14:44	42.3	20	9/19/2006 15:12
43.8	20	9/19/2006 14:44	42.1	20	9/19/2006 15:12
42.5	20	9/19/2006 14:44	42.2	20	9/19/2006 15:12
42.1	20	9/19/2006 14:44	42.5	20	9/19/2006 15:12
42	20	9/19/2006 14:44	42.1	20	9/19/2006 15:12
42.2	20	9/19/2006 14:44	42.3	20	9/19/2006 15:12
42.4	20	9/19/2006 14:44	42.2	20	9/19/2006 15:12
42.9	20	9/19/2006 14:44	42.3	20	9/19/2006 15:12
42.8	20	9/19/2006 14:44	42.2	20	9/19/2006 15:12
42.8	20	9/19/2006 14:44	42.4	20	9/19/2006 15:12
43.2	20	9/19/2006 14:44	42.1	20	9/19/2006 15:12
42.9	20	9/19/2006 14:44	41.8	20	9/19/2006 15:12
42.6	20	9/19/2006 14:44	41.7	20	9/19/2006 15:12
42.7	20	9/19/2006 14:44	41.9	20	9/19/2006 15:12
43.1	20	9/19/2006 14:44	42	20	9/19/2006 15:12
51.2	20	9/19/2006 14:44	42.1	20	9/19/2006 15:12
65.3	20	9/19/2006 14:44	41.9	20	9/19/2006 15:12
91	20	9/19/2006 14:44	41.8	20	9/19/2006 15:12
86.4	20	9/19/2006 14:45	42	20	9/19/2006 15:12
59.3	20	9/19/2006 14:45	42.1	20	9/19/2006 15:12
49	20	9/19/2006 14:45	42	20	9/19/2006 15:12
46.7	20	9/19/2006 14:45	42	20	9/19/2006 15:12
46	20	9/19/2006 14:45	42	20	9/19/2006 15:12
43.8	20	9/19/2006 14:45	42	20	9/19/2006 15:12
45.1	20	9/19/2006 14:45	42	20	9/19/2006 15:12
49.5	20	9/19/2006 14:45	75.5	20	9/19/2006 15:12
56.4	20	9/19/2006 14:45	318	20	9/19/2006 15:12
67.9	20	9/19/2006 14:45	174	20	9/19/2006 15:13
90.4	20	9/19/2006 14:45	88.7	20	9/19/2006 15:13
73.9	20	9/19/2006 14:45	144	20	9/19/2006 15:13
147	20	9/19/2006 14:45	712	20	9/19/2006 15:13
363	20	9/19/2006 14:45	416	20	9/19/2006 15:13
416	20	9/19/2006 14:45	1220	20	9/19/2006 15:13
267	20	9/19/2006 14:45	485	20	9/19/2006 15:13
141	20	9/19/2006 14:45	264	20	9/19/2006 15:13
121	20	9/19/2006 14:45	173	20	9/19/2006 15:13
107	20	9/19/2006 14:45	103	20	9/19/2006 15:13
89.6	20	9/19/2006 14:45	140	20	9/19/2006 15:13
66	20	9/19/2006 14:45	93.7	20	9/19/2006 15:13
58.5	20	9/19/2006 14:45	403	20	9/19/2006 15:13
56.3	20	9/19/2006 14:45	263	20	9/19/2006 15:13
52.1	20	9/19/2006 14:45	65.9	20	9/19/2006 15:13
50.1	20	9/19/2006 14:45	205	20	9/19/2006 15:13
49.7	20	9/19/2006 14:45	343	20	9/19/2006 15:13
47.8	20	9/19/2006 14:45	604	20	9/19/2006 15:13
46.1	20	9/19/2006 14:45	418	20	9/19/2006 15:13
45.2	20	9/19/2006 14:45	283	20	9/19/2006 15:13
44.1	20	9/19/2006 14:45	263	20	9/19/2006 15:13
44.3	20	9/19/2006 14:45	263	20	9/19/2006 15:13
44	20	9/19/2006 14:45	382	20	9/19/2006 15:13
43.1	20	9/19/2006 14:45	360	20	9/19/2006 15:13
43.1	20	9/19/2006 14:46	266	20	9/19/2006 15:13
42.8	20	9/19/2006 14:46	245	20	9/19/2006 15:13
42.6	20	9/19/2006 14:46	248	20	9/19/2006 15:13
42.5	20	9/19/2006 14:46	239	20	9/19/2006 15:13
65.6	20	9/19/2006 14:46	189	20	9/19/2006 15:13
67.4	20	9/19/2006 14:46	172	20	9/19/2006 15:13
60.4	20	9/19/2006 14:46	147	20	9/19/2006 15:13
55.8	20	9/19/2006 14:46	111	20	9/19/2006 15:13
56.3	20	9/19/2006 14:46	131	20	9/19/2006 15:14

Path Measurement Data Site 2 Path 3			Path Measurement Data Site 2 Path 4		
ppm*m	pathlength	Timestamp (Mountain time)	ppm*m	pathlength	Timestamp (Mountain time)
61.8	20	9/19/2006 14:46	123	20	9/19/2006 15:14
62.3	20	9/19/2006 14:46	67.6	20	9/19/2006 15:14
50.8	20	9/19/2006 14:46	51.9	20	9/19/2006 15:14
57.3	20	9/19/2006 14:46	43.3	20	9/19/2006 15:14
65	20	9/19/2006 14:46	43	20	9/19/2006 15:14
59.3	20	9/19/2006 14:46	42.9	20	9/19/2006 15:14
80.7	20	9/19/2006 14:46	42.8	20	9/19/2006 15:14
70.1	20	9/19/2006 14:46	42.8	20	9/19/2006 15:14
68.8	20	9/19/2006 14:46	42.9	20	9/19/2006 15:14
55.3	20	9/19/2006 14:46	42.4	20	9/19/2006 15:14
48.4	20	9/19/2006 14:46	42.3	20	9/19/2006 15:14
50.1	20	9/19/2006 14:46	42.2	20	9/19/2006 15:14
55.3	20	9/19/2006 14:46	42.2	20	9/19/2006 15:14
180	20	9/19/2006 14:46	42.2	20	9/19/2006 15:14
94.9	20	9/19/2006 14:46	42.4	20	9/19/2006 15:14
61.6	20	9/19/2006 14:46	42.1	20	9/19/2006 15:14
242	20	9/19/2006 14:46	42.2	20	9/19/2006 15:14
425	20	9/19/2006 14:46	42.4	20	9/19/2006 15:14
455	20	9/19/2006 14:46	41.9	20	9/19/2006 15:14
292	20	9/19/2006 14:46	42	20	9/19/2006 15:14
262	20	9/19/2006 14:46	42	20	9/19/2006 15:14
196	20	9/19/2006 14:46	41.9	20	9/19/2006 15:14
154	20	9/19/2006 14:46	41.8	20	9/19/2006 15:14
124	20	9/19/2006 14:46	42	20	9/19/2006 15:14
50.6	20	9/19/2006 14:46	41.9	20	9/19/2006 15:14
42.2	20	9/19/2006 14:46	42	20	9/19/2006 15:14
41	20	9/19/2006 14:47	41.9	20	9/19/2006 15:14
41.3	20	9/19/2006 14:47	42.2	20	9/19/2006 15:14
41.2	20	9/19/2006 14:47	42.3	20	9/19/2006 15:14
41.5	20	9/19/2006 14:47	42	20	9/19/2006 15:14
41.2	20	9/19/2006 14:47	42.3	20	9/19/2006 15:14
42.9	20	9/19/2006 14:47	42.4	20	9/19/2006 15:14
44.4	20	9/19/2006 14:47	42.1	20	9/19/2006 15:14
51.4	20	9/19/2006 14:47	42.2	20	9/19/2006 15:15
69.3	20	9/19/2006 14:47	42.5	20	9/19/2006 15:15
86.1	20	9/19/2006 14:47	42.2	20	9/19/2006 15:15
100	20	9/19/2006 14:47	42.4	20	9/19/2006 15:15
92.1	20	9/19/2006 14:47	43	20	9/19/2006 15:15
87.9	20	9/19/2006 14:47	43.8	20	9/19/2006 15:15
77.5	20	9/19/2006 14:47	64.8	20	9/19/2006 15:15
93.5	20	9/19/2006 14:47	74.6	20	9/19/2006 15:15
75.5	20	9/19/2006 14:47	108	20	9/19/2006 15:15
64.9	20	9/19/2006 14:47	130	20	9/19/2006 15:15
61.2	20	9/19/2006 14:47	220	20	9/19/2006 15:15
63.4	20	9/19/2006 14:47	180	20	9/19/2006 15:15
64.7	20	9/19/2006 14:47	197	20	9/19/2006 15:15
60.4	20	9/19/2006 14:47	411	20	9/19/2006 15:15
53.2	20	9/19/2006 14:47	1278	20	9/19/2006 15:15
46.8	20	9/19/2006 14:47	1015	20	9/19/2006 15:15
42.9	20	9/19/2006 14:47	373	20	9/19/2006 15:15
41.1	20	9/19/2006 14:47	138	20	9/19/2006 15:15
41.1	20	9/19/2006 14:47	159	20	9/19/2006 15:15
41	20	9/19/2006 14:47	79.7	20	9/19/2006 15:15
41	20	9/19/2006 14:47	86.2	20	9/19/2006 15:15
41.2	20	9/19/2006 14:47	115	20	9/19/2006 15:15
40.9	20	9/19/2006 14:47	221	20	9/19/2006 15:15
40.7	20	9/19/2006 14:47	165	20	9/19/2006 15:15
41.2	20	9/19/2006 14:47	67.4	20	9/19/2006 15:15
41	20	9/19/2006 14:47	99	20	9/19/2006 15:15
41.2	20	9/19/2006 14:48	60.5	20	9/19/2006 15:15

Path Measurement Data Site 2 Path 3			Path Measurement Data Site 2 Path 4		
ppm*m	pathlength	Timestamp (Mountain time)	ppm*m	pathlength	Timestamp (Mountain time)
40.9	20	9/19/2006 14:48	44.9	20	9/19/2006 15:15
41	20	9/19/2006 14:48	44	20	9/19/2006 15:15
41	20	9/19/2006 14:48	50.4	20	9/19/2006 15:15
41.3	20	9/19/2006 14:48	78.1	20	9/19/2006 15:15
41.3	20	9/19/2006 14:48	97	20	9/19/2006 15:15
41.1	20	9/19/2006 14:48	68.6	20	9/19/2006 15:15
40.8	20	9/19/2006 14:48	52	20	9/19/2006 15:15
41	20	9/19/2006 14:48	50.9	20	9/19/2006 15:16
41.3	20	9/19/2006 14:48	48.4	20	9/19/2006 15:16
41.3	20	9/19/2006 14:48	65.8	20	9/19/2006 15:16
41.4	20	9/19/2006 14:48	64.8	20	9/19/2006 15:16
41.2	20	9/19/2006 14:48	50.2	20	9/19/2006 15:16
40.9	20	9/19/2006 14:48	42.7	20	9/19/2006 15:16
40.6	20	9/19/2006 14:48	42.3	20	9/19/2006 15:16
41.2	20	9/19/2006 14:48	42.4	20	9/19/2006 15:16
41.1	20	9/19/2006 14:48	42.5	20	9/19/2006 15:16
88.1	20	9/19/2006 14:48	42.8	20	9/19/2006 15:16
279	20	9/19/2006 14:48	42.3	20	9/19/2006 15:16
576	20	9/19/2006 14:48	42.2	20	9/19/2006 15:16
550	20	9/19/2006 14:48	42.2	20	9/19/2006 15:16
507	20	9/19/2006 14:48	42.9	20	9/19/2006 15:16
406	20	9/19/2006 14:48	42.9	20	9/19/2006 15:16
435	20	9/19/2006 14:48	42.9	20	9/19/2006 15:16
382	20	9/19/2006 14:48	42.9	20	9/19/2006 15:16
419	20	9/19/2006 14:48	42.9	20	9/19/2006 15:16
426	20	9/19/2006 14:48	42.8	20	9/19/2006 15:16
438	20	9/19/2006 14:48	43	20	9/19/2006 15:16
343	20	9/19/2006 14:48	42.9	20	9/19/2006 15:16
323	20	9/19/2006 14:48	42.8	20	9/19/2006 15:16
244	20	9/19/2006 14:48	42.9	20	9/19/2006 15:16
221	20	9/19/2006 14:48	42.8	20	9/19/2006 15:16
198	20	9/19/2006 14:48	42.7	20	9/19/2006 15:16
221	20	9/19/2006 14:49	42.8	20	9/19/2006 15:16
196	20	9/19/2006 14:49	42.7	20	9/19/2006 15:16
279	20	9/19/2006 14:49	42.7	20	9/19/2006 15:16
589	20	9/19/2006 14:49	42.6	20	9/19/2006 15:16
502	20	9/19/2006 14:49	42.9	20	9/19/2006 15:16
399	20	9/19/2006 14:49	42.9	20	9/19/2006 15:16
211	20	9/19/2006 14:49	42.8	20	9/19/2006 15:16
246	20	9/19/2006 14:49	43	20	9/19/2006 15:16
843	20	9/19/2006 14:49	43.1	20	9/19/2006 15:17
501	20	9/19/2006 14:49	42.8	20	9/19/2006 15:17
357	20	9/19/2006 14:49	43	20	9/19/2006 15:17
256	20	9/19/2006 14:49	42.9	20	9/19/2006 15:17
153	20	9/19/2006 14:49	42.9	20	9/19/2006 15:17
94.3	20	9/19/2006 14:49	43	20	9/19/2006 15:17
76.6	20	9/19/2006 14:49	42.3	20	9/19/2006 15:17
69.3	20	9/19/2006 14:49	43	20	9/19/2006 15:17
64.6	20	9/19/2006 14:49	43	20	9/19/2006 15:17
62	20	9/19/2006 14:49	42.9	20	9/19/2006 15:17
60	20	9/19/2006 14:49	42.6	20	9/19/2006 15:17
127	20	9/19/2006 14:49	42.4	20	9/19/2006 15:17
245	20	9/19/2006 14:49	42.8	20	9/19/2006 15:17
117	20	9/19/2006 14:49	43	20	9/19/2006 15:17
111	20	9/19/2006 14:49	42.8	20	9/19/2006 15:17
133	20	9/19/2006 14:49	42.8	20	9/19/2006 15:17
94	20	9/19/2006 14:49	42.7	20	9/19/2006 15:17
78.4	20	9/19/2006 14:49	42.8	20	9/19/2006 15:17
118	20	9/19/2006 14:49	42.7	20	9/19/2006 15:17
154	20	9/19/2006 14:49	42.7	20	9/19/2006 15:17

Path Measurement Data Site 2 Path 3			Path Measurement Data Site 2 Path 4		
ppm*m	pathlength	Timestamp (Mountain time)	ppm*m	pathlength	Timestamp (Mountain time)
596	20	9/19/2006 14:49	42.6	20	9/19/2006 15:17
636	20	9/19/2006 14:49	42.9	20	9/19/2006 15:17
505	20	9/19/2006 14:49	42.9	20	9/19/2006 15:17
792	20	9/19/2006 14:49	42.4	20	9/19/2006 15:17
371	20	9/19/2006 14:49	43	20	9/19/2006 15:17
744	20	9/19/2006 14:49	42.8	20	9/19/2006 15:17
574	20	9/19/2006 14:50	42.4	20	9/19/2006 15:17
365	20	9/19/2006 14:50	42.6	20	9/19/2006 15:17
259	20	9/19/2006 14:50	42.4	20	9/19/2006 15:17
405	20	9/19/2006 14:50	42.9	20	9/19/2006 15:17
280	20	9/19/2006 14:50	42.9	20	9/19/2006 15:17
865	20	9/19/2006 14:50	43.2	20	9/19/2006 15:17
1004	20	9/19/2006 14:50	43.5	20	9/19/2006 15:17
721	20	9/19/2006 14:50	43.4	20	9/19/2006 15:18
488	20	9/19/2006 14:50	43.1	20	9/19/2006 15:18
254	20	9/19/2006 14:50	43.1	20	9/19/2006 15:18
139	20	9/19/2006 14:50	43.5	20	9/19/2006 15:18
119	20	9/19/2006 14:50	43.2	20	9/19/2006 15:18
105	20	9/19/2006 14:50	43	20	9/19/2006 15:18
106	20	9/19/2006 14:50	43.5	20	9/19/2006 15:18
111	20	9/19/2006 14:50	43.5	20	9/19/2006 15:18
149	20	9/19/2006 14:50	43.3	20	9/19/2006 15:18
164	20	9/19/2006 14:50	43.1	20	9/19/2006 15:18
145	20	9/19/2006 14:50	43.4	20	9/19/2006 15:18
323	20	9/19/2006 14:50	43.3	20	9/19/2006 15:18
417	20	9/19/2006 14:50	43.3	20	9/19/2006 15:18
374	20	9/19/2006 14:50	43.3	20	9/19/2006 15:18
456	20	9/19/2006 14:50	43.4	20	9/19/2006 15:18
653	20	9/19/2006 14:50	43.4	20	9/19/2006 15:18
664	20	9/19/2006 14:50	43.2	20	9/19/2006 15:18
637	20	9/19/2006 14:50	43.5	20	9/19/2006 15:18
1023	20	9/19/2006 14:50	43.3	20	9/19/2006 15:18
1163	20	9/19/2006 14:50	43.4	20	9/19/2006 15:18
397	20	9/19/2006 14:50	43.1	20	9/19/2006 15:18
499	20	9/19/2006 14:50	43.4	20	9/19/2006 15:18
890	20	9/19/2006 14:50	43.3	20	9/19/2006 15:18
660	20	9/19/2006 14:50	43.5	20	9/19/2006 15:18
317	20	9/19/2006 14:50	43.4	20	9/19/2006 15:18
404	20	9/19/2006 14:50	43.6	20	9/19/2006 15:18
683	20	9/19/2006 14:51	43.1	20	9/19/2006 15:18
701	20	9/19/2006 14:51	43.2	20	9/19/2006 15:18
391	20	9/19/2006 14:51	43	20	9/19/2006 15:18
716	20	9/19/2006 14:51	43.4	20	9/19/2006 15:18
553	20	9/19/2006 14:51	43.1	20	9/19/2006 15:18
636	20	9/19/2006 14:51	43.1	20	9/19/2006 15:18
574	20	9/19/2006 14:51	43.5	20	9/19/2006 15:18
836	20	9/19/2006 14:51	43.8	20	9/19/2006 15:18
884	20	9/19/2006 14:51			
375	20	9/19/2006 14:51			
214	20	9/19/2006 14:51			
145	20	9/19/2006 14:51			
111	20	9/19/2006 14:51			
127	20	9/19/2006 14:51			
163	20	9/19/2006 14:51			
108	20	9/19/2006 14:51			
80	20	9/19/2006 14:51			
89.3	20	9/19/2006 14:51			
71.4	20	9/19/2006 14:51			
58	20	9/19/2006 14:51			
60.8	20	9/19/2006 14:51			

Path Measurement Data Site 2 Path 3			Path Measurement Data Site 2 Path 4		
ppm*m	pathlength	Timestamp (Mountain time)	ppm*m	pathlength	Timestamp (Mountain time)
55.6	20	9/19/2006 14:51			
66.3	20	9/19/2006 14:51			
91.7	20	9/19/2006 14:51			
123	20	9/19/2006 14:51			
114	20	9/19/2006 14:51			
109	20	9/19/2006 14:51			
96	20	9/19/2006 14:51			
92.8	20	9/19/2006 14:51			
96.6	20	9/19/2006 14:51			
84.8	20	9/19/2006 14:51			
77.1	20	9/19/2006 14:51			
68.5	20	9/19/2006 14:51			
73.2	20	9/19/2006 14:51			
71.7	20	9/19/2006 14:52			
76.7	20	9/19/2006 14:52			
78	20	9/19/2006 14:52			
91.9	20	9/19/2006 14:52			
125	20	9/19/2006 14:52			
117	20	9/19/2006 14:52			
149	20	9/19/2006 14:52			
262	20	9/19/2006 14:52			
279	20	9/19/2006 14:52			
469	20	9/19/2006 14:52			
495	20	9/19/2006 14:52			
260	20	9/19/2006 14:52			
260	20	9/19/2006 14:52			
528	20	9/19/2006 14:52			
1027	20	9/19/2006 14:52			
698	20	9/19/2006 14:52			
228	20	9/19/2006 14:52			
143	20	9/19/2006 14:52			
110	20	9/19/2006 14:52			
76.4	20	9/19/2006 14:52			
221	20	9/19/2006 14:52			
270	20	9/19/2006 14:52			
208	20	9/19/2006 14:52			
178	20	9/19/2006 14:52			
185	20	9/19/2006 14:52			
186	20	9/19/2006 14:52			
203	20	9/19/2006 14:52			
185	20	9/19/2006 14:52			
147	20	9/19/2006 14:52			
128	20	9/19/2006 14:52			
112	20	9/19/2006 14:52			
91.5	20	9/19/2006 14:52			
81.9	20	9/19/2006 14:52			
72.4	20	9/19/2006 14:52			
63.6	20	9/19/2006 14:53			
52.6	20	9/19/2006 14:53			
48.1	20	9/19/2006 14:53			
44.4	20	9/19/2006 14:53			
43.6	20	9/19/2006 14:53			
50.6	20	9/19/2006 14:53			
114	20	9/19/2006 14:53			
238	20	9/19/2006 14:53			
223	20	9/19/2006 14:53			
141	20	9/19/2006 14:53			
104	20	9/19/2006 14:53			
122	20	9/19/2006 14:53			
110	20	9/19/2006 14:53			



Path Measurement Data Site 2 Path 3			Path Measurement Data Site 2 Path 4		
ppm*m	pathlength	Timestamp (Mountain time)	ppm*m	pathlength	Timestamp (Mountain time)
114	20	9/19/2006 14:53			
184	20	9/19/2006 14:53			
316	20	9/19/2006 14:53			
277	20	9/19/2006 14:53			
192	20	9/19/2006 14:53			
178	20	9/19/2006 14:53			
95.6	20	9/19/2006 14:53			
83.2	20	9/19/2006 14:53			
47.6	20	9/19/2006 14:53			
78.6	20	9/19/2006 14:53			
104	20	9/19/2006 14:53			
48.4	20	9/19/2006 14:53			
196	20	9/19/2006 14:53			
1576	20	9/19/2006 14:53			
957	20	9/19/2006 14:53			
649	20	9/19/2006 14:53			
596	20	9/19/2006 14:53			
462	20	9/19/2006 14:53			
531	20	9/19/2006 14:53			
604	20	9/19/2006 14:53			
634	20	9/19/2006 14:54			
515	20	9/19/2006 14:54			
299	20	9/19/2006 14:54			
176	20	9/19/2006 14:54			
180	20	9/19/2006 14:54			
217	20	9/19/2006 14:54			
179	20	9/19/2006 14:54			

Path Measurement Data Site 3 Path 1			Path Measurement Data Site 3 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
29.8	14.6	9/20/2006 8:03	2679	19	9/20/2006 8:29
29.8	14.6	9/20/2006 8:03	2382	19	9/20/2006 8:29
29.7	14.6	9/20/2006 8:03	1375	19	9/20/2006 8:29
29.8	14.6	9/20/2006 8:03	834	19	9/20/2006 8:29
29.6	14.6	9/20/2006 8:03	521	19	9/20/2006 8:29
29.9	14.6	9/20/2006 8:03	675	19	9/20/2006 8:29
29.8	14.6	9/20/2006 8:03	269	19	9/20/2006 8:29
30	14.6	9/20/2006 8:03	89	19	9/20/2006 8:29
29.9	14.6	9/20/2006 8:03	64.8	19	9/20/2006 8:30
29.6	14.6	9/20/2006 8:03	60.9	19	9/20/2006 8:30
29.7	14.6	9/20/2006 8:03	57.3	19	9/20/2006 8:30
29.7	14.6	9/20/2006 8:03	49.2	19	9/20/2006 8:30
29.7	14.6	9/20/2006 8:03	2654	19	9/20/2006 8:31
29.9	14.6	9/20/2006 8:04	1633	19	9/20/2006 8:31
29.7	14.6	9/20/2006 8:04	966	19	9/20/2006 8:31
29.8	14.6	9/20/2006 8:04	853	19	9/20/2006 8:31
29.8	14.6	9/20/2006 8:04	724	19	9/20/2006 8:31
29.7	14.6	9/20/2006 8:04	646	19	9/20/2006 8:31
29.9	14.6	9/20/2006 8:04	740	19	9/20/2006 8:31
29.3	14.6	9/20/2006 8:04	613	19	9/20/2006 8:31
29.4	14.6	9/20/2006 8:04	612	19	9/20/2006 8:31
29.4	14.6	9/20/2006 8:04	744	19	9/20/2006 8:31
29.5	14.6	9/20/2006 8:04	350	19	9/20/2006 8:31
29.5	14.6	9/20/2006 8:04	76.1	19	9/20/2006 8:31
29.6	14.6	9/20/2006 8:04	58.3	19	9/20/2006 8:31
29.5	14.6	9/20/2006 8:04	43.4	19	9/20/2006 8:31
29.6	14.6	9/20/2006 8:04	40.3	19	9/20/2006 8:31
29.5	14.6	9/20/2006 8:04	39.9	19	9/20/2006 8:31
29.6	14.6	9/20/2006 8:04	40	19	9/20/2006 8:31
29.5	14.6	9/20/2006 8:04	41.9	19	9/20/2006 8:31
29.4	14.6	9/20/2006 8:04	42.2	19	9/20/2006 8:31
29.7	14.6	9/20/2006 8:04	42.9	19	9/20/2006 8:31
29.3	14.6	9/20/2006 8:04	47.9	19	9/20/2006 8:31
29.4	14.6	9/20/2006 8:04	51.2	19	9/20/2006 8:31
29.4	14.6	9/20/2006 8:04	52	19	9/20/2006 8:31
29.3	14.6	9/20/2006 8:04	50.5	19	9/20/2006 8:31
29.4	14.6	9/20/2006 8:04	51.5	19	9/20/2006 8:31
29.4	14.6	9/20/2006 8:04	52.8	19	9/20/2006 8:32
29.5	14.6	9/20/2006 8:04	56	19	9/20/2006 8:32
29.6	14.6	9/20/2006 8:04	57.3	19	9/20/2006 8:32
29.6	14.6	9/20/2006 8:04	58.1	19	9/20/2006 8:32
29.3	14.6	9/20/2006 8:04	56.1	19	9/20/2006 8:32
29.7	14.6	9/20/2006 8:04	50.6	19	9/20/2006 8:32
29.4	14.6	9/20/2006 8:04	50.5	19	9/20/2006 8:32
29.4	14.6	9/20/2006 8:04	51.1	19	9/20/2006 8:32
29.4	14.6	9/20/2006 8:04	49.8	19	9/20/2006 8:32
29.6	14.6	9/20/2006 8:04	55.9	19	9/20/2006 8:32
29.6	14.6	9/20/2006 8:04	56.3	19	9/20/2006 8:32
29.5	14.6	9/20/2006 8:05	54.1	19	9/20/2006 8:32
29.6	14.6	9/20/2006 8:05	52.7	19	9/20/2006 8:32
30.4	14.6	9/20/2006 8:05	47.2	19	9/20/2006 8:32
30.1	14.6	9/20/2006 8:05	1482	19	9/20/2006 8:32
30	14.6	9/20/2006 8:05	461	19	9/20/2006 8:32
30.1	14.6	9/20/2006 8:05	594	19	9/20/2006 8:32
30.2	14.6	9/20/2006 8:05	474	19	9/20/2006 8:32
30.3	14.6	9/20/2006 8:05	404	19	9/20/2006 8:32
30.1	14.6	9/20/2006 8:05	463	19	9/20/2006 8:32
30.2	14.6	9/20/2006 8:05	337	19	9/20/2006 8:32
30.1	14.6	9/20/2006 8:05	165	19	9/20/2006 8:32
30.1	14.6	9/20/2006 8:05	52.1	19	9/20/2006 8:32

Path Measurement Data Site 3 Path 1			Path Measurement Data Site 3 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
30.4	14.6	9/20/2006 8:05	39.7	19	9/20/2006 8:32
30.1	14.6	9/20/2006 8:05	39.6	19	9/20/2006 8:32
30.3	14.6	9/20/2006 8:05	39.5	19	9/20/2006 8:32
30.3	14.6	9/20/2006 8:05	39.1	19	9/20/2006 8:32
30.1	14.6	9/20/2006 8:05	39.2	19	9/20/2006 8:32
30.1	14.6	9/20/2006 8:05	39.3	19	9/20/2006 8:32
30.2	14.6	9/20/2006 8:05	39.3	19	9/20/2006 8:32
30.1	14.6	9/20/2006 8:05	39.3	19	9/20/2006 8:32
30.4	14.6	9/20/2006 8:05	39.6	19	9/20/2006 8:32
30	14.6	9/20/2006 8:05	39.4	19	9/20/2006 8:32
30.2	14.6	9/20/2006 8:05	39.5	19	9/20/2006 8:33
30	14.6	9/20/2006 8:05	39.3	19	9/20/2006 8:33
30.3	14.6	9/20/2006 8:05	39.5	19	9/20/2006 8:33
30.1	14.6	9/20/2006 8:05	39.3	19	9/20/2006 8:33
30.2	14.6	9/20/2006 8:05	39.1	19	9/20/2006 8:33
29.9	14.6	9/20/2006 8:05	39.5	19	9/20/2006 8:33
30.3	14.6	9/20/2006 8:05	39.3	19	9/20/2006 8:33
30.3	14.6	9/20/2006 8:05	39.5	19	9/20/2006 8:33
30.3	14.6	9/20/2006 8:05	107	19	9/20/2006 8:33
30.1	14.6	9/20/2006 8:05	120	19	9/20/2006 8:33
30.2	14.6	9/20/2006 8:05	817	19	9/20/2006 8:33
30.1	14.6	9/20/2006 8:05	1604	19	9/20/2006 8:33
30.2	14.6	9/20/2006 8:06	638	19	9/20/2006 8:33
30.1	14.6	9/20/2006 8:06	2385	19	9/20/2006 8:33
30.1	14.6	9/20/2006 8:06	1763	19	9/20/2006 8:33
30.3	14.6	9/20/2006 8:06	1258	19	9/20/2006 8:33
30.3	14.6	9/20/2006 8:06	764	19	9/20/2006 8:33
30.1	14.6	9/20/2006 8:06	393	19	9/20/2006 8:33
30.1	14.6	9/20/2006 8:06	289	19	9/20/2006 8:33
30.3	14.6	9/20/2006 8:06	225	19	9/20/2006 8:33
30.2	14.6	9/20/2006 8:06	736	19	9/20/2006 8:33
30.1	14.6	9/20/2006 8:06	2220	19	9/20/2006 8:33
30.2	14.6	9/20/2006 8:06	2755	19	9/20/2006 8:33
29.9	14.6	9/20/2006 8:06	1630	19	9/20/2006 8:33
30.2	14.6	9/20/2006 8:06	1360	19	9/20/2006 8:33
30.1	14.6	9/20/2006 8:06	2757	19	9/20/2006 8:33
30.2	14.6	9/20/2006 8:06	2782	19	9/20/2006 8:33
29.9	14.6	9/20/2006 8:06	2197	19	9/20/2006 8:33
30	14.6	9/20/2006 8:06	1869	19	9/20/2006 8:33
30.2	14.6	9/20/2006 8:06	1925	19	9/20/2006 8:33
29.6	14.6	9/20/2006 8:06	1632	19	9/20/2006 8:33
29.7	14.6	9/20/2006 8:06	1310	19	9/20/2006 8:33
29.5	14.6	9/20/2006 8:06	1059	19	9/20/2006 8:33
29.6	14.6	9/20/2006 8:06	957	19	9/20/2006 8:34
29.6	14.6	9/20/2006 8:06	831	19	9/20/2006 8:34
29.7	14.6	9/20/2006 8:06	666	19	9/20/2006 8:34
29.6	14.6	9/20/2006 8:06	589	19	9/20/2006 8:34
29.6	14.6	9/20/2006 8:06	801	19	9/20/2006 8:34
29.6	14.6	9/20/2006 8:06	448	19	9/20/2006 8:34
29.5	14.6	9/20/2006 8:06	133	19	9/20/2006 8:34
29.7	14.6	9/20/2006 8:06	205	19	9/20/2006 8:34
29.7	14.6	9/20/2006 8:06	205	19	9/20/2006 8:34
29.8	14.6	9/20/2006 8:06	271	19	9/20/2006 8:34
29.6	14.6	9/20/2006 8:06	256	19	9/20/2006 8:34
142	14.6	9/20/2006 8:06	281	19	9/20/2006 8:34
2141	14.6	9/20/2006 8:06	267	19	9/20/2006 8:34
1128	14.6	9/20/2006 8:07	193	19	9/20/2006 8:34
589	14.6	9/20/2006 8:07	227	19	9/20/2006 8:34
376	14.6	9/20/2006 8:07	194	19	9/20/2006 8:34
252	14.6	9/20/2006 8:07	172	19	9/20/2006 8:34

Path Measurement Data Site 3 Path 1			Path Measurement Data Site 3 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
251	14.6	9/20/2006 8:07	179	19	9/20/2006 8:34
281	14.6	9/20/2006 8:07	178	19	9/20/2006 8:34
111	14.6	9/20/2006 8:07	136	19	9/20/2006 8:34
35.4	14.6	9/20/2006 8:07	155	19	9/20/2006 8:34
29.7	14.6	9/20/2006 8:08	105	19	9/20/2006 8:34
29.9	14.6	9/20/2006 8:08	325	19	9/20/2006 8:34
30.1	14.6	9/20/2006 8:08	494	19	9/20/2006 8:34
30.1	14.6	9/20/2006 8:08	630	19	9/20/2006 8:34
30	14.6	9/20/2006 8:08	862	19	9/20/2006 8:34
29.6	14.6	9/20/2006 8:08	879	19	9/20/2006 8:34
29.9	14.6	9/20/2006 8:08	541	19	9/20/2006 8:34
30.3	14.6	9/20/2006 8:08	855	19	9/20/2006 8:34
29.8	14.6	9/20/2006 8:08	1671	19	9/20/2006 8:34
30	14.6	9/20/2006 8:08	681	19	9/20/2006 8:34
29.8	14.6	9/20/2006 8:09	1758	19	9/20/2006 8:34
30.1	14.6	9/20/2006 8:09	1124	19	9/20/2006 8:34
29.9	14.6	9/20/2006 8:09	1461	19	9/20/2006 8:35
29.8	14.6	9/20/2006 8:09	1136	19	9/20/2006 8:35
29.9	14.6	9/20/2006 8:09	999	19	9/20/2006 8:35
29.7	14.6	9/20/2006 8:09	2120	19	9/20/2006 8:35
29.9	14.6	9/20/2006 8:09	2553	19	9/20/2006 8:35
29.6	14.6	9/20/2006 8:09	2488	19	9/20/2006 8:35
29.9	14.6	9/20/2006 8:09	2359	19	9/20/2006 8:35
29.8	14.6	9/20/2006 8:09	1905	19	9/20/2006 8:35
29.8	14.6	9/20/2006 8:09	1699	19	9/20/2006 8:35
30	14.6	9/20/2006 8:09	1834	19	9/20/2006 8:35
29.9	14.6	9/20/2006 8:09	1210	19	9/20/2006 8:35
29.9	14.6	9/20/2006 8:09	555	19	9/20/2006 8:35
29.7	14.6	9/20/2006 8:09	414	19	9/20/2006 8:35
31.7	14.6	9/20/2006 8:09	579	19	9/20/2006 8:35
32.1	14.6	9/20/2006 8:09	794	19	9/20/2006 8:35
33	14.6	9/20/2006 8:09	1119	19	9/20/2006 8:35
34.9	14.6	9/20/2006 8:09	2049	19	9/20/2006 8:35
34.7	14.6	9/20/2006 8:09	2258	19	9/20/2006 8:35
34	14.6	9/20/2006 8:09	2122	19	9/20/2006 8:35
33.7	14.6	9/20/2006 8:09	1033	19	9/20/2006 8:35
33.8	14.6	9/20/2006 8:09	1347	19	9/20/2006 8:35
34.4	14.6	9/20/2006 8:09	716	19	9/20/2006 8:35
34.6	14.6	9/20/2006 8:09	495	19	9/20/2006 8:35
32.8	14.6	9/20/2006 8:09	1502	19	9/20/2006 8:35
30.1	14.6	9/20/2006 8:09	704	19	9/20/2006 8:35
29.7	14.6	9/20/2006 8:09	507	19	9/20/2006 8:35
29.4	14.6	9/20/2006 8:09	723	19	9/20/2006 8:35
29.8	14.6	9/20/2006 8:09	1096	19	9/20/2006 8:35
29.5	14.6	9/20/2006 8:09	976	19	9/20/2006 8:35
29.5	14.6	9/20/2006 8:09	1677	19	9/20/2006 8:35
29.7	14.6	9/20/2006 8:09	1159	19	9/20/2006 8:35
29.5	14.6	9/20/2006 8:09	830	19	9/20/2006 8:35
29.9	14.6	9/20/2006 8:10	645	19	9/20/2006 8:36
29.5	14.6	9/20/2006 8:10	303	19	9/20/2006 8:36
29.6	14.6	9/20/2006 8:10	234	19	9/20/2006 8:36
29.7	14.6	9/20/2006 8:10	191	19	9/20/2006 8:36
29.8	14.6	9/20/2006 8:10	54.3	19	9/20/2006 8:36
29.9	14.6	9/20/2006 8:10	46.9	19	9/20/2006 8:36
29.4	14.6	9/20/2006 8:10	44	19	9/20/2006 8:36
29.4	14.6	9/20/2006 8:10	43.5	19	9/20/2006 8:36
29.2	14.6	9/20/2006 8:10	42.7	19	9/20/2006 8:36
29.4	14.6	9/20/2006 8:10	41.4	19	9/20/2006 8:36
29.1	14.6	9/20/2006 8:10	41.8	19	9/20/2006 8:36
29.5	14.6	9/20/2006 8:10	42.8	19	9/20/2006 8:36

Path Measurement Data Site 3 Path 1			Path Measurement Data Site 3 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
29.2	14.6	9/20/2006 8:10	43.9	19	9/20/2006 8:36
29.1	14.6	9/20/2006 8:10	49.1	19	9/20/2006 8:36
29.1	14.6	9/20/2006 8:10	49.9	19	9/20/2006 8:36
29.2	14.6	9/20/2006 8:10	50.5	19	9/20/2006 8:36
29.4	14.6	9/20/2006 8:10	57.5	19	9/20/2006 8:36
29.2	14.6	9/20/2006 8:10	60.5	19	9/20/2006 8:36
29.3	14.6	9/20/2006 8:10	57.3	19	9/20/2006 8:36
29.2	14.6	9/20/2006 8:10	49.7	19	9/20/2006 8:36
29.3	14.6	9/20/2006 8:10	47.1	19	9/20/2006 8:36
29.4	14.6	9/20/2006 8:10	53.6	19	9/20/2006 8:36
29.4	14.6	9/20/2006 8:10	49.4	19	9/20/2006 8:36
29	14.6	9/20/2006 8:10	43.1	19	9/20/2006 8:36
29.2	14.6	9/20/2006 8:10	41	19	9/20/2006 8:36
29.2	14.6	9/20/2006 8:10	40.6	19	9/20/2006 8:36
29.4	14.6	9/20/2006 8:10	45	19	9/20/2006 8:36
29	14.6	9/20/2006 8:10	121	19	9/20/2006 8:36
29.1	14.6	9/20/2006 8:10	1927	19	9/20/2006 8:36
29.1	14.6	9/20/2006 8:10	1691	19	9/20/2006 8:36
29.3	14.6	9/20/2006 8:10	2000	19	9/20/2006 8:36
29.2	14.6	9/20/2006 8:10	1402	19	9/20/2006 8:36
29.2	14.6	9/20/2006 8:10	544	19	9/20/2006 8:36
29.3	14.6	9/20/2006 8:10	256	19	9/20/2006 8:37
29.3	14.6	9/20/2006 8:11	114	19	9/20/2006 8:37
29.2	14.6	9/20/2006 8:11	286	19	9/20/2006 8:37
29.3	14.6	9/20/2006 8:11	447	19	9/20/2006 8:37
29.1	14.6	9/20/2006 8:11	1020	19	9/20/2006 8:37
29.1	14.6	9/20/2006 8:11	1049	19	9/20/2006 8:37
29.1	14.6	9/20/2006 8:11	429	19	9/20/2006 8:37
29.4	14.6	9/20/2006 8:11	341	19	9/20/2006 8:37
29.5	14.6	9/20/2006 8:11	286	19	9/20/2006 8:37
29.3	14.6	9/20/2006 8:11	225	19	9/20/2006 8:37
29.2	14.6	9/20/2006 8:11	147	19	9/20/2006 8:37
29.2	14.6	9/20/2006 8:11	113	19	9/20/2006 8:37
29.1	14.6	9/20/2006 8:11	108	19	9/20/2006 8:37
29.3	14.6	9/20/2006 8:11	104	19	9/20/2006 8:37
29.5	14.6	9/20/2006 8:11	100	19	9/20/2006 8:37
29.4	14.6	9/20/2006 8:11	82.9	19	9/20/2006 8:37
29.3	14.6	9/20/2006 8:11	72.1	19	9/20/2006 8:37
29.2	14.6	9/20/2006 8:11	62.7	19	9/20/2006 8:37
29.1	14.6	9/20/2006 8:11	60.4	19	9/20/2006 8:37
29.2	14.6	9/20/2006 8:11	64.7	19	9/20/2006 8:37
29.2	14.6	9/20/2006 8:11	61.1	19	9/20/2006 8:37
29.2	14.6	9/20/2006 8:11	54.9	19	9/20/2006 8:37
29.2	14.6	9/20/2006 8:11	54	19	9/20/2006 8:37
28.9	14.6	9/20/2006 8:11	54.6	19	9/20/2006 8:37
29.1	14.6	9/20/2006 8:11	52.1	19	9/20/2006 8:37
29.1	14.6	9/20/2006 8:11	52.6	19	9/20/2006 8:37
28.9	14.6	9/20/2006 8:11	109	19	9/20/2006 8:37
28.9	14.6	9/20/2006 8:11	417	19	9/20/2006 8:37
28.9	14.6	9/20/2006 8:11	442	19	9/20/2006 8:37
28.8	14.6	9/20/2006 8:11	699	19	9/20/2006 8:37
28.9	14.6	9/20/2006 8:11	569	19	9/20/2006 8:37
29	14.6	9/20/2006 8:11	1535	19	9/20/2006 8:37
28.9	14.6	9/20/2006 8:11	1141	19	9/20/2006 8:37
29	14.6	9/20/2006 8:11	1436	19	9/20/2006 8:37
28.8	14.6	9/20/2006 8:11	1933	19	9/20/2006 8:38
28.9	14.6	9/20/2006 8:12	1576	19	9/20/2006 8:38
29	14.6	9/20/2006 8:12	1704	19	9/20/2006 8:38
28.9	14.6	9/20/2006 8:12	1115	19	9/20/2006 8:38
28.9	14.6	9/20/2006 8:12	631	19	9/20/2006 8:38

Path Measurement Data Site 3 Path 1			Path Measurement Data Site 3 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
29	14.6	9/20/2006 8:12	397	19	9/20/2006 8:38
29	14.6	9/20/2006 8:12	479	19	9/20/2006 8:38
28.9	14.6	9/20/2006 8:12	212	19	9/20/2006 8:38
28.8	14.6	9/20/2006 8:12	372	19	9/20/2006 8:38
29	14.6	9/20/2006 8:12	313	19	9/20/2006 8:38
29	14.6	9/20/2006 8:12	105	19	9/20/2006 8:38
29	14.6	9/20/2006 8:12	41	19	9/20/2006 8:38
29	14.6	9/20/2006 8:12	42.5	19	9/20/2006 8:38
28.9	14.6	9/20/2006 8:12	149	19	9/20/2006 8:38
168	14.6	9/20/2006 8:12	440	19	9/20/2006 8:38
29.6	14.6	9/20/2006 8:13	417	19	9/20/2006 8:38
29.8	14.6	9/20/2006 8:13	125	19	9/20/2006 8:38
29.7	14.6	9/20/2006 8:13	112	19	9/20/2006 8:38
29.5	14.6	9/20/2006 8:13	139	19	9/20/2006 8:38
29.6	14.6	9/20/2006 8:13	226	19	9/20/2006 8:38
29.6	14.6	9/20/2006 8:13	188	19	9/20/2006 8:38
29.6	14.6	9/20/2006 8:13	182	19	9/20/2006 8:38
29.6	14.6	9/20/2006 8:13	221	19	9/20/2006 8:38
29.4	14.6	9/20/2006 8:13	185	19	9/20/2006 8:38
29.6	14.6	9/20/2006 8:13	168	19	9/20/2006 8:38
29.6	14.6	9/20/2006 8:13	155	19	9/20/2006 8:38
29.6	14.6	9/20/2006 8:13	135	19	9/20/2006 8:38
29.4	14.6	9/20/2006 8:13	113	19	9/20/2006 8:38
29.6	14.6	9/20/2006 8:13	95	19	9/20/2006 8:38
29.5	14.6	9/20/2006 8:13	70.9	19	9/20/2006 8:38
29.6	14.6	9/20/2006 8:13	55.9	19	9/20/2006 8:38
29.5	14.6	9/20/2006 8:13	48.8	19	9/20/2006 8:38
29.3	14.6	9/20/2006 8:13	44.7	19	9/20/2006 8:38
29.6	14.6	9/20/2006 8:13	45.3	19	9/20/2006 8:39
29.4	14.6	9/20/2006 8:13	51.1	19	9/20/2006 8:39
29.3	14.6	9/20/2006 8:13	50.5	19	9/20/2006 8:39
29.6	14.6	9/20/2006 8:13	49.1	19	9/20/2006 8:39
29.6	14.6	9/20/2006 8:13	45.3	19	9/20/2006 8:39
29.9	14.6	9/20/2006 8:14	47.7	19	9/20/2006 8:39
29.3	14.6	9/20/2006 8:14	46.4	19	9/20/2006 8:39
29.5	14.6	9/20/2006 8:14	47.4	19	9/20/2006 8:39
29.7	14.6	9/20/2006 8:14	49.6	19	9/20/2006 8:39
29.6	14.6	9/20/2006 8:14	48.8	19	9/20/2006 8:39
29.5	14.6	9/20/2006 8:14	48.5	19	9/20/2006 8:39
29.6	14.6	9/20/2006 8:14	49.5	19	9/20/2006 8:39
29.8	14.6	9/20/2006 8:14	51.6	19	9/20/2006 8:39
29.6	14.6	9/20/2006 8:14	52.7	19	9/20/2006 8:39
29.5	14.6	9/20/2006 8:14	44.4	19	9/20/2006 8:39
29.4	14.6	9/20/2006 8:14	45	19	9/20/2006 8:39
29.6	14.6	9/20/2006 8:14	54.4	19	9/20/2006 8:39
29.7	14.6	9/20/2006 8:14	273	19	9/20/2006 8:39
29.6	14.6	9/20/2006 8:14	943	19	9/20/2006 8:39
126	14.6	9/20/2006 8:14	663	19	9/20/2006 8:39
1693	14.6	9/20/2006 8:14	176	19	9/20/2006 8:39
1335	14.6	9/20/2006 8:14	88.5	19	9/20/2006 8:39
930	14.6	9/20/2006 8:14	66.6	19	9/20/2006 8:39
878	14.6	9/20/2006 8:14	40.3	19	9/20/2006 8:39
725	14.6	9/20/2006 8:14	40.2	19	9/20/2006 8:39
803	14.6	9/20/2006 8:14	40.4	19	9/20/2006 8:39
1080	14.6	9/20/2006 8:14	40.2	19	9/20/2006 8:39
551	14.6	9/20/2006 8:14	40.3	19	9/20/2006 8:39
878	14.6	9/20/2006 8:14	40.2	19	9/20/2006 8:39
765	14.6	9/20/2006 8:14	40	19	9/20/2006 8:39
798	14.6	9/20/2006 8:14	40.3	19	9/20/2006 8:39
577	14.6	9/20/2006 8:14	40.1	19	9/20/2006 8:39

Path Measurement Data Site 3 Path 1			Path Measurement Data Site 3 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
1167	14.6	9/20/2006 8:14	40.2	19	9/20/2006 8:39
1556	14.6	9/20/2006 8:14	40.2	19	9/20/2006 8:39
1639	14.6	9/20/2006 8:14	40.3	19	9/20/2006 8:39
2282	14.6	9/20/2006 8:14	40	19	9/20/2006 8:40
1932	14.6	9/20/2006 8:14	40.5	19	9/20/2006 8:40
1631	14.6	9/20/2006 8:14	40	19	9/20/2006 8:40
1587	14.6	9/20/2006 8:15	40.4	19	9/20/2006 8:40
1466	14.6	9/20/2006 8:15	40.6	19	9/20/2006 8:40
882	14.6	9/20/2006 8:15	40.7	19	9/20/2006 8:40
231	14.6	9/20/2006 8:15	40.6	19	9/20/2006 8:40
31.1	14.6	9/20/2006 8:15	40.5	19	9/20/2006 8:40
30	14.6	9/20/2006 8:15	40.4	19	9/20/2006 8:40
29.9	14.6	9/20/2006 8:15	40.6	19	9/20/2006 8:40
29.7	14.6	9/20/2006 8:15	40.6	19	9/20/2006 8:40
30.1	14.6	9/20/2006 8:15	40.4	19	9/20/2006 8:40
29.9	14.6	9/20/2006 8:15	40.6	19	9/20/2006 8:40
29.9	14.6	9/20/2006 8:15	40.7	19	9/20/2006 8:40
30	14.6	9/20/2006 8:15	40.4	19	9/20/2006 8:40
30.1	14.6	9/20/2006 8:15	40.8	19	9/20/2006 8:40
30	14.6	9/20/2006 8:15	42.1	19	9/20/2006 8:40
30.2	14.6	9/20/2006 8:15	43	19	9/20/2006 8:40
30.2	14.6	9/20/2006 8:15	40.4	19	9/20/2006 8:40
30	14.6	9/20/2006 8:15	40.7	19	9/20/2006 8:40
30	14.6	9/20/2006 8:15	41.3	19	9/20/2006 8:40
29.9	14.6	9/20/2006 8:15	41.1	19	9/20/2006 8:40
30	14.6	9/20/2006 8:15	40.6	19	9/20/2006 8:40
29.9	14.6	9/20/2006 8:15	40.7	19	9/20/2006 8:40
29.7	14.6	9/20/2006 8:15	40.8	19	9/20/2006 8:40
29.9	14.6	9/20/2006 8:15	40.9	19	9/20/2006 8:40
29.8	14.6	9/20/2006 8:15	40.8	19	9/20/2006 8:40
30	14.6	9/20/2006 8:15	40.6	19	9/20/2006 8:40
30	14.6	9/20/2006 8:15	40.5	19	9/20/2006 8:40
29.9	14.6	9/20/2006 8:15	40.3	19	9/20/2006 8:40
30.1	14.6	9/20/2006 8:15	40.4	19	9/20/2006 8:40
29.9	14.6	9/20/2006 8:15	40.5	19	9/20/2006 8:40
30	14.6	9/20/2006 8:15	40.4	19	9/20/2006 8:40
30	14.6	9/20/2006 8:15	40.3	19	9/20/2006 8:40
29.9	14.6	9/20/2006 8:15	40.7	19	9/20/2006 8:41
30	14.6	9/20/2006 8:15	40.5	19	9/20/2006 8:41
29.8	14.6	9/20/2006 8:15	40.2	19	9/20/2006 8:41
30	14.6	9/20/2006 8:15	40.5	19	9/20/2006 8:41
29.9	14.6	9/20/2006 8:16	40.6	19	9/20/2006 8:41
29.8	14.6	9/20/2006 8:16	40.6	19	9/20/2006 8:41
29.9	14.6	9/20/2006 8:16	40.3	19	9/20/2006 8:41
29.9	14.6	9/20/2006 8:16	40.3	19	9/20/2006 8:41
29.8	14.6	9/20/2006 8:16	40.5	19	9/20/2006 8:41
29.9	14.6	9/20/2006 8:16	40.5	19	9/20/2006 8:41
30	14.6	9/20/2006 8:16	40.7	19	9/20/2006 8:41
29.9	14.6	9/20/2006 8:16	40.6	19	9/20/2006 8:41
30.1	14.6	9/20/2006 8:16	40.7	19	9/20/2006 8:41
29.9	14.6	9/20/2006 8:16	40.8	19	9/20/2006 8:41
30	14.6	9/20/2006 8:16	40.7	19	9/20/2006 8:41
29.9	14.6	9/20/2006 8:16	40.8	19	9/20/2006 8:41
30	14.6	9/20/2006 8:16	40.4	19	9/20/2006 8:41
30.1	14.6	9/20/2006 8:16	40.5	19	9/20/2006 8:41
29.9	14.6	9/20/2006 8:16	40.6	19	9/20/2006 8:41
29.8	14.6	9/20/2006 8:16	40.7	19	9/20/2006 8:41
29.9	14.6	9/20/2006 8:16	40.5	19	9/20/2006 8:41
30	14.6	9/20/2006 8:16	40.3	19	9/20/2006 8:41
29.9	14.6	9/20/2006 8:16	40.7	19	9/20/2006 8:41

Path Measurement Data Site 3 Path 1			Path Measurement Data Site 3 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
29.9	14.6	9/20/2006 8:16	40.7	19	9/20/2006 8:41
30	14.6	9/20/2006 8:16	40.6	19	9/20/2006 8:41
30	14.6	9/20/2006 8:16	40.5	19	9/20/2006 8:41
30	14.6	9/20/2006 8:16	40.8	19	9/20/2006 8:41
29.8	14.6	9/20/2006 8:16	40.8	19	9/20/2006 8:41
29.9	14.6	9/20/2006 8:16	40.8	19	9/20/2006 8:41
30	14.6	9/20/2006 8:16	40.4	19	9/20/2006 8:41
29.8	14.6	9/20/2006 8:16	40.5	19	9/20/2006 8:41
29.9	14.6	9/20/2006 8:16	40.8	19	9/20/2006 8:41
30.1	14.6	9/20/2006 8:16	40.4	19	9/20/2006 8:41
30	14.6	9/20/2006 8:16	40.5	19	9/20/2006 8:41
30	14.6	9/20/2006 8:16	40.5	19	9/20/2006 8:42
30.2	14.6	9/20/2006 8:16	40.6	19	9/20/2006 8:42
29.8	14.6	9/20/2006 8:16	40.5	19	9/20/2006 8:42
29.8	14.6	9/20/2006 8:16	40.7	19	9/20/2006 8:42
30	14.6	9/20/2006 8:17	40.4	19	9/20/2006 8:42
30.3	14.6	9/20/2006 8:17	40.6	19	9/20/2006 8:42
29.9	14.6	9/20/2006 8:17	40.6	19	9/20/2006 8:42
30.2	14.6	9/20/2006 8:17	40.4	19	9/20/2006 8:42
29.9	14.6	9/20/2006 8:17	42.1	19	9/20/2006 8:42
30.2	14.6	9/20/2006 8:17	76.8	19	9/20/2006 8:42
30.1	14.6	9/20/2006 8:17	126	19	9/20/2006 8:42
30	14.6	9/20/2006 8:17	143	19	9/20/2006 8:42
29.9	14.6	9/20/2006 8:17	132	19	9/20/2006 8:42
30.1	14.6	9/20/2006 8:17	116	19	9/20/2006 8:42
30.2	14.6	9/20/2006 8:17	120	19	9/20/2006 8:42
29.9	14.6	9/20/2006 8:17	126	19	9/20/2006 8:42
36.8	14.6	9/20/2006 8:17	61.7	19	9/20/2006 8:42
30	14.6	9/20/2006 8:17	43.3	19	9/20/2006 8:42
30.1	14.6	9/20/2006 8:17	44.8	19	9/20/2006 8:42
29.9	14.6	9/20/2006 8:17	59	19	9/20/2006 8:42
30	14.6	9/20/2006 8:17	42.7	19	9/20/2006 8:42
30.1	14.6	9/20/2006 8:17	40.8	19	9/20/2006 8:42
30	14.6	9/20/2006 8:17	40.3	19	9/20/2006 8:42
30	14.6	9/20/2006 8:17	40.4	19	9/20/2006 8:42
30.1	14.6	9/20/2006 8:17	40.4	19	9/20/2006 8:42
30	14.6	9/20/2006 8:17	40.4	19	9/20/2006 8:42
29.8	14.6	9/20/2006 8:17	40.2	19	9/20/2006 8:42
29.9	14.6	9/20/2006 8:17	40.5	19	9/20/2006 8:42
30.2	14.6	9/20/2006 8:17	40.4	19	9/20/2006 8:42
30.3	14.6	9/20/2006 8:17	40.2	19	9/20/2006 8:42
30.1	14.6	9/20/2006 8:17	40.5	19	9/20/2006 8:42
30.3	14.6	9/20/2006 8:17	40.4	19	9/20/2006 8:42
30.2	14.6	9/20/2006 8:17	40.4	19	9/20/2006 8:42
30.2	14.6	9/20/2006 8:17	40.6	19	9/20/2006 8:42
30	14.6	9/20/2006 8:17	40.4	19	9/20/2006 8:43
30.3	14.6	9/20/2006 8:17	40.6	19	9/20/2006 8:43
30.1	14.6	9/20/2006 8:17	40.5	19	9/20/2006 8:43
30.2	14.6	9/20/2006 8:17	40.5	19	9/20/2006 8:43
30.3	14.6	9/20/2006 8:18	40.4	19	9/20/2006 8:43
30.2	14.6	9/20/2006 8:18	40.6	19	9/20/2006 8:43
30.1	14.6	9/20/2006 8:18	40.6	19	9/20/2006 8:43
30.3	14.6	9/20/2006 8:18	40.4	19	9/20/2006 8:43
30.1	14.6	9/20/2006 8:18	40.8	19	9/20/2006 8:43
30	14.6	9/20/2006 8:18	40.3	19	9/20/2006 8:43
30.1	14.6	9/20/2006 8:18	40.7	19	9/20/2006 8:43
29.9	14.6	9/20/2006 8:18	40.5	19	9/20/2006 8:43
30.1	14.6	9/20/2006 8:18	40.4	19	9/20/2006 8:43
30.2	14.6	9/20/2006 8:18	40.5	19	9/20/2006 8:43
30.2	14.6	9/20/2006 8:18	40.8	19	9/20/2006 8:43



Path Measurement Data Site 3 Path 1			Path Measurement Data Site 3 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
30	14.6	9/20/2006 8:18	40.6	19	9/20/2006 8:43
30.3	14.6	9/20/2006 8:18	40.5	19	9/20/2006 8:43
30.3	14.6	9/20/2006 8:18	40.6	19	9/20/2006 8:43
30.2	14.6	9/20/2006 8:18	40.3	19	9/20/2006 8:43
30.2	14.6	9/20/2006 8:18	40.7	19	9/20/2006 8:43
30.1	14.6	9/20/2006 8:18	40.4	19	9/20/2006 8:43
30.2	14.6	9/20/2006 8:18	40.7	19	9/20/2006 8:43
30.2	14.6	9/20/2006 8:18	40.6	19	9/20/2006 8:43
30.1	14.6	9/20/2006 8:18	40.5	19	9/20/2006 8:43
30.1	14.6	9/20/2006 8:18	40.6	19	9/20/2006 8:43
30.2	14.6	9/20/2006 8:18	40.2	19	9/20/2006 8:43
30	14.6	9/20/2006 8:18	40.5	19	9/20/2006 8:43
30.2	14.6	9/20/2006 8:18	40.6	19	9/20/2006 8:43
30.1	14.6	9/20/2006 8:18	40.5	19	9/20/2006 8:43
30.1	14.6	9/20/2006 8:18	41.4	19	9/20/2006 8:43
30.2	14.6	9/20/2006 8:18	42.7	19	9/20/2006 8:43
30.2	14.6	9/20/2006 8:18	48.3	19	9/20/2006 8:43
30.3	14.6	9/20/2006 8:18	45.1	19	9/20/2006 8:43
30.2	14.6	9/20/2006 8:18	41.1	19	9/20/2006 8:43
30.1	14.6	9/20/2006 8:18	40.5	19	9/20/2006 8:44
30.2	14.6	9/20/2006 8:18	40.5	19	9/20/2006 8:44
30.1	14.6	9/20/2006 8:18	40.4	19	9/20/2006 8:44
30.1	14.6	9/20/2006 8:18	40.8	19	9/20/2006 8:44
30	14.6	9/20/2006 8:19	40.4	19	9/20/2006 8:44
30.3	14.6	9/20/2006 8:19	40.6	19	9/20/2006 8:44
30.1	14.6	9/20/2006 8:19	40.6	19	9/20/2006 8:44
30.3	14.6	9/20/2006 8:19	40.5	19	9/20/2006 8:44
30.1	14.6	9/20/2006 8:19	40.7	19	9/20/2006 8:44
30.2	14.6	9/20/2006 8:19	40.6	19	9/20/2006 8:44
30	14.6	9/20/2006 8:19	40.7	19	9/20/2006 8:44
30.3	14.6	9/20/2006 8:19	40.6	19	9/20/2006 8:44
30.4	14.6	9/20/2006 8:19	40.1	19	9/20/2006 8:44
30.1	14.6	9/20/2006 8:19	40.4	19	9/20/2006 8:44
30.2	14.6	9/20/2006 8:19	40.3	19	9/20/2006 8:44
30.3	14.6	9/20/2006 8:19	40.3	19	9/20/2006 8:44
97.8	14.6	9/20/2006 8:19	40.3	19	9/20/2006 8:44
156	14.6	9/20/2006 8:19	40.6	19	9/20/2006 8:44
157	14.6	9/20/2006 8:19	40.5	19	9/20/2006 8:44
879	14.6	9/20/2006 8:19	40.9	19	9/20/2006 8:44
1209	14.6	9/20/2006 8:19	40.7	19	9/20/2006 8:44
1293	14.6	9/20/2006 8:19	40.5	19	9/20/2006 8:44
1627	14.6	9/20/2006 8:19	40.4	19	9/20/2006 8:44
902	14.6	9/20/2006 8:19	40.5	19	9/20/2006 8:44
48.4	14.6	9/20/2006 8:19	40.6	19	9/20/2006 8:44
34.9	14.6	9/20/2006 8:19	40.6	19	9/20/2006 8:44
31.3	14.6	9/20/2006 8:19	40.3	19	9/20/2006 8:44
31	14.6	9/20/2006 8:19	41	19	9/20/2006 8:44
30.2	14.6	9/20/2006 8:19	56.3	19	9/20/2006 8:44
30.4	14.6	9/20/2006 8:19	356	19	9/20/2006 8:44
30.1	14.6	9/20/2006 8:19	2149	19	9/20/2006 8:44
30.1	14.6	9/20/2006 8:19	2109	19	9/20/2006 8:44
30.3	14.6	9/20/2006 8:19	1354	19	9/20/2006 8:44
30.2	14.6	9/20/2006 8:19	1069	19	9/20/2006 8:44
30.1	14.6	9/20/2006 8:19	335	19	9/20/2006 8:45
30.5	14.6	9/20/2006 8:19	92.1	19	9/20/2006 8:45
36.5	14.6	9/20/2006 8:19	449	19	9/20/2006 8:45
47.5	14.6	9/20/2006 8:19	243	19	9/20/2006 8:45
141	14.6	9/20/2006 8:20	389	19	9/20/2006 8:45
156	14.6	9/20/2006 8:20	476	19	9/20/2006 8:45
778	14.6	9/20/2006 8:20	360	19	9/20/2006 8:45

Path Measurement Data Site 3 Path 1			Path Measurement Data Site 3 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
1806	14.6	9/20/2006 8:20	78.6	19	9/20/2006 8:45
1580	14.6	9/20/2006 8:20	189	19	9/20/2006 8:45
1344	14.6	9/20/2006 8:20	206	19	9/20/2006 8:45
778	14.6	9/20/2006 8:20	715	19	9/20/2006 8:45
222	14.6	9/20/2006 8:20	952	19	9/20/2006 8:45
38.8	14.6	9/20/2006 8:20	1159	19	9/20/2006 8:45
31.2	14.6	9/20/2006 8:20	1574	19	9/20/2006 8:45
30.6	14.6	9/20/2006 8:20	1887	19	9/20/2006 8:45
30.2	14.6	9/20/2006 8:20	2434	19	9/20/2006 8:45
30.1	14.6	9/20/2006 8:20	2182	19	9/20/2006 8:45
30.4	14.6	9/20/2006 8:20	1643	19	9/20/2006 8:45
30.1	14.6	9/20/2006 8:20	1901	19	9/20/2006 8:45
30.2	14.6	9/20/2006 8:20	2028	19	9/20/2006 8:45
30	14.6	9/20/2006 8:20	1451	19	9/20/2006 8:45
30	14.6	9/20/2006 8:20	1118	19	9/20/2006 8:45
30.1	14.6	9/20/2006 8:20	1259	19	9/20/2006 8:45
30	14.6	9/20/2006 8:20	2753	19	9/20/2006 8:45
30.2	14.6	9/20/2006 8:20	1732	19	9/20/2006 8:45
30.2	14.6	9/20/2006 8:20	1737	19	9/20/2006 8:45
30.2	14.6	9/20/2006 8:20	1179	19	9/20/2006 8:45
30.2	14.6	9/20/2006 8:20	407	19	9/20/2006 8:45
30.3	14.6	9/20/2006 8:20	289	19	9/20/2006 8:45
30.5	14.6	9/20/2006 8:20	201	19	9/20/2006 8:45
30.6	14.6	9/20/2006 8:20	378	19	9/20/2006 8:45
30.6	14.6	9/20/2006 8:20	1498	19	9/20/2006 8:45
30.6	14.6	9/20/2006 8:20	1405	19	9/20/2006 8:45
30.5	14.6	9/20/2006 8:20	1505	19	9/20/2006 8:46
30.5	14.6	9/20/2006 8:20	1214	19	9/20/2006 8:46
30.2	14.6	9/20/2006 8:20	1293	19	9/20/2006 8:46
30.1	14.6	9/20/2006 8:20	897	19	9/20/2006 8:46
30.3	14.6	9/20/2006 8:21	476	19	9/20/2006 8:46
30.4	14.6	9/20/2006 8:21	284	19	9/20/2006 8:46
30.2	14.6	9/20/2006 8:21	167	19	9/20/2006 8:46
30.2	14.6	9/20/2006 8:21	233	19	9/20/2006 8:46
30.2	14.6	9/20/2006 8:21	279	19	9/20/2006 8:46
30.4	14.6	9/20/2006 8:21	276	19	9/20/2006 8:46
30.4	14.6	9/20/2006 8:21	162	19	9/20/2006 8:46
30.5	14.6	9/20/2006 8:21	240	19	9/20/2006 8:46
30.5	14.6	9/20/2006 8:21	324	19	9/20/2006 8:46
30.3	14.6	9/20/2006 8:21	467	19	9/20/2006 8:46
30.4	14.6	9/20/2006 8:21	481	19	9/20/2006 8:46
30.3	14.6	9/20/2006 8:21	382	19	9/20/2006 8:46
30.4	14.6	9/20/2006 8:21	317	19	9/20/2006 8:46
30.1	14.6	9/20/2006 8:21	211	19	9/20/2006 8:46
30.2	14.6	9/20/2006 8:21	114	19	9/20/2006 8:46
30.2	14.6	9/20/2006 8:21	77.3	19	9/20/2006 8:46
30.1	14.6	9/20/2006 8:21	62.7	19	9/20/2006 8:46
30.1	14.6	9/20/2006 8:21	54.4	19	9/20/2006 8:46
30.4	14.6	9/20/2006 8:21	51.2	19	9/20/2006 8:46
30.2	14.6	9/20/2006 8:21	53.6	19	9/20/2006 8:46
30.2	14.6	9/20/2006 8:21	62.3	19	9/20/2006 8:46
30.1	14.6	9/20/2006 8:21	81.4	19	9/20/2006 8:46
30.3	14.6	9/20/2006 8:21	117	19	9/20/2006 8:46
30.3	14.6	9/20/2006 8:21	117	19	9/20/2006 8:46
30.2	14.6	9/20/2006 8:21	104	19	9/20/2006 8:46
30.5	14.6	9/20/2006 8:21	99.4	19	9/20/2006 8:46
30.3	14.6	9/20/2006 8:21	83.5	19	9/20/2006 8:46
30.2	14.6	9/20/2006 8:21	69.1	19	9/20/2006 8:46
30.2	14.6	9/20/2006 8:21	58.4	19	9/20/2006 8:47
30.2	14.6	9/20/2006 8:21	49.6	19	9/20/2006 8:47

Path Measurement Data Site 3 Path 1			Path Measurement Data Site 3 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
30.3	14.6	9/20/2006 8:21	49.4	19	9/20/2006 8:47
30.3	14.6	9/20/2006 8:21	48.1	19	9/20/2006 8:47
30.3	14.6	9/20/2006 8:21	49	19	9/20/2006 8:47
30.5	14.6	9/20/2006 8:21	47.9	19	9/20/2006 8:47
30.4	14.6	9/20/2006 8:21	47.3	19	9/20/2006 8:47
30.3	14.6	9/20/2006 8:22	46.7	19	9/20/2006 8:47
30.4	14.6	9/20/2006 8:22	47.4	19	9/20/2006 8:47
30.4	14.6	9/20/2006 8:22	48.1	19	9/20/2006 8:47
30.4	14.6	9/20/2006 8:22	51.8	19	9/20/2006 8:47
30.4	14.6	9/20/2006 8:22	513	19	9/20/2006 8:47
39.8	14.6	9/20/2006 8:22	1059	19	9/20/2006 8:47
30.2	14.6	9/20/2006 8:22	952	19	9/20/2006 8:47
30.1	14.6	9/20/2006 8:22	1162	19	9/20/2006 8:47
30.1	14.6	9/20/2006 8:22	2230	19	9/20/2006 8:47
30.1	14.6	9/20/2006 8:22	1434	19	9/20/2006 8:47
30.1	14.6	9/20/2006 8:22	767	19	9/20/2006 8:47
30.1	14.6	9/20/2006 8:22	708	19	9/20/2006 8:47
30.2	14.6	9/20/2006 8:22	424	19	9/20/2006 8:47
30.2	14.6	9/20/2006 8:22	402	19	9/20/2006 8:47
30.2	14.6	9/20/2006 8:22	617	19	9/20/2006 8:47
30.2	14.6	9/20/2006 8:22	1184	19	9/20/2006 8:47
30.3	14.6	9/20/2006 8:22	1623	19	9/20/2006 8:47
30.2	14.6	9/20/2006 8:22	1871	19	9/20/2006 8:47
30.3	14.6	9/20/2006 8:22	1946	19	9/20/2006 8:47
30.2	14.6	9/20/2006 8:22	1566	19	9/20/2006 8:47
30.2	14.6	9/20/2006 8:22	801	19	9/20/2006 8:47
30.2	14.6	9/20/2006 8:22	458	19	9/20/2006 8:47
30.3	14.6	9/20/2006 8:22	521	19	9/20/2006 8:47
30.3	14.6	9/20/2006 8:22	956	19	9/20/2006 8:47
29.9	14.6	9/20/2006 8:22	969	19	9/20/2006 8:47
30.1	14.6	9/20/2006 8:22	860	19	9/20/2006 8:47
30.3	14.6	9/20/2006 8:22	793	19	9/20/2006 8:47
30.1	14.6	9/20/2006 8:22	1410	19	9/20/2006 8:48
30.1	14.6	9/20/2006 8:22	871	19	9/20/2006 8:48
30.1	14.6	9/20/2006 8:22	587	19	9/20/2006 8:48
30.2	14.6	9/20/2006 8:22	897	19	9/20/2006 8:48
30	14.6	9/20/2006 8:22	618	19	9/20/2006 8:48
30	14.6	9/20/2006 8:23	820	19	9/20/2006 8:48
29.9	14.6	9/20/2006 8:23	1496	19	9/20/2006 8:48
30	14.6	9/20/2006 8:23	1213	19	9/20/2006 8:48
30.3	14.6	9/20/2006 8:23	963	19	9/20/2006 8:48
30	14.6	9/20/2006 8:23	1901	19	9/20/2006 8:48
30.2	14.6	9/20/2006 8:23	940	19	9/20/2006 8:48
30.2	14.6	9/20/2006 8:23	522	19	9/20/2006 8:48
30.1	14.6	9/20/2006 8:23	1446	19	9/20/2006 8:48
30.2	14.6	9/20/2006 8:23	1863	19	9/20/2006 8:48
30.1	14.6	9/20/2006 8:23	1569	19	9/20/2006 8:48
29.9	14.6	9/20/2006 8:23	1902	19	9/20/2006 8:48
30.1	14.6	9/20/2006 8:23	1630	19	9/20/2006 8:48
30	14.6	9/20/2006 8:23	1723	19	9/20/2006 8:48
30	14.6	9/20/2006 8:23	1405	19	9/20/2006 8:48
30	14.6	9/20/2006 8:23	285	19	9/20/2006 8:48
30	14.6	9/20/2006 8:23	613	19	9/20/2006 8:48
30.2	14.6	9/20/2006 8:23	598	19	9/20/2006 8:48
30.2	14.6	9/20/2006 8:23	518	19	9/20/2006 8:48
30.3	14.6	9/20/2006 8:23	383	19	9/20/2006 8:48
30.2	14.6	9/20/2006 8:23	345	19	9/20/2006 8:48
30.2	14.6	9/20/2006 8:23	216	19	9/20/2006 8:48
30.1	14.6	9/20/2006 8:23	199	19	9/20/2006 8:48
30.1	14.6	9/20/2006 8:23	152	19	9/20/2006 8:48

Path Measurement Data Site 3 Path 1			Path Measurement Data Site 3 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
30.2	14.6	9/20/2006 8:23	86.1	19	9/20/2006 8:48
30.3	14.6	9/20/2006 8:23	65.1	19	9/20/2006 8:48
30.2	14.6	9/20/2006 8:24	57.6	19	9/20/2006 8:48
30.5	14.6	9/20/2006 8:24	46.8	19	9/20/2006 8:48
30.4	14.6	9/20/2006 8:24	44.4	19	9/20/2006 8:48
30.6	14.6	9/20/2006 8:24	42.9	19	9/20/2006 8:49
30.3	14.6	9/20/2006 8:24	43.8	19	9/20/2006 8:49
			42.6	19	9/20/2006 8:49
			45.5	19	9/20/2006 8:49
			45.6	19	9/20/2006 8:49
			42.8	19	9/20/2006 8:49
			41.3	19	9/20/2006 8:49
			40.6	19	9/20/2006 8:49
			41.5	19	9/20/2006 8:49
			40.8	19	9/20/2006 8:49
			39.8	19	9/20/2006 8:49
			40	19	9/20/2006 8:49
			39.9	19	9/20/2006 8:49
			39.9	19	9/20/2006 8:49
			40	19	9/20/2006 8:49
			44.4	19	9/20/2006 8:49
			117	19	9/20/2006 8:49
			276	19	9/20/2006 8:49
			418	19	9/20/2006 8:49
			343	19	9/20/2006 8:49
			287	19	9/20/2006 8:49
			211	19	9/20/2006 8:49
			227	19	9/20/2006 8:49
			301	19	9/20/2006 8:49
			178	19	9/20/2006 8:49
			168	19	9/20/2006 8:49
			140	19	9/20/2006 8:49
			187	19	9/20/2006 8:49
			152	19	9/20/2006 8:49
			131	19	9/20/2006 8:49
			144	19	9/20/2006 8:49
			102	19	9/20/2006 8:49
			92.7	19	9/20/2006 8:49
			78.1	19	9/20/2006 8:49
			58.6	19	9/20/2006 8:50
			49.8	19	9/20/2006 8:50
			44	19	9/20/2006 8:50
			41.1	19	9/20/2006 8:50
			41.1	19	9/20/2006 8:50
			41.4	19	9/20/2006 8:50
			42	19	9/20/2006 8:50
			42	19	9/20/2006 8:50
			41.7	19	9/20/2006 8:50
			41.6	19	9/20/2006 8:50
			41.6	19	9/20/2006 8:50
			40.8	19	9/20/2006 8:50
			40.8	19	9/20/2006 8:50
			40.4	19	9/20/2006 8:50
			40	19	9/20/2006 8:50
			39.8	19	9/20/2006 8:50
			40	19	9/20/2006 8:50
			39.8	19	9/20/2006 8:50
			186	19	9/20/2006 8:50
			335	19	9/20/2006 8:50
			713	19	9/20/2006 8:50

Path Measurement Data Site 3 Path 1			Path Measurement Data Site 3 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
			1228	19	9/20/2006 8:50
			2162	19	9/20/2006 8:50
			482	19	9/20/2006 8:50
			322	19	9/20/2006 8:50
			591	19	9/20/2006 8:50
			1180	19	9/20/2006 8:50
			562	19	9/20/2006 8:50
			700	19	9/20/2006 8:50
			764	19	9/20/2006 8:50
			1997	19	9/20/2006 8:50
			1837	19	9/20/2006 8:50
			2197	19	9/20/2006 8:50
			1461	19	9/20/2006 8:50
			1668	19	9/20/2006 8:51
			1399	19	9/20/2006 8:51
			1799	19	9/20/2006 8:51
			992	19	9/20/2006 8:51
			951	19	9/20/2006 8:51
			896	19	9/20/2006 8:51
			1365	19	9/20/2006 8:51
			1459	19	9/20/2006 8:51
			1601	19	9/20/2006 8:51
			1161	19	9/20/2006 8:51
			1005	19	9/20/2006 8:51
			777	19	9/20/2006 8:51
			548	19	9/20/2006 8:51
			710	19	9/20/2006 8:51
			671	19	9/20/2006 8:51
			703	19	9/20/2006 8:51
			635	19	9/20/2006 8:51
			981	19	9/20/2006 8:51
			901	19	9/20/2006 8:51
			765	19	9/20/2006 8:51
			557	19	9/20/2006 8:51
			158	19	9/20/2006 8:51
			64.5	19	9/20/2006 8:51
			42.3	19	9/20/2006 8:51
			40	19	9/20/2006 8:51
			39.9	19	9/20/2006 8:51
			40	19	9/20/2006 8:51
			40.4	19	9/20/2006 8:51
			40.3	19	9/20/2006 8:51
			40.4	19	9/20/2006 8:51
			40.4	19	9/20/2006 8:51
			41	19	9/20/2006 8:51
			43.1	19	9/20/2006 8:51
			45.1	19	9/20/2006 8:51
			45.3	19	9/20/2006 8:52
			47.6	19	9/20/2006 8:52
			48.6	19	9/20/2006 8:52
			42.7	19	9/20/2006 8:52
			41.1	19	9/20/2006 8:52
			41.5	19	9/20/2006 8:52
			44.6	19	9/20/2006 8:52
			47.8	19	9/20/2006 8:52
			48.9	19	9/20/2006 8:52
			49	19	9/20/2006 8:52
			47.5	19	9/20/2006 8:52
			45.7	19	9/20/2006 8:52
			43.6	19	9/20/2006 8:52

Path Measurement Data Site 3 Path 1			Path Measurement Data Site 3 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
			41.8	19	9/20/2006 8:52
			41.1	19	9/20/2006 8:52
			40.7	19	9/20/2006 8:52
			40.2	19	9/20/2006 8:52
			40.3	19	9/20/2006 8:52
			40.1	19	9/20/2006 8:52
			40.2	19	9/20/2006 8:52
			40.1	19	9/20/2006 8:52
			39.9	19	9/20/2006 8:52
			39.9	19	9/20/2006 8:52
			39.9	19	9/20/2006 8:52
			40.1	19	9/20/2006 8:52
			40.2	19	9/20/2006 8:52
			40.2	19	9/20/2006 8:52
			39.9	19	9/20/2006 8:52
			39.7	19	9/20/2006 8:52
			40.2	19	9/20/2006 8:52
			40	19	9/20/2006 8:52
			40	19	9/20/2006 8:52
			39.6	19	9/20/2006 8:52
			39.9	19	9/20/2006 8:52
			39.9	19	9/20/2006 8:53
			39.8	19	9/20/2006 8:53
			40	19	9/20/2006 8:53
			40	19	9/20/2006 8:53
			40	19	9/20/2006 8:53
			40	19	9/20/2006 8:53
			40	19	9/20/2006 8:53
			39.7	19	9/20/2006 8:53
			39.9	19	9/20/2006 8:53
			39.9	19	9/20/2006 8:53
			40.1	19	9/20/2006 8:53
			39.9	19	9/20/2006 8:53
			40.1	19	9/20/2006 8:53
			39.8	19	9/20/2006 8:53
			40.2	19	9/20/2006 8:53
			40	19	9/20/2006 8:53
			40	19	9/20/2006 8:53
			39.9	19	9/20/2006 8:53
			40.1	19	9/20/2006 8:53
			40	19	9/20/2006 8:53
			39.9	19	9/20/2006 8:53
			41.3	19	9/20/2006 8:53
			56.5	19	9/20/2006 8:53
			131	19	9/20/2006 8:53
			328	19	9/20/2006 8:53
			671	19	9/20/2006 8:53
			821	19	9/20/2006 8:53
			1058	19	9/20/2006 8:53
			1216	19	9/20/2006 8:53
			1439	19	9/20/2006 8:53
			1907	19	9/20/2006 8:53
			1782	19	9/20/2006 8:53
			1181	19	9/20/2006 8:53
			861	19	9/20/2006 8:53
			1312	19	9/20/2006 8:54
			1208	19	9/20/2006 8:54
			1743	19	9/20/2006 8:54
			1815	19	9/20/2006 8:54
			2338	19	9/20/2006 8:54

Path Measurement Data Site 3 Path 1			Path Measurement Data Site 3 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
			2334	19	9/20/2006 8:54
			2186	19	9/20/2006 8:54
			1081	19	9/20/2006 8:54
			1267	19	9/20/2006 8:54
			1130	19	9/20/2006 8:54
			1166	19	9/20/2006 8:54
			319	19	9/20/2006 8:54
			276	19	9/20/2006 8:54
			185	19	9/20/2006 8:54
			97.8	19	9/20/2006 8:54
			227	19	9/20/2006 8:54
			346	19	9/20/2006 8:54
			246	19	9/20/2006 8:54
			189	19	9/20/2006 8:54
			220	19	9/20/2006 8:54
			196	19	9/20/2006 8:54
			328	19	9/20/2006 8:54
			1038	19	9/20/2006 8:54
			1148	19	9/20/2006 8:54
			888	19	9/20/2006 8:54
			535	19	9/20/2006 8:54
			466	19	9/20/2006 8:54
			403	19	9/20/2006 8:54
			342	19	9/20/2006 8:54
			104	19	9/20/2006 8:54
			73.3	19	9/20/2006 8:54
			61.1	19	9/20/2006 8:54
			40.7	19	9/20/2006 8:54
			40.3	19	9/20/2006 8:55
			40.6	19	9/20/2006 8:55
			40.5	19	9/20/2006 8:55
			40.5	19	9/20/2006 8:55
			40.5	19	9/20/2006 8:55
			40.3	19	9/20/2006 8:55
			40.2	19	9/20/2006 8:55
			40.4	19	9/20/2006 8:55
			40.4	19	9/20/2006 8:55
			42.1	19	9/20/2006 8:55
			41.1	19	9/20/2006 8:55
			48.6	19	9/20/2006 8:55
			53.4	19	9/20/2006 8:55
			55.1	19	9/20/2006 8:55
			58.2	19	9/20/2006 8:55
			64.5	19	9/20/2006 8:55
			49.2	19	9/20/2006 8:55
			48.6	19	9/20/2006 8:55
			42	19	9/20/2006 8:55
			40.4	19	9/20/2006 8:55
			40.6	19	9/20/2006 8:55
			40.3	19	9/20/2006 8:55
			40.6	19	9/20/2006 8:55
			40.3	19	9/20/2006 8:55
			40.2	19	9/20/2006 8:55
			40.3	19	9/20/2006 8:55
			40.3	19	9/20/2006 8:55
			40.2	19	9/20/2006 8:55
			40.4	19	9/20/2006 8:55
			40.3	19	9/20/2006 8:55
			40.3	19	9/20/2006 8:55
			40.2	19	9/20/2006 8:55

Path Measurement Data Site 3 Path 1			Path Measurement Data Site 3 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
			40.3	19	9/20/2006 8:55
			40.5	19	9/20/2006 8:55
			40.1	19	9/20/2006 8:55
			40.5	19	9/20/2006 8:56
			40.2	19	9/20/2006 8:56
			40.3	19	9/20/2006 8:56
			40.3	19	9/20/2006 8:56
			40.4	19	9/20/2006 8:56
			40.4	19	9/20/2006 8:56
			40.2	19	9/20/2006 8:56
			40.2	19	9/20/2006 8:56
			40.5	19	9/20/2006 8:56
			40.3	19	9/20/2006 8:56
			40.3	19	9/20/2006 8:56
			40.3	19	9/20/2006 8:56
			40.4	19	9/20/2006 8:56
			40.7	19	9/20/2006 8:56
			40.2	19	9/20/2006 8:56
			40.1	19	9/20/2006 8:56
			40.2	19	9/20/2006 8:56
			40.1	19	9/20/2006 8:56
			40.2	19	9/20/2006 8:56
			40.2	19	9/20/2006 8:56
			40.1	19	9/20/2006 8:56
			40.1	19	9/20/2006 8:56
			40.1	19	9/20/2006 8:56
			40.2	19	9/20/2006 8:56
			142	19	9/20/2006 8:56
			976	19	9/20/2006 8:56
			1592	19	9/20/2006 8:56
			306	19	9/20/2006 8:56
			516	19	9/20/2006 8:56
			574	19	9/20/2006 8:56
			1944	19	9/20/2006 8:56
			743	19	9/20/2006 8:56
			299	19	9/20/2006 8:56
			204	19	9/20/2006 8:57
			276	19	9/20/2006 8:57
			165	19	9/20/2006 8:57
			167	19	9/20/2006 8:57
			161	19	9/20/2006 8:57
			130	19	9/20/2006 8:57
			110	19	9/20/2006 8:57
			122	19	9/20/2006 8:57
			100	19	9/20/2006 8:57
			86.8	19	9/20/2006 8:57
			71.5	19	9/20/2006 8:57
			63.6	19	9/20/2006 8:57
			61.3	19	9/20/2006 8:57
			51.7	19	9/20/2006 8:57
			69	19	9/20/2006 8:57
			316	19	9/20/2006 8:57
			534	19	9/20/2006 8:57
			637	19	9/20/2006 8:57
			111	19	9/20/2006 8:57
			116	19	9/20/2006 8:57
			373	19	9/20/2006 8:57
			439	19	9/20/2006 8:57
			105	19	9/20/2006 8:57
			66.2	19	9/20/2006 8:57



Path Measurement Data Site 3 Path 1			Path Measurement Data Site 3 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
			56.3	19	9/20/2006 8:57
			41.6	19	9/20/2006 8:57
			50.2	19	9/20/2006 8:57
			55	19	9/20/2006 8:57
			120	19	9/20/2006 8:57
			52.1	19	9/20/2006 8:57
			42.4	19	9/20/2006 8:57
			40.8	19	9/20/2006 8:57
			40.2	19	9/20/2006 8:57
			40.3	19	9/20/2006 8:57
			40.2	19	9/20/2006 8:58
			40	19	9/20/2006 8:58
			40.3	19	9/20/2006 8:58
			40.3	19	9/20/2006 8:58
			40.7	19	9/20/2006 8:58
			41	19	9/20/2006 8:58
			41.9	19	9/20/2006 8:58
			40.5	19	9/20/2006 8:58
			40	19	9/20/2006 8:58
			39.8	19	9/20/2006 8:58
			39.8	19	9/20/2006 8:58
			40.2	19	9/20/2006 8:58
			39.8	19	9/20/2006 8:58
			40	19	9/20/2006 8:58
			40	19	9/20/2006 8:58
			40.2	19	9/20/2006 8:58
			39.9	19	9/20/2006 8:58
			40	19	9/20/2006 8:58
			39.9	19	9/20/2006 8:58
			40.1	19	9/20/2006 8:58
			39.7	19	9/20/2006 8:58
			39.9	19	9/20/2006 8:58
			39.9	19	9/20/2006 8:58
			39.8	19	9/20/2006 8:58
			40	19	9/20/2006 8:58
			40	19	9/20/2006 8:58
			39.9	19	9/20/2006 8:58
			40	19	9/20/2006 8:58
			39.9	19	9/20/2006 8:58
			40.1	19	9/20/2006 8:58
			40.1	19	9/20/2006 8:58
			39.9	19	9/20/2006 8:58
			40.5	19	9/20/2006 8:58
			40.3	19	9/20/2006 8:58
			40.4	19	9/20/2006 8:59
			40.1	19	9/20/2006 8:59
			39.9	19	9/20/2006 8:59
			40.2	19	9/20/2006 8:59
			40.3	19	9/20/2006 8:59
			40	19	9/20/2006 8:59
			39.9	19	9/20/2006 8:59
			40.2	19	9/20/2006 8:59
			40.1	19	9/20/2006 8:59
			40	19	9/20/2006 8:59
			40.1	19	9/20/2006 8:59
			40.1	19	9/20/2006 8:59
			40	19	9/20/2006 8:59
			40.1	19	9/20/2006 8:59
			40.1	19	9/20/2006 8:59
			40.3	19	9/20/2006 8:59

Path Measurement Data Site 3 Path 1			Path Measurement Data Site 3 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
			40	19	9/20/2006 8:59
			40.2	19	9/20/2006 8:59
			40.1	19	9/20/2006 8:59
			40.2	19	9/20/2006 8:59
			40.2	19	9/20/2006 8:59
			40.2	19	9/20/2006 8:59
			40.1	19	9/20/2006 8:59
			39.8	19	9/20/2006 8:59
			40.1	19	9/20/2006 8:59
			39.9	19	9/20/2006 8:59
			39.9	19	9/20/2006 8:59
			40.2	19	9/20/2006 8:59
			40	19	9/20/2006 8:59
			40.1	19	9/20/2006 8:59
			40.2	19	9/20/2006 8:59
			40.2	19	9/20/2006 8:59
			40.1	19	9/20/2006 8:59
			39.9	19	9/20/2006 8:59
			40	19	9/20/2006 9:00
			40	19	9/20/2006 9:00
			40	19	9/20/2006 9:00
			40.3	19	9/20/2006 9:00
			40.2	19	9/20/2006 9:00
			40.1	19	9/20/2006 9:00
			40.1	19	9/20/2006 9:00
			39.8	19	9/20/2006 9:00
			40.1	19	9/20/2006 9:00
			40.1	19	9/20/2006 9:00
			40.1	19	9/20/2006 9:00
			40	19	9/20/2006 9:00
			40	19	9/20/2006 9:00
			40.1	19	9/20/2006 9:00
			40	19	9/20/2006 9:00
			40.2	19	9/20/2006 9:00
			40.1	19	9/20/2006 9:00
			40.1	19	9/20/2006 9:00
			39.9	19	9/20/2006 9:00
			39.8	19	9/20/2006 9:00
			39.7	19	9/20/2006 9:00
			40	19	9/20/2006 9:00
			40	19	9/20/2006 9:00
			40	19	9/20/2006 9:00
			39.9	19	9/20/2006 9:00
			39.9	19	9/20/2006 9:00
			39.9	19	9/20/2006 9:00
			40	19	9/20/2006 9:00
			39.7	19	9/20/2006 9:00
			40.2	19	9/20/2006 9:00
			40	19	9/20/2006 9:00
			40.3	19	9/20/2006 9:00
			40	19	9/20/2006 9:00
			39.9	19	9/20/2006 9:01
			40.1	19	9/20/2006 9:01
			40.2	19	9/20/2006 9:01
			40.1	19	9/20/2006 9:01
			40.1	19	9/20/2006 9:01
			40	19	9/20/2006 9:01
			39.9	19	9/20/2006 9:01
			40.1	19	9/20/2006 9:01
			40.2	19	9/20/2006 9:01

Path Measurement Data Site 3 Path 1			Path Measurement Data Site 3 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
			40.2	19	9/20/2006 9:01
			39.9	19	9/20/2006 9:01
			40.1	19	9/20/2006 9:01
			40.1	19	9/20/2006 9:01
			40.2	19	9/20/2006 9:01
			40.2	19	9/20/2006 9:01
			40.2	19	9/20/2006 9:01
			40.1	19	9/20/2006 9:01
			40	19	9/20/2006 9:01
			40.2	19	9/20/2006 9:01
			40.2	19	9/20/2006 9:01
			40.2	19	9/20/2006 9:01
			39.9	19	9/20/2006 9:01
			40.1	19	9/20/2006 9:01
			40.3	19	9/20/2006 9:01
			40.4	19	9/20/2006 9:01
			39.9	19	9/20/2006 9:01
			39.9	19	9/20/2006 9:01
			40	19	9/20/2006 9:01
			40	19	9/20/2006 9:01
			40.1	19	9/20/2006 9:01
			39.7	19	9/20/2006 9:01
			39.9	19	9/20/2006 9:01
			40.1	19	9/20/2006 9:01
			40	19	9/20/2006 9:01
			40	19	9/20/2006 9:02
			39.9	19	9/20/2006 9:02
			40.1	19	9/20/2006 9:02
			40.3	19	9/20/2006 9:02
			40.1	19	9/20/2006 9:02
			40	19	9/20/2006 9:02
			40.3	19	9/20/2006 9:02
			40.4	19	9/20/2006 9:02
			40.3	19	9/20/2006 9:02
			40.1	19	9/20/2006 9:02
			40.3	19	9/20/2006 9:02
			40	19	9/20/2006 9:02
			39.9	19	9/20/2006 9:02
			40	19	9/20/2006 9:02
			40	19	9/20/2006 9:02
			40.1	19	9/20/2006 9:02
			39.9	19	9/20/2006 9:02
			39.8	19	9/20/2006 9:02
			39.8	19	9/20/2006 9:02
			39.8	19	9/20/2006 9:02
			39.8	19	9/20/2006 9:02
			40.1	19	9/20/2006 9:02
			40	19	9/20/2006 9:02
			40	19	9/20/2006 9:02
			40.3	19	9/20/2006 9:02
			52.9	19	9/20/2006 9:02
			110	19	9/20/2006 9:02
			105	19	9/20/2006 9:02
			240	19	9/20/2006 9:02
			396	19	9/20/2006 9:02
			820	19	9/20/2006 9:02
			1298	19	9/20/2006 9:02
			981	19	9/20/2006 9:02
			754	19	9/20/2006 9:02
			521	19	9/20/2006 9:03

Path Measurement Data Site 3 Path 1			Path Measurement Data Site 3 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
			421	19	9/20/2006 9:03
			312	19	9/20/2006 9:03
			344	19	9/20/2006 9:03
			743	19	9/20/2006 9:03
			1182	19	9/20/2006 9:03
			2247	19	9/20/2006 9:03
			2322	19	9/20/2006 9:03
			2577	19	9/20/2006 9:03
			852	19	9/20/2006 9:03
			944	19	9/20/2006 9:03
			1459	19	9/20/2006 9:03
			1098	19	9/20/2006 9:03
			1407	19	9/20/2006 9:03
			1819	19	9/20/2006 9:03
			2772	19	9/20/2006 9:03
			2375	19	9/20/2006 9:03
			1639	19	9/20/2006 9:03
			915	19	9/20/2006 9:03
			994	19	9/20/2006 9:03
			1084	19	9/20/2006 9:03
			1585	19	9/20/2006 9:03
			2750	19	9/20/2006 9:03
			2412	19	9/20/2006 9:03
			2279	19	9/20/2006 9:03
			2651	19	9/20/2006 9:03
			2210	19	9/20/2006 9:03
			2618	19	9/20/2006 9:03
			2607	19	9/20/2006 9:03
			2259	19	9/20/2006 9:03
			2634	19	9/20/2006 9:03
			2108	19	9/20/2006 9:03
			538	19	9/20/2006 9:04
			244	19	9/20/2006 9:04
			1470	19	9/20/2006 9:04
			1105	19	9/20/2006 9:04
			1295	19	9/20/2006 9:04
			912	19	9/20/2006 9:04
			2379	19	9/20/2006 9:04
			1969	19	9/20/2006 9:04
3			1777	19	9/20/2006 9:04
			1329	19	9/20/2006 9:04
			1054	19	9/20/2006 9:04
			1356	19	9/20/2006 9:04
			860	19	9/20/2006 9:04
			427	19	9/20/2006 9:04
			255	19	9/20/2006 9:04
			213	19	9/20/2006 9:04
			1310	19	9/20/2006 9:04
			2621	19	9/20/2006 9:04
			2376	19	9/20/2006 9:04
			2575	19	9/20/2006 9:04
			2586	19	9/20/2006 9:04
			2277	19	9/20/2006 9:04
			2192	19	9/20/2006 9:04
			1044	19	9/20/2006 9:04
			135	19	9/20/2006 9:04
			89.1	19	9/20/2006 9:04
			97.3	19	9/20/2006 9:04
			86.8	19	9/20/2006 9:04
			81.8	19	9/20/2006 9:04

Path Measurement Data Site 3 Path 1			Path Measurement Data Site 3 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
			84	19	9/20/2006 9:04
			236	19	9/20/2006 9:04
			384	19	9/20/2006 9:04
			121	19	9/20/2006 9:04
			82.9	19	9/20/2006 9:05
			81.9	19	9/20/2006 9:05
			79.4	19	9/20/2006 9:05
			79.5	19	9/20/2006 9:05
			65.5	19	9/20/2006 9:05
			65	19	9/20/2006 9:05
			72.5	19	9/20/2006 9:05
			96.7	19	9/20/2006 9:05
			163	19	9/20/2006 9:05
			151	19	9/20/2006 9:05
			105	19	9/20/2006 9:05
			102	19	9/20/2006 9:05
			95.7	19	9/20/2006 9:05
			69.1	19	9/20/2006 9:05
			72.6	19	9/20/2006 9:05
			65.1	19	9/20/2006 9:05
			59.2	19	9/20/2006 9:05
			50.6	19	9/20/2006 9:05
			43.6	19	9/20/2006 9:05
			43	19	9/20/2006 9:05
			40.5	19	9/20/2006 9:05
			40.5	19	9/20/2006 9:05
			40.1	19	9/20/2006 9:05
			149	19	9/20/2006 9:05
			736	19	9/20/2006 9:05
			2053	19	9/20/2006 9:05
			1673	19	9/20/2006 9:05
			1454	19	9/20/2006 9:05
			1800	19	9/20/2006 9:05
			2512	19	9/20/2006 9:05
			2701	19	9/20/2006 9:05
			2333	19	9/20/2006 9:05
			1090	19	9/20/2006 9:05
			1247	19	9/20/2006 9:06
			1263	19	9/20/2006 9:06
			1159	19	9/20/2006 9:06
			2099	19	9/20/2006 9:06
			1850	19	9/20/2006 9:06
			1996	19	9/20/2006 9:06
			2233	19	9/20/2006 9:06
			1841	19	9/20/2006 9:06
			2164	19	9/20/2006 9:06
			1593	19	9/20/2006 9:06
			1858	19	9/20/2006 9:06
			2353	19	9/20/2006 9:06
			1747	19	9/20/2006 9:06
			1197	19	9/20/2006 9:06
			2868	19	9/20/2006 9:06
			2935	19	9/20/2006 9:06
			2405	19	9/20/2006 9:06
			1928	19	9/20/2006 9:06
			1218	19	9/20/2006 9:06
			1363	19	9/20/2006 9:06
			1373	19	9/20/2006 9:06
			1161	19	9/20/2006 9:06
			1366	19	9/20/2006 9:06

Path Measurement Data Site 3 Path 1			Path Measurement Data Site 3 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
			1492	19	9/20/2006 9:06
			1575	19	9/20/2006 9:06
			1586	19	9/20/2006 9:06
			1677	19	9/20/2006 9:06
			1948	19	9/20/2006 9:06
			1790	19	9/20/2006 9:06
			1177	19	9/20/2006 9:06
			737	19	9/20/2006 9:07
			509	19	9/20/2006 9:07
			462	19	9/20/2006 9:07
			308	19	9/20/2006 9:07
			148	19	9/20/2006 9:07
			107	19	9/20/2006 9:07
			76.2	19	9/20/2006 9:07
			67.7	19	9/20/2006 9:07
			89.5	19	9/20/2006 9:07
			61	19	9/20/2006 9:07
			45.9	19	9/20/2006 9:07
			43.2	19	9/20/2006 9:07
			43	19	9/20/2006 9:07
			52.1	19	9/20/2006 9:07
			45	19	9/20/2006 9:07
			44.3	19	9/20/2006 9:07
			44.5	19	9/20/2006 9:07
			41.8	19	9/20/2006 9:07
			45.1	19	9/20/2006 9:07
			41.8	19	9/20/2006 9:07
			41.7	19	9/20/2006 9:07
			42	19	9/20/2006 9:07
			40.8	19	9/20/2006 9:07
			43.1	19	9/20/2006 9:07
			42.2	19	9/20/2006 9:07
			41.8	19	9/20/2006 9:07
			41.8	19	9/20/2006 9:07
			41.4	19	9/20/2006 9:07
			41.6	19	9/20/2006 9:07
			41.2	19	9/20/2006 9:07
			41	19	9/20/2006 9:07
			40.6	19	9/20/2006 9:07
			41	19	9/20/2006 9:07
			41.4	19	9/20/2006 9:07
			40.9	19	9/20/2006 9:08
			41	19	9/20/2006 9:08
			40.6	19	9/20/2006 9:08
			41	19	9/20/2006 9:08
			40.6	19	9/20/2006 9:08
			40.2	19	9/20/2006 9:08
			40.2	19	9/20/2006 9:08
			40.5	19	9/20/2006 9:08
			40.5	19	9/20/2006 9:08
			40.3	19	9/20/2006 9:08
			40.3	19	9/20/2006 9:08
			40.2	19	9/20/2006 9:08
			40	19	9/20/2006 9:08
			40.1	19	9/20/2006 9:08
			39.8	19	9/20/2006 9:08
			39.9	19	9/20/2006 9:08
			40.2	19	9/20/2006 9:08
			39.9	19	9/20/2006 9:08
			40.1	19	9/20/2006 9:08

Path Measurement Data Site 3 Path 1			Path Measurement Data Site 3 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
			39.9	19	9/20/2006 9:08
			40	19	9/20/2006 9:08
			39.9	19	9/20/2006 9:08
			39.9	19	9/20/2006 9:08
			39.8	19	9/20/2006 9:08
			39.9	19	9/20/2006 9:08
			40	19	9/20/2006 9:08
			39.9	19	9/20/2006 9:08
			39.8	19	9/20/2006 9:08
			39.7	19	9/20/2006 9:08
			39.9	19	9/20/2006 9:08
			40	19	9/20/2006 9:08
			40	19	9/20/2006 9:08
			39.6	19	9/20/2006 9:08
			40	19	9/20/2006 9:08
			39.7	19	9/20/2006 9:09
			39.9	19	9/20/2006 9:09
			40	19	9/20/2006 9:09
			39.7	19	9/20/2006 9:09
			39.9	19	9/20/2006 9:09
			40	19	9/20/2006 9:09
			40	19	9/20/2006 9:09
			40	19	9/20/2006 9:09
			39.9	19	9/20/2006 9:09
			39.8	19	9/20/2006 9:09
			39.8	19	9/20/2006 9:09
			40	19	9/20/2006 9:09
			39.9	19	9/20/2006 9:09
			40.1	19	9/20/2006 9:09
			39.9	19	9/20/2006 9:09
			40	19	9/20/2006 9:09
			40	19	9/20/2006 9:09
			39.8	19	9/20/2006 9:09
			39.9	19	9/20/2006 9:09
			39.9	19	9/20/2006 9:09
			40	19	9/20/2006 9:09
			40.1	19	9/20/2006 9:09
			40.1	19	9/20/2006 9:09
			40.1	19	9/20/2006 9:09
			40.3	19	9/20/2006 9:09
			40.2	19	9/20/2006 9:09
			183	19	9/20/2006 9:09
			103	19	9/20/2006 9:09
			2137	19	9/20/2006 9:09
			1553	19	9/20/2006 9:09
			337	19	9/20/2006 9:09
			297	19	9/20/2006 9:09
			139	19	9/20/2006 9:09
			65.8	19	9/20/2006 9:10
			100	19	9/20/2006 9:10
			191	19	9/20/2006 9:10
			268	19	9/20/2006 9:10
			202	19	9/20/2006 9:10
			251	19	9/20/2006 9:10
			1215	19	9/20/2006 9:10
			900	19	9/20/2006 9:10
			1055	19	9/20/2006 9:10
			694	19	9/20/2006 9:10
			441	19	9/20/2006 9:10
			454	19	9/20/2006 9:10

Path Measurement Data Site 3 Path 1			Path Measurement Data Site 3 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
			475	19	9/20/2006 9:10
			272	19	9/20/2006 9:10
			77.3	19	9/20/2006 9:10
			584	19	9/20/2006 9:10
			751	19	9/20/2006 9:10
			1013	19	9/20/2006 9:10
			463	19	9/20/2006 9:10
			431	19	9/20/2006 9:10
			1327	19	9/20/2006 9:10
			972	19	9/20/2006 9:10
			493	19	9/20/2006 9:10
			271	19	9/20/2006 9:10
			1100	19	9/20/2006 9:10
			548	19	9/20/2006 9:10
			1625	19	9/20/2006 9:10
			1743	19	9/20/2006 9:10
			1614	19	9/20/2006 9:10
			656	19	9/20/2006 9:10
			334	19	9/20/2006 9:10
			198	19	9/20/2006 9:10
			838	19	9/20/2006 9:10
			934	19	9/20/2006 9:11
			182	19	9/20/2006 9:11
			300	19	9/20/2006 9:11
			202	19	9/20/2006 9:11
			991	19	9/20/2006 9:11
			168	19	9/20/2006 9:11
			931	19	9/20/2006 9:11
			1207	19	9/20/2006 9:11
			1205	19	9/20/2006 9:11
			630	19	9/20/2006 9:11
			871	19	9/20/2006 9:11
			618	19	9/20/2006 9:11
			322	19	9/20/2006 9:11
			244	19	9/20/2006 9:11
			455	19	9/20/2006 9:11
			819	19	9/20/2006 9:11
			306	19	9/20/2006 9:11
			2341	19	9/20/2006 9:11
			1816	19	9/20/2006 9:11
			997	19	9/20/2006 9:11
			355	19	9/20/2006 9:11
			1340	19	9/20/2006 9:11
			2438	19	9/20/2006 9:11
			2323	19	9/20/2006 9:11
			1497	19	9/20/2006 9:11
			1432	19	9/20/2006 9:11
			1156	19	9/20/2006 9:11
			1246	19	9/20/2006 9:11
			1248	19	9/20/2006 9:11
			772	19	9/20/2006 9:11
			1884	19	9/20/2006 9:11
			1898	19	9/20/2006 9:11
			2430	19	9/20/2006 9:11
			2267	19	9/20/2006 9:12
			2427	19	9/20/2006 9:12
			2405	19	9/20/2006 9:12
			1518	19	9/20/2006 9:12
			1942	19	9/20/2006 9:12
			1358	19	9/20/2006 9:12



Path Measurement Data Site 3 Path 1			Path Measurement Data Site 3 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
			352	19	9/20/2006 9:12
			283	19	9/20/2006 9:12
			1993	19	9/20/2006 9:12
			716	19	9/20/2006 9:12
			1029	19	9/20/2006 9:12
			533	19	9/20/2006 9:12
			2594	19	9/20/2006 9:12
			2228	19	9/20/2006 9:12
			942	19	9/20/2006 9:12
			223	19	9/20/2006 9:12
			74.3	19	9/20/2006 9:12
			95.4	19	9/20/2006 9:12
			78	19	9/20/2006 9:12
			1225	19	9/20/2006 9:12
			1728	19	9/20/2006 9:12
			2417	19	9/20/2006 9:12
			2144	19	9/20/2006 9:12
			2175	19	9/20/2006 9:12
			2054	19	9/20/2006 9:12
			2434	19	9/20/2006 9:12
			2101	19	9/20/2006 9:12
			1539	19	9/20/2006 9:12
			1210	19	9/20/2006 9:12
			1851	19	9/20/2006 9:13
			297	19	9/20/2006 9:13
			283	19	9/20/2006 9:13
			414	19	9/20/2006 9:13
			136	19	9/20/2006 9:13
			113	19	9/20/2006 9:13
			119	19	9/20/2006 9:13
			101	19	9/20/2006 9:13
			82.3	19	9/20/2006 9:13
			150	19	9/20/2006 9:13
			183	19	9/20/2006 9:13
			194	19	9/20/2006 9:13
			212	19	9/20/2006 9:13
			201	19	9/20/2006 9:13
			197	19	9/20/2006 9:13
			202	19	9/20/2006 9:13
			169	19	9/20/2006 9:13
			255	19	9/20/2006 9:13
			1138	19	9/20/2006 9:13
			2496	19	9/20/2006 9:13
			1517	19	9/20/2006 9:13
			400	19	9/20/2006 9:13
			957	19	9/20/2006 9:13
			1856	19	9/20/2006 9:13
			1752	19	9/20/2006 9:13
			728	19	9/20/2006 9:13
			706	19	9/20/2006 9:13
			447	19	9/20/2006 9:13
			111	19	9/20/2006 9:13
			291	19	9/20/2006 9:13
			50.1	19	9/20/2006 9:13
			41.1	19	9/20/2006 9:13
			40	19	9/20/2006 9:13
			41.2	19	9/20/2006 9:13
			40.1	19	9/20/2006 9:14
			39.8	19	9/20/2006 9:14
			40	19	9/20/2006 9:14

Path Measurement Data Site 3 Path 1			Path Measurement Data Site 3 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
			39.8	19	9/20/2006 9:14
			39.6	19	9/20/2006 9:14
			40	19	9/20/2006 9:14
			40.5	19	9/20/2006 9:14
			50	19	9/20/2006 9:14
			187	19	9/20/2006 9:14
			258	19	9/20/2006 9:14
			308	19	9/20/2006 9:14
			156	19	9/20/2006 9:14
			75.4	19	9/20/2006 9:14
			50.3	19	9/20/2006 9:14
			45.2	19	9/20/2006 9:14
			43.2	19	9/20/2006 9:14
			40.6	19	9/20/2006 9:14
			40.1	19	9/20/2006 9:14
			40.2	19	9/20/2006 9:14
			40.2	19	9/20/2006 9:14
			40	19	9/20/2006 9:14
			40.2	19	9/20/2006 9:14
			40.2	19	9/20/2006 9:14
			40.3	19	9/20/2006 9:14
			40	19	9/20/2006 9:14
			40	19	9/20/2006 9:14
			39.9	19	9/20/2006 9:14
			40	19	9/20/2006 9:14
			40.3	19	9/20/2006 9:14
			42.5	19	9/20/2006 9:14
			45.5	19	9/20/2006 9:14
			46	19	9/20/2006 9:14
			49.9	19	9/20/2006 9:14
			52.4	19	9/20/2006 9:14
			50.4	19	9/20/2006 9:15
			47.3	19	9/20/2006 9:15
			45.7	19	9/20/2006 9:15
			41.7	19	9/20/2006 9:15
			40.5	19	9/20/2006 9:15
			39.9	19	9/20/2006 9:15
			39.9	19	9/20/2006 9:15
			39.9	19	9/20/2006 9:15
			40.1	19	9/20/2006 9:15
			40	19	9/20/2006 9:15
			40.4	19	9/20/2006 9:15
			40.7	19	9/20/2006 9:15
			40.9	19	9/20/2006 9:15
			40.9	19	9/20/2006 9:15
			41	19	9/20/2006 9:15
			40.5	19	9/20/2006 9:15
			41	19	9/20/2006 9:15
			40.8	19	9/20/2006 9:15
			43.5	19	9/20/2006 9:15
			176	19	9/20/2006 9:15
			619	19	9/20/2006 9:15
			1028	19	9/20/2006 9:15
			1170	19	9/20/2006 9:15
			1132	19	9/20/2006 9:15
			1655	19	9/20/2006 9:15
			872	19	9/20/2006 9:15
			109	19	9/20/2006 9:15
			68.6	19	9/20/2006 9:15
			41.5	19	9/20/2006 9:15

Path Measurement Data Site 3 Path 1			Path Measurement Data Site 3 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
			39.9	19	9/20/2006 9:15
			39.5	19	9/20/2006 9:15
			39.7	19	9/20/2006 9:15
			40	19	9/20/2006 9:16
			39.9	19	9/20/2006 9:16
			39.7	19	9/20/2006 9:16
			39.9	19	9/20/2006 9:16
			39.7	19	9/20/2006 9:16
			39.9	19	9/20/2006 9:16
			39.9	19	9/20/2006 9:16
			39.9	19	9/20/2006 9:16
			40	19	9/20/2006 9:16
			39.7	19	9/20/2006 9:16
			39.8	19	9/20/2006 9:16
			41.1	19	9/20/2006 9:16
			41.3	19	9/20/2006 9:16
			45.2	19	9/20/2006 9:16
			88.1	19	9/20/2006 9:16
			84.8	19	9/20/2006 9:16
			358	19	9/20/2006 9:16
			935	19	9/20/2006 9:16
			1178	19	9/20/2006 9:16
			591	19	9/20/2006 9:16
			253	19	9/20/2006 9:16
			301	19	9/20/2006 9:16
			620	19	9/20/2006 9:16
			406	19	9/20/2006 9:16
			772	19	9/20/2006 9:16
			589	19	9/20/2006 9:16
			824	19	9/20/2006 9:16
			1165	19	9/20/2006 9:16
			760	19	9/20/2006 9:16
			506	19	9/20/2006 9:16
			263	19	9/20/2006 9:16
			94.8	19	9/20/2006 9:16
			77.6	19	9/20/2006 9:16
			91.3	19	9/20/2006 9:16
			115	19	9/20/2006 9:17
			246	19	9/20/2006 9:17
			260	19	9/20/2006 9:17
			181	19	9/20/2006 9:17
			175	19	9/20/2006 9:17
			144	19	9/20/2006 9:17
			122	19	9/20/2006 9:17
			107	19	9/20/2006 9:17
			258	19	9/20/2006 9:17
			726	19	9/20/2006 9:17
			1055	19	9/20/2006 9:17
			1704	19	9/20/2006 9:17
			1438	19	9/20/2006 9:17
			467	19	9/20/2006 9:17
			187	19	9/20/2006 9:17

Path Measurement Data Site 4 Path 1			Path Measurement Data Site 4 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
27.8	10.7	9/21/2006 9:26	48.6	12.8	9/21/2006 9:54
21.7	10.7	9/21/2006 9:26	47.4	12.8	9/21/2006 9:54
21.5	10.7	9/21/2006 9:26	45.5	12.8	9/21/2006 9:54
21.1	10.7	9/21/2006 9:26	49.9	12.8	9/21/2006 9:54
71.7	10.7	9/21/2006 9:26	50.9	12.8	9/21/2006 9:54
49.7	10.7	9/21/2006 9:26	47.5	12.8	9/21/2006 9:54
38.8	10.7	9/21/2006 9:26	43.2	12.8	9/21/2006 9:54
51.5	10.7	9/21/2006 9:26	44.1	12.8	9/21/2006 9:54
51.2	10.7	9/21/2006 9:26	60.6	12.8	9/21/2006 9:54
31.6	10.7	9/21/2006 9:26	57.6	12.8	9/21/2006 9:54
21.8	10.7	9/21/2006 9:26	45.8	12.8	9/21/2006 9:54
28.4	10.7	9/21/2006 9:26	39.1	12.8	9/21/2006 9:54
42.5	10.7	9/21/2006 9:26	39.3	12.8	9/21/2006 9:54
42.9	10.7	9/21/2006 9:26	38.1	12.8	9/21/2006 9:54
31.5	10.7	9/21/2006 9:26	47.2	12.8	9/21/2006 9:54
27.9	10.7	9/21/2006 9:26	39.4	12.8	9/21/2006 9:54
29.1	10.7	9/21/2006 9:26	42.3	12.8	9/21/2006 9:54
34.3	10.7	9/21/2006 9:26	39.3	12.8	9/21/2006 9:55
29.8	10.7	9/21/2006 9:26	35.8	12.8	9/21/2006 9:55
21.5	10.7	9/21/2006 9:26	33.6	12.8	9/21/2006 9:55
21.2	10.7	9/21/2006 9:26	28.9	12.8	9/21/2006 9:55
21.5	10.7	9/21/2006 9:26	55.3	12.8	9/21/2006 9:55
34.3	10.7	9/21/2006 9:26	307	12.8	9/21/2006 9:55
21.1	10.7	9/21/2006 9:26	31.3	12.8	9/21/2006 9:55
21.2	10.7	9/21/2006 9:26	84.9	12.8	9/21/2006 9:55
28.5	10.7	9/21/2006 9:26	209	12.8	9/21/2006 9:55
38.5	10.7	9/21/2006 9:27	264	12.8	9/21/2006 9:55
24.6	10.7	9/21/2006 9:27	221	12.8	9/21/2006 9:55
21.7	10.7	9/21/2006 9:27	436	12.8	9/21/2006 9:55
30.7	10.7	9/21/2006 9:27	468	12.8	9/21/2006 9:55
23.7	10.7	9/21/2006 9:27	113	12.8	9/21/2006 9:55
26.6	10.7	9/21/2006 9:27	83.8	12.8	9/21/2006 9:55
31.3	10.7	9/21/2006 9:27	73.2	12.8	9/21/2006 9:55
29.2	10.7	9/21/2006 9:27	146	12.8	9/21/2006 9:55
23.9	10.7	9/21/2006 9:27	84.3	12.8	9/21/2006 9:55
29	10.7	9/21/2006 9:27	85.8	12.8	9/21/2006 9:55
33.8	10.7	9/21/2006 9:27	48.6	12.8	9/21/2006 9:55
35.3	10.7	9/21/2006 9:27	41.3	12.8	9/21/2006 9:55
57.6	10.7	9/21/2006 9:27	45.9	12.8	9/21/2006 9:55
61.4	10.7	9/21/2006 9:27	43	12.8	9/21/2006 9:55
29	10.7	9/21/2006 9:27	28.3	12.8	9/21/2006 9:55
22.7	10.7	9/21/2006 9:27	38.5	12.8	9/21/2006 9:55
23.3	10.7	9/21/2006 9:27	36.4	12.8	9/21/2006 9:55
22.3	10.7	9/21/2006 9:27	44.7	12.8	9/21/2006 9:55
22.8	10.7	9/21/2006 9:27	78.3	12.8	9/21/2006 9:55
23.1	10.7	9/21/2006 9:27	47.2	12.8	9/21/2006 9:55
23.8	10.7	9/21/2006 9:27	36.2	12.8	9/21/2006 9:55
25.8	10.7	9/21/2006 9:27	96.3	12.8	9/21/2006 9:55
29.8	10.7	9/21/2006 9:27	37.5	12.8	9/21/2006 9:55
30.5	10.7	9/21/2006 9:27	61.9	12.8	9/21/2006 9:55
29.6	10.7	9/21/2006 9:27	43.8	12.8	9/21/2006 9:56
27.6	10.7	9/21/2006 9:27	62.2	12.8	9/21/2006 9:56
27.4	10.7	9/21/2006 9:27	123	12.8	9/21/2006 9:56
26.5	10.7	9/21/2006 9:27	223	12.8	9/21/2006 9:56
28	10.7	9/21/2006 9:27	166	12.8	9/21/2006 9:56
36.9	10.7	9/21/2006 9:27	96	12.8	9/21/2006 9:56
60.3	10.7	9/21/2006 9:27	96.4	12.8	9/21/2006 9:56
38.7	10.7	9/21/2006 9:27	128	12.8	9/21/2006 9:56
34.5	10.7	9/21/2006 9:27	232	12.8	9/21/2006 9:56
33.4	10.7	9/21/2006 9:27	498	12.8	9/21/2006 9:56

Path Measurement Data Site 4 Path 1			Path Measurement Data Site 4 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
34.5	10.7	9/21/2006 9:28	218	12.8	9/21/2006 9:56
37.4	10.7	9/21/2006 9:28	293	12.8	9/21/2006 9:56
73.1	10.7	9/21/2006 9:28	311	12.8	9/21/2006 9:56
82	10.7	9/21/2006 9:28	169	12.8	9/21/2006 9:56
57.4	10.7	9/21/2006 9:28	50.4	12.8	9/21/2006 9:56
45.4	10.7	9/21/2006 9:28	62.9	12.8	9/21/2006 9:56
43.6	10.7	9/21/2006 9:28	54.9	12.8	9/21/2006 9:56
45.9	10.7	9/21/2006 9:28	259	12.8	9/21/2006 9:56
49.1	10.7	9/21/2006 9:28	89.9	12.8	9/21/2006 9:56
45.4	10.7	9/21/2006 9:28	63	12.8	9/21/2006 9:56
57.6	10.7	9/21/2006 9:28	51.1	12.8	9/21/2006 9:56
75.6	10.7	9/21/2006 9:28	62	12.8	9/21/2006 9:56
90	10.7	9/21/2006 9:28	126	12.8	9/21/2006 9:56
63.7	10.7	9/21/2006 9:28	68.1	12.8	9/21/2006 9:56
67.7	10.7	9/21/2006 9:28	38.2	12.8	9/21/2006 9:56
69.5	10.7	9/21/2006 9:28	54.4	12.8	9/21/2006 9:56
77.4	10.7	9/21/2006 9:28	187	12.8	9/21/2006 9:56
73.1	10.7	9/21/2006 9:28	89.3	12.8	9/21/2006 9:56
117	10.7	9/21/2006 9:28	63.1	12.8	9/21/2006 9:56
83.5	10.7	9/21/2006 9:28	96.8	12.8	9/21/2006 9:56
83.8	10.7	9/21/2006 9:28	100	12.8	9/21/2006 9:56
89.5	10.7	9/21/2006 9:28	128	12.8	9/21/2006 9:56
56	10.7	9/21/2006 9:28	40.4	12.8	9/21/2006 9:56
70.9	10.7	9/21/2006 9:28	41.5	12.8	9/21/2006 9:57
51.8	10.7	9/21/2006 9:28	35.1	12.8	9/21/2006 9:57
103	10.7	9/21/2006 9:28	48.5	12.8	9/21/2006 9:57
161	10.7	9/21/2006 9:28	39.9	12.8	9/21/2006 9:57
536	10.7	9/21/2006 9:28	53	12.8	9/21/2006 9:57
728	10.7	9/21/2006 9:28	49.3	12.8	9/21/2006 9:57
1165	10.7	9/21/2006 9:28	58.2	12.8	9/21/2006 9:57
95.2	10.7	9/21/2006 9:28	93.9	12.8	9/21/2006 9:57
134	10.7	9/21/2006 9:28	50.8	12.8	9/21/2006 9:57
54.8	10.7	9/21/2006 9:28	48.3	12.8	9/21/2006 9:57
54.9	10.7	9/21/2006 9:28	75	12.8	9/21/2006 9:57
51.1	10.7	9/21/2006 9:29	83.3	12.8	9/21/2006 9:57
59.6	10.7	9/21/2006 9:29	58.3	12.8	9/21/2006 9:57
46	10.7	9/21/2006 9:29	47.4	12.8	9/21/2006 9:57
43.3	10.7	9/21/2006 9:29	42	12.8	9/21/2006 9:57
36.5	10.7	9/21/2006 9:29	41.2	12.8	9/21/2006 9:57
32.2	10.7	9/21/2006 9:29	42.2	12.8	9/21/2006 9:57
27.3	10.7	9/21/2006 9:29	149	12.8	9/21/2006 9:57
30.4	10.7	9/21/2006 9:29	599	12.8	9/21/2006 9:57
33.8	10.7	9/21/2006 9:29	587	12.8	9/21/2006 9:57
30	10.7	9/21/2006 9:29	1437	12.8	9/21/2006 9:57
26.6	10.7	9/21/2006 9:29	732	12.8	9/21/2006 9:57
27.6	10.7	9/21/2006 9:29	70.8	12.8	9/21/2006 9:57
25.4	10.7	9/21/2006 9:29	143	12.8	9/21/2006 9:57
30.1	10.7	9/21/2006 9:29	259	12.8	9/21/2006 9:57
27.9	10.7	9/21/2006 9:29	34.7	12.8	9/21/2006 9:57
28	10.7	9/21/2006 9:29	38.3	12.8	9/21/2006 9:57
26.3	10.7	9/21/2006 9:29	72.8	12.8	9/21/2006 9:57
29.1	10.7	9/21/2006 9:29	86	12.8	9/21/2006 9:57
29.5	10.7	9/21/2006 9:29	87.1	12.8	9/21/2006 9:57
28.7	10.7	9/21/2006 9:29	141	12.8	9/21/2006 9:57
28.8	10.7	9/21/2006 9:29	178	12.8	9/21/2006 9:57
29.5	10.7	9/21/2006 9:29	107	12.8	9/21/2006 9:57
31.7	10.7	9/21/2006 9:29	60.6	12.8	9/21/2006 9:57
29.6	10.7	9/21/2006 9:29	47.3	12.8	9/21/2006 9:58
35.2	10.7	9/21/2006 9:29	52.3	12.8	9/21/2006 9:58
37.6	10.7	9/21/2006 9:29	57.5	12.8	9/21/2006 9:58

Path Measurement Data Site 4 Path 1			Path Measurement Data Site 4 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
40	10.7	9/21/2006 9:29	53.5	12.8	9/21/2006 9:58
42.2	10.7	9/21/2006 9:29	46.1	12.8	9/21/2006 9:58
48.5	10.7	9/21/2006 9:29	42	12.8	9/21/2006 9:58
42.6	10.7	9/21/2006 9:29	40.2	12.8	9/21/2006 9:58
48.9	10.7	9/21/2006 9:29	45.5	12.8	9/21/2006 9:58
52.8	10.7	9/21/2006 9:29	45.2	12.8	9/21/2006 9:58
66.2	10.7	9/21/2006 9:29	45.2	12.8	9/21/2006 9:58
79.3	10.7	9/21/2006 9:29	44.8	12.8	9/21/2006 9:58
76.9	10.7	9/21/2006 9:30	38.5	12.8	9/21/2006 9:58
84.2	10.7	9/21/2006 9:30	36.3	12.8	9/21/2006 9:58
129	10.7	9/21/2006 9:30	37.4	12.8	9/21/2006 9:58
181	10.7	9/21/2006 9:30	38.9	12.8	9/21/2006 9:58
253	10.7	9/21/2006 9:30	44.6	12.8	9/21/2006 9:58
214	10.7	9/21/2006 9:30	44.3	12.8	9/21/2006 9:58
213	10.7	9/21/2006 9:30	41.7	12.8	9/21/2006 9:58
210	10.7	9/21/2006 9:30	40.7	12.8	9/21/2006 9:58
191	10.7	9/21/2006 9:30	38.1	12.8	9/21/2006 9:58
196	10.7	9/21/2006 9:30	36.2	12.8	9/21/2006 9:58
189	10.7	9/21/2006 9:30	30.7	12.8	9/21/2006 9:58
162	10.7	9/21/2006 9:30	29	12.8	9/21/2006 9:58
150	10.7	9/21/2006 9:30	29.2	12.8	9/21/2006 9:58
122	10.7	9/21/2006 9:30	28.1	12.8	9/21/2006 9:58
129	10.7	9/21/2006 9:30	27.8	12.8	9/21/2006 9:58
132	10.7	9/21/2006 9:30	29	12.8	9/21/2006 9:58
172	10.7	9/21/2006 9:30	26.8	12.8	9/21/2006 9:58
134	10.7	9/21/2006 9:30	24.9	12.8	9/21/2006 9:58
112	10.7	9/21/2006 9:30	25.5	12.8	9/21/2006 9:58
99.6	10.7	9/21/2006 9:30	25	12.8	9/21/2006 9:58
85.6	10.7	9/21/2006 9:30	24.9	12.8	9/21/2006 9:58
47.7	10.7	9/21/2006 9:30	25.4	12.8	9/21/2006 9:58
50.2	10.7	9/21/2006 9:30	25.2	12.8	9/21/2006 9:58
83.6	10.7	9/21/2006 9:30	25.2	12.8	9/21/2006 9:59
55.4	10.7	9/21/2006 9:30	25.1	12.8	9/21/2006 9:59
44	10.7	9/21/2006 9:30	25.2	12.8	9/21/2006 9:59
44.5	10.7	9/21/2006 9:30	25.2	12.8	9/21/2006 9:59
31.4	10.7	9/21/2006 9:30	25	12.8	9/21/2006 9:59
32.7	10.7	9/21/2006 9:30	25.3	12.8	9/21/2006 9:59
39.2	10.7	9/21/2006 9:30	25.1	12.8	9/21/2006 9:59
45.6	10.7	9/21/2006 9:30	25.1	12.8	9/21/2006 9:59
36.7	10.7	9/21/2006 9:30	25.4	12.8	9/21/2006 9:59
26.9	10.7	9/21/2006 9:30	25.4	12.8	9/21/2006 9:59
35.8	10.7	9/21/2006 9:30	25.1	12.8	9/21/2006 9:59
34.6	10.7	9/21/2006 9:31	25	12.8	9/21/2006 9:59
22.9	10.7	9/21/2006 9:31	25.3	12.8	9/21/2006 9:59
39.5	10.7	9/21/2006 9:31	25.2	12.8	9/21/2006 9:59
36.3	10.7	9/21/2006 9:31	25.1	12.8	9/21/2006 9:59
24.4	10.7	9/21/2006 9:31	25	12.8	9/21/2006 9:59
25.3	10.7	9/21/2006 9:31	25.1	12.8	9/21/2006 9:59
41	10.7	9/21/2006 9:31	25.2	12.8	9/21/2006 9:59
45.8	10.7	9/21/2006 9:31	25.2	12.8	9/21/2006 9:59
32.3	10.7	9/21/2006 9:31	25.2	12.8	9/21/2006 9:59
33.2	10.7	9/21/2006 9:31	25.1	12.8	9/21/2006 9:59
37.2	10.7	9/21/2006 9:31	24.9	12.8	9/21/2006 9:59
24.6	10.7	9/21/2006 9:31	25	12.8	9/21/2006 9:59
33.7	10.7	9/21/2006 9:31	25	12.8	9/21/2006 9:59
37.8	10.7	9/21/2006 9:31	25.1	12.8	9/21/2006 9:59
26.8	10.7	9/21/2006 9:31	25.3	12.8	9/21/2006 9:59
34.4	10.7	9/21/2006 9:31	25.3	12.8	9/21/2006 9:59
28.9	10.7	9/21/2006 9:31	25.4	12.8	9/21/2006 9:59
27.4	10.7	9/21/2006 9:31	25	12.8	9/21/2006 9:59

Path Measurement Data Site 4 Path 1			Path Measurement Data Site 4 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
38.8	10.7	9/21/2006 9:31	24.8	12.8	9/21/2006 9:59
34.9	10.7	9/21/2006 9:31	25.1	12.8	9/21/2006 9:59
26.5	10.7	9/21/2006 9:31	25	12.8	9/21/2006 9:59
28.9	10.7	9/21/2006 9:31	25.1	12.8	9/21/2006 9:59
27.7	10.7	9/21/2006 9:31	25.1	12.8	9/21/2006 9:59
37.2	10.7	9/21/2006 9:31	24.8	12.8	9/21/2006 10:00
29.2	10.7	9/21/2006 9:31	24.7	12.8	9/21/2006 10:00
28.1	10.7	9/21/2006 9:31	24.9	12.8	9/21/2006 10:00
21.4	10.7	9/21/2006 9:31	24.8	12.8	9/21/2006 10:00
32.1	10.7	9/21/2006 9:31	24.7	12.8	9/21/2006 10:00
27.2	10.7	9/21/2006 9:31	24.8	12.8	9/21/2006 10:00
30.7	10.7	9/21/2006 9:31	24.9	12.8	9/21/2006 10:00
38.1	10.7	9/21/2006 9:31	24.7	12.8	9/21/2006 10:00
29.8	10.7	9/21/2006 9:31	24.8	12.8	9/21/2006 10:00
33.3	10.7	9/21/2006 9:31	24.8	12.8	9/21/2006 10:00
35.6	10.7	9/21/2006 9:31	25.3	12.8	9/21/2006 10:00
29.5	10.7	9/21/2006 9:31	24.7	12.8	9/21/2006 10:00
23.9	10.7	9/21/2006 9:32	25	12.8	9/21/2006 10:00
26.4	10.7	9/21/2006 9:32	25.1	12.8	9/21/2006 10:00
33.6	10.7	9/21/2006 9:32	25.8	12.8	9/21/2006 10:00
28.8	10.7	9/21/2006 9:32	25.1	12.8	9/21/2006 10:00
35.6	10.7	9/21/2006 9:32	25.3	12.8	9/21/2006 10:00
27.7	10.7	9/21/2006 9:32	25.7	12.8	9/21/2006 10:00
23.5	10.7	9/21/2006 9:32	25	12.8	9/21/2006 10:00
27.8	10.7	9/21/2006 9:32	24.9	12.8	9/21/2006 10:00
29.8	10.7	9/21/2006 9:32	25	12.8	9/21/2006 10:00
29.4	10.7	9/21/2006 9:32	25	12.8	9/21/2006 10:00
29.9	10.7	9/21/2006 9:32	25	12.8	9/21/2006 10:00
25.8	10.7	9/21/2006 9:32	25	12.8	9/21/2006 10:00
28.4	10.7	9/21/2006 9:32	25.1	12.8	9/21/2006 10:00
29.2	10.7	9/21/2006 9:32	24.8	12.8	9/21/2006 10:00
27.6	10.7	9/21/2006 9:32	24.8	12.8	9/21/2006 10:00
27.3	10.7	9/21/2006 9:32	24.8	12.8	9/21/2006 10:00
21.2	10.7	9/21/2006 9:32	24.9	12.8	9/21/2006 10:00
23.3	10.7	9/21/2006 9:32	24.8	12.8	9/21/2006 10:00
38.4	10.7	9/21/2006 9:32	24.8	12.8	9/21/2006 10:00
34.4	10.7	9/21/2006 9:32	25	12.8	9/21/2006 10:00
24.6	10.7	9/21/2006 9:32	24.9	12.8	9/21/2006 10:00
28.3	10.7	9/21/2006 9:32	25	12.8	9/21/2006 10:00
34.3	10.7	9/21/2006 9:32	24.9	12.8	9/21/2006 10:01
30.6	10.7	9/21/2006 9:32	24.7	12.8	9/21/2006 10:01
33.8	10.7	9/21/2006 9:32	24.8	12.8	9/21/2006 10:01
30.3	10.7	9/21/2006 9:32	24.6	12.8	9/21/2006 10:01
20.9	10.7	9/21/2006 9:32	24.6	12.8	9/21/2006 10:01
22	10.7	9/21/2006 9:32	24.6	12.8	9/21/2006 10:01
26.7	10.7	9/21/2006 9:32	24.5	12.8	9/21/2006 10:01
30.3	10.7	9/21/2006 9:32	25.2	12.8	9/21/2006 10:01
30.5	10.7	9/21/2006 9:32	24.7	12.8	9/21/2006 10:01
34.6	10.7	9/21/2006 9:32	24.4	12.8	9/21/2006 10:01
26	10.7	9/21/2006 9:32	24.3	12.8	9/21/2006 10:01
28.4	10.7	9/21/2006 9:32	24.5	12.8	9/21/2006 10:01
41.4	10.7	9/21/2006 9:33	24.7	12.8	9/21/2006 10:01
35	10.7	9/21/2006 9:33	24.4	12.8	9/21/2006 10:01
33.9	10.7	9/21/2006 9:33	24.8	12.8	9/21/2006 10:01
25.6	10.7	9/21/2006 9:33	24.9	12.8	9/21/2006 10:01
35.2	10.7	9/21/2006 9:33	24.4	12.8	9/21/2006 10:01
27.7	10.7	9/21/2006 9:33	24.4	12.8	9/21/2006 10:01
38.1	10.7	9/21/2006 9:33	24.6	12.8	9/21/2006 10:01
35.6	10.7	9/21/2006 9:33	24.6	12.8	9/21/2006 10:01
25.4	10.7	9/21/2006 9:33	24.8	12.8	9/21/2006 10:01

Path Measurement Data Site 4 Path 1			Path Measurement Data Site 4 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
32.1	10.7	9/21/2006 9:33	24.4	12.8	9/21/2006 10:01
37.3	10.7	9/21/2006 9:33	24.6	12.8	9/21/2006 10:01
28.1	10.7	9/21/2006 9:33	24.8	12.8	9/21/2006 10:01
35.3	10.7	9/21/2006 9:33	24.9	12.8	9/21/2006 10:01
39	10.7	9/21/2006 9:33	24.8	12.8	9/21/2006 10:01
25.2	10.7	9/21/2006 9:33	24.8	12.8	9/21/2006 10:01
33.9	10.7	9/21/2006 9:33	24.8	12.8	9/21/2006 10:01
42.6	10.7	9/21/2006 9:33	24.6	12.8	9/21/2006 10:01
40.8	10.7	9/21/2006 9:33	24.7	12.8	9/21/2006 10:01
37.9	10.7	9/21/2006 9:33	24.9	12.8	9/21/2006 10:01
31.7	10.7	9/21/2006 9:33	25.3	12.8	9/21/2006 10:01
21	10.7	9/21/2006 9:33	25.7	12.8	9/21/2006 10:01
37.2	10.7	9/21/2006 9:33	25	12.8	9/21/2006 10:01
21.2	10.7	9/21/2006 9:33	24.6	12.8	9/21/2006 10:02
21.3	10.7	9/21/2006 9:33	24.5	12.8	9/21/2006 10:02
23.7	10.7	9/21/2006 9:33	25.1	12.8	9/21/2006 10:02
36	10.7	9/21/2006 9:33	24.8	12.8	9/21/2006 10:02
54.3	10.7	9/21/2006 9:33	25	12.8	9/21/2006 10:02
38.6	10.7	9/21/2006 9:33	25.1	12.8	9/21/2006 10:02
57.8	10.7	9/21/2006 9:33	24.5	12.8	9/21/2006 10:02
43.3	10.7	9/21/2006 9:33	25.1	12.8	9/21/2006 10:02
29.5	10.7	9/21/2006 9:33	24.7	12.8	9/21/2006 10:02
25.4	10.7	9/21/2006 9:33	24.7	12.8	9/21/2006 10:02
23.2	10.7	9/21/2006 9:33	24.6	12.8	9/21/2006 10:02
25.1	10.7	9/21/2006 9:33	24.6	12.8	9/21/2006 10:02
31.5	10.7	9/21/2006 9:34	24.7	12.8	9/21/2006 10:02
32	10.7	9/21/2006 9:34	24.5	12.8	9/21/2006 10:02
34.6	10.7	9/21/2006 9:34	24.6	12.8	9/21/2006 10:02
24.8	10.7	9/21/2006 9:34	24.7	12.8	9/21/2006 10:02
23.3	10.7	9/21/2006 9:34	25.2	12.8	9/21/2006 10:02
26.1	10.7	9/21/2006 9:34	24.5	12.8	9/21/2006 10:02
23	10.7	9/21/2006 9:34	24.9	12.8	9/21/2006 10:02
22.2	10.7	9/21/2006 9:34	24.3	12.8	9/21/2006 10:02
21.6	10.7	9/21/2006 9:34	24.3	12.8	9/21/2006 10:02
21.4	10.7	9/21/2006 9:34	24.4	12.8	9/21/2006 10:02
21.2	10.7	9/21/2006 9:34	24.2	12.8	9/21/2006 10:02
21.4	10.7	9/21/2006 9:34	24.8	12.8	9/21/2006 10:02
22.6	10.7	9/21/2006 9:34	24.8	12.8	9/21/2006 10:02
24.1	10.7	9/21/2006 9:34	24.5	12.8	9/21/2006 10:02
28.6	10.7	9/21/2006 9:34	24.5	12.8	9/21/2006 10:02
710	10.7	9/21/2006 9:34	24.5	12.8	9/21/2006 10:02
24.2	10.7	9/21/2006 9:34	24.4	12.8	9/21/2006 10:02
22.3	10.7	9/21/2006 9:34	24.4	12.8	9/21/2006 10:02
21.9	10.7	9/21/2006 9:34	24.4	12.8	9/21/2006 10:02
23.7	10.7	9/21/2006 9:34	24.3	12.8	9/21/2006 10:02
28.1	10.7	9/21/2006 9:34	24.4	12.8	9/21/2006 10:02
47.1	10.7	9/21/2006 9:34	24.4	12.8	9/21/2006 10:02
39.8	10.7	9/21/2006 9:34	24.5	12.8	9/21/2006 10:02
39.3	10.7	9/21/2006 9:34	24.4	12.8	9/21/2006 10:03
40	10.7	9/21/2006 9:34	24.7	12.8	9/21/2006 10:03
113	10.7	9/21/2006 9:34	24.9	12.8	9/21/2006 10:03
424	10.7	9/21/2006 9:34	24.7	12.8	9/21/2006 10:03
1081	10.7	9/21/2006 9:34	24.6	12.8	9/21/2006 10:03
1067	10.7	9/21/2006 9:34	24.5	12.8	9/21/2006 10:03
2319	10.7	9/21/2006 9:34	24.8	12.8	9/21/2006 10:03
1581	10.7	9/21/2006 9:34	24.5	12.8	9/21/2006 10:03
1097	10.7	9/21/2006 9:34	24.7	12.8	9/21/2006 10:03
734	10.7	9/21/2006 9:34	24.5	12.8	9/21/2006 10:03
213	10.7	9/21/2006 9:34	24.3	12.8	9/21/2006 10:03
98.9	10.7	9/21/2006 9:35	24.2	12.8	9/21/2006 10:03



Path Measurement Data Site 4 Path 1			Path Measurement Data Site 4 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
79.2	10.7	9/21/2006 9:35	24.1	12.8	9/21/2006 10:03
919	10.7	9/21/2006 9:35	24.2	12.8	9/21/2006 10:03
900	10.7	9/21/2006 9:35	24.1	12.8	9/21/2006 10:03
173	10.7	9/21/2006 9:35	23.9	12.8	9/21/2006 10:03
56.8	10.7	9/21/2006 9:35	24.1	12.8	9/21/2006 10:03
45.2	10.7	9/21/2006 9:35	24.2	12.8	9/21/2006 10:03
44.7	10.7	9/21/2006 9:35	24.1	12.8	9/21/2006 10:03
46.8	10.7	9/21/2006 9:35	24.1	12.8	9/21/2006 10:03
43.6	10.7	9/21/2006 9:35	23.9	12.8	9/21/2006 10:03
51.8	10.7	9/21/2006 9:35	23.9	12.8	9/21/2006 10:03
22.5	10.7	9/21/2006 9:35	23.9	12.8	9/21/2006 10:03
28.5	10.7	9/21/2006 9:35	24.1	12.8	9/21/2006 10:03
32	10.7	9/21/2006 9:35	24.1	12.8	9/21/2006 10:03
25.2	10.7	9/21/2006 9:35	23.9	12.8	9/21/2006 10:03
24.3	10.7	9/21/2006 9:35	23.7	12.8	9/21/2006 10:03
26	10.7	9/21/2006 9:35	24	12.8	9/21/2006 10:03
22.4	10.7	9/21/2006 9:35	24	12.8	9/21/2006 10:03
25.1	10.7	9/21/2006 9:35	24.1	12.8	9/21/2006 10:03
34.2	10.7	9/21/2006 9:35	24	12.8	9/21/2006 10:03
27.7	10.7	9/21/2006 9:35	24	12.8	9/21/2006 10:03
26.4	10.7	9/21/2006 9:35	23.9	12.8	9/21/2006 10:03
27.5	10.7	9/21/2006 9:35	24	12.8	9/21/2006 10:03
25.4	10.7	9/21/2006 9:35	24	12.8	9/21/2006 10:04
27.3	10.7	9/21/2006 9:35	24.1	12.8	9/21/2006 10:04
34.2	10.7	9/21/2006 9:35	23.8	12.8	9/21/2006 10:04
25.3	10.7	9/21/2006 9:35	23.9	12.8	9/21/2006 10:04
30.6	10.7	9/21/2006 9:35	24	12.8	9/21/2006 10:04
27.7	10.7	9/21/2006 9:35	24.1	12.8	9/21/2006 10:04
25.6	10.7	9/21/2006 9:35	24.1	12.8	9/21/2006 10:04
31.7	10.7	9/21/2006 9:35	24	12.8	9/21/2006 10:04
29.2	10.7	9/21/2006 9:35	24.1	12.8	9/21/2006 10:04
22.3	10.7	9/21/2006 9:35	24.2	12.8	9/21/2006 10:04
29.5	10.7	9/21/2006 9:35	24.1	12.8	9/21/2006 10:04
39.6	10.7	9/21/2006 9:36	24.2	12.8	9/21/2006 10:04
33.9	10.7	9/21/2006 9:36	24.2	12.8	9/21/2006 10:04
37.7	10.7	9/21/2006 9:36	24	12.8	9/21/2006 10:04
26.8	10.7	9/21/2006 9:36	24.4	12.8	9/21/2006 10:04
28.2	10.7	9/21/2006 9:36	24.4	12.8	9/21/2006 10:04
24.5	10.7	9/21/2006 9:36	24.4	12.8	9/21/2006 10:04
25.4	10.7	9/21/2006 9:36	24.5	12.8	9/21/2006 10:04
24.1	10.7	9/21/2006 9:36	24.3	12.8	9/21/2006 10:04
28.8	10.7	9/21/2006 9:36	24.4	12.8	9/21/2006 10:04
25.6	10.7	9/21/2006 9:36	24.4	12.8	9/21/2006 10:04
28.9	10.7	9/21/2006 9:36	24.4	12.8	9/21/2006 10:04
27	10.7	9/21/2006 9:36	24.5	12.8	9/21/2006 10:04
32.2	10.7	9/21/2006 9:36	24.7	12.8	9/21/2006 10:04
42.7	10.7	9/21/2006 9:36	24.8	12.8	9/21/2006 10:04
30.7	10.7	9/21/2006 9:36	24.5	12.8	9/21/2006 10:04
23.9	10.7	9/21/2006 9:36	24.3	12.8	9/21/2006 10:04
24.9	10.7	9/21/2006 9:36	24.3	12.8	9/21/2006 10:04
30.9	10.7	9/21/2006 9:36	24	12.8	9/21/2006 10:04
32.3	10.7	9/21/2006 9:36	24.2	12.8	9/21/2006 10:04
38.3	10.7	9/21/2006 9:36	24.3	12.8	9/21/2006 10:04
38	10.7	9/21/2006 9:36	24.3	12.8	9/21/2006 10:04
23.9	10.7	9/21/2006 9:36	24.1	12.8	9/21/2006 10:04
22.3	10.7	9/21/2006 9:36	24.1	12.8	9/21/2006 10:04
32.6	10.7	9/21/2006 9:36	24.3	12.8	9/21/2006 10:05
33.1	10.7	9/21/2006 9:36	24.2	12.8	9/21/2006 10:05
36.9	10.7	9/21/2006 9:36	24.3	12.8	9/21/2006 10:05
41.2	10.7	9/21/2006 9:36	24.3	12.8	9/21/2006 10:05

Path Measurement Data Site 4 Path 1			Path Measurement Data Site 4 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
29.5	10.7	9/21/2006 9:36	24.1	12.8	9/21/2006 10:05
42.3	10.7	9/21/2006 9:36	24.2	12.8	9/21/2006 10:05
43.8	10.7	9/21/2006 9:36	24.1	12.8	9/21/2006 10:05
30.6	10.7	9/21/2006 9:36	24.1	12.8	9/21/2006 10:05
43.9	10.7	9/21/2006 9:36	24.1	12.8	9/21/2006 10:05
58	10.7	9/21/2006 9:36	24	12.8	9/21/2006 10:05
28	10.7	9/21/2006 9:36	24.3	12.8	9/21/2006 10:05
22.6	10.7	9/21/2006 9:37	24.2	12.8	9/21/2006 10:05
24.1	10.7	9/21/2006 9:37	24.2	12.8	9/21/2006 10:05
24.4	10.7	9/21/2006 9:37	24	12.8	9/21/2006 10:05
33.7	10.7	9/21/2006 9:37	24.1	12.8	9/21/2006 10:05
34	10.7	9/21/2006 9:37	24.3	12.8	9/21/2006 10:05
34.8	10.7	9/21/2006 9:37	23.9	12.8	9/21/2006 10:05
37.1	10.7	9/21/2006 9:37	24.1	12.8	9/21/2006 10:05
36.9	10.7	9/21/2006 9:37	26.3	12.8	9/21/2006 10:05
36.3	10.7	9/21/2006 9:37	67.1	12.8	9/21/2006 10:05
35.3	10.7	9/21/2006 9:37	51.9	12.8	9/21/2006 10:05
34.8	10.7	9/21/2006 9:37	49.4	12.8	9/21/2006 10:05
32.6	10.7	9/21/2006 9:37	64.8	12.8	9/21/2006 10:05
44.6	10.7	9/21/2006 9:37	80.6	12.8	9/21/2006 10:05
49.2	10.7	9/21/2006 9:37	48.8	12.8	9/21/2006 10:05
37.6	10.7	9/21/2006 9:37	35.4	12.8	9/21/2006 10:05
48.6	10.7	9/21/2006 9:37	30.5	12.8	9/21/2006 10:05
44.4	10.7	9/21/2006 9:37	46.1	12.8	9/21/2006 10:05
47.4	10.7	9/21/2006 9:37	45.7	12.8	9/21/2006 10:05
42.1	10.7	9/21/2006 9:37	51.5	12.8	9/21/2006 10:05
34.6	10.7	9/21/2006 9:37	32.7	12.8	9/21/2006 10:05
45.9	10.7	9/21/2006 9:37	31	12.8	9/21/2006 10:05
41.5	10.7	9/21/2006 9:37	31.2	12.8	9/21/2006 10:05
35	10.7	9/21/2006 9:37	33	12.8	9/21/2006 10:05
33.2	10.7	9/21/2006 9:37	30.1	12.8	9/21/2006 10:06
43.3	10.7	9/21/2006 9:37	28.9	12.8	9/21/2006 10:06
42	10.7	9/21/2006 9:37	28	12.8	9/21/2006 10:06
36.7	10.7	9/21/2006 9:37	25.7	12.8	9/21/2006 10:06
33.7	10.7	9/21/2006 9:37	24.8	12.8	9/21/2006 10:06
37.8	10.7	9/21/2006 9:37	25.1	12.8	9/21/2006 10:06
52.3	10.7	9/21/2006 9:37	24.7	12.8	9/21/2006 10:06
45.4	10.7	9/21/2006 9:37	24.3	12.8	9/21/2006 10:06
50.3	10.7	9/21/2006 9:37	25.3	12.8	9/21/2006 10:06
36.2	10.7	9/21/2006 9:37	24.2	12.8	9/21/2006 10:06
44.1	10.7	9/21/2006 9:37	23.8	12.8	9/21/2006 10:06
40.7	10.7	9/21/2006 9:38	23.7	12.8	9/21/2006 10:06
54.2	10.7	9/21/2006 9:38	23.8	12.8	9/21/2006 10:06
74.6	10.7	9/21/2006 9:38	24	12.8	9/21/2006 10:06
70	10.7	9/21/2006 9:38	24	12.8	9/21/2006 10:06
36.6	10.7	9/21/2006 9:38	23.8	12.8	9/21/2006 10:06
30.4	10.7	9/21/2006 9:38	24	12.8	9/21/2006 10:06
57.2	10.7	9/21/2006 9:38	23.8	12.8	9/21/2006 10:06
41.3	10.7	9/21/2006 9:38	23.9	12.8	9/21/2006 10:06
43.7	10.7	9/21/2006 9:38	24.1	12.8	9/21/2006 10:06
35.4	10.7	9/21/2006 9:38	24.1	12.8	9/21/2006 10:06
44.9	10.7	9/21/2006 9:38	24	12.8	9/21/2006 10:06
29.1	10.7	9/21/2006 9:38	23.9	12.8	9/21/2006 10:06
45.3	10.7	9/21/2006 9:38	24.3	12.8	9/21/2006 10:06
43.4	10.7	9/21/2006 9:38	24.2	12.8	9/21/2006 10:06
35.7	10.7	9/21/2006 9:38	24.1	12.8	9/21/2006 10:06
23.6	10.7	9/21/2006 9:38	24.2	12.8	9/21/2006 10:06
33.3	10.7	9/21/2006 9:38	30.6	12.8	9/21/2006 10:06
24.9	10.7	9/21/2006 9:38	31.1	12.8	9/21/2006 10:06
25.4	10.7	9/21/2006 9:38	26.7	12.8	9/21/2006 10:06

Path Measurement Data Site 4 Path 1			Path Measurement Data Site 4 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
24.9	10.7	9/21/2006 9:38	29.8	12.8	9/21/2006 10:06
49.6	10.7	9/21/2006 9:38	82.2	12.8	9/21/2006 10:06
30.8	10.7	9/21/2006 9:38	170	12.8	9/21/2006 10:06
27.9	10.7	9/21/2006 9:38	184	12.8	9/21/2006 10:06
24.8	10.7	9/21/2006 9:38	736	12.8	9/21/2006 10:07
24.2	10.7	9/21/2006 9:38	1134	12.8	9/21/2006 10:07
24.3	10.7	9/21/2006 9:38	665	12.8	9/21/2006 10:07
27.5	10.7	9/21/2006 9:38	1269	12.8	9/21/2006 10:07
26.8	10.7	9/21/2006 9:38	717	12.8	9/21/2006 10:07
24.1	10.7	9/21/2006 9:38	692	12.8	9/21/2006 10:07
24	10.7	9/21/2006 9:38	388	12.8	9/21/2006 10:07
24.7	10.7	9/21/2006 9:38	620	12.8	9/21/2006 10:07
26.4	10.7	9/21/2006 9:38	678	12.8	9/21/2006 10:07
28.7	10.7	9/21/2006 9:38	431	12.8	9/21/2006 10:07
52.2	10.7	9/21/2006 9:38	576	12.8	9/21/2006 10:07
46	10.7	9/21/2006 9:38	561	12.8	9/21/2006 10:07
32.3	10.7	9/21/2006 9:39	281	12.8	9/21/2006 10:07
37.3	10.7	9/21/2006 9:39	217	12.8	9/21/2006 10:07
31	10.7	9/21/2006 9:39	107	12.8	9/21/2006 10:07
22.1	10.7	9/21/2006 9:39	65.9	12.8	9/21/2006 10:07
24.4	10.7	9/21/2006 9:39	78.2	12.8	9/21/2006 10:07
27.1	10.7	9/21/2006 9:39	88.3	12.8	9/21/2006 10:07
54.7	10.7	9/21/2006 9:39	63	12.8	9/21/2006 10:07
32	10.7	9/21/2006 9:39	41.8	12.8	9/21/2006 10:07
62.1	10.7	9/21/2006 9:39	51.3	12.8	9/21/2006 10:07
37.7	10.7	9/21/2006 9:39	53.5	12.8	9/21/2006 10:07
35.9	10.7	9/21/2006 9:39	44.2	12.8	9/21/2006 10:07
32.4	10.7	9/21/2006 9:39	41.7	12.8	9/21/2006 10:07
29.1	10.7	9/21/2006 9:39	39.7	12.8	9/21/2006 10:07
21.5	10.7	9/21/2006 9:39	31.8	12.8	9/21/2006 10:07
27.1	10.7	9/21/2006 9:39	28.1	12.8	9/21/2006 10:07
21.1	10.7	9/21/2006 9:39	28.9	12.8	9/21/2006 10:07
23.3	10.7	9/21/2006 9:39	30.2	12.8	9/21/2006 10:07
29.9	10.7	9/21/2006 9:39	36.5	12.8	9/21/2006 10:07
21.3	10.7	9/21/2006 9:39	40.4	12.8	9/21/2006 10:07
21.3	10.7	9/21/2006 9:39	39.1	12.8	9/21/2006 10:07
36.7	10.7	9/21/2006 9:39	39.2	12.8	9/21/2006 10:07
33.2	10.7	9/21/2006 9:39	35.4	12.8	9/21/2006 10:07
27.4	10.7	9/21/2006 9:39	35.5	12.8	9/21/2006 10:08
22.2	10.7	9/21/2006 9:39	36.3	12.8	9/21/2006 10:08
37.5	10.7	9/21/2006 9:39	47	12.8	9/21/2006 10:08
28.4	10.7	9/21/2006 9:39	61.1	12.8	9/21/2006 10:08
24.8	10.7	9/21/2006 9:39	56	12.8	9/21/2006 10:08
26	10.7	9/21/2006 9:39	48.4	12.8	9/21/2006 10:08
35.3	10.7	9/21/2006 9:39	107	12.8	9/21/2006 10:08
26.2	10.7	9/21/2006 9:39	463	12.8	9/21/2006 10:08
29.2	10.7	9/21/2006 9:39	480	12.8	9/21/2006 10:08
25.2	10.7	9/21/2006 9:39	349	12.8	9/21/2006 10:08
28.4	10.7	9/21/2006 9:39	191	12.8	9/21/2006 10:08
25.7	10.7	9/21/2006 9:39	187	12.8	9/21/2006 10:08
23.4	10.7	9/21/2006 9:40	148	12.8	9/21/2006 10:08
40.6	10.7	9/21/2006 9:40	121	12.8	9/21/2006 10:08
24.5	10.7	9/21/2006 9:40	78.2	12.8	9/21/2006 10:08
31.3	10.7	9/21/2006 9:40	63.4	12.8	9/21/2006 10:08
24.9	10.7	9/21/2006 9:40	59.2	12.8	9/21/2006 10:08
21.8	10.7	9/21/2006 9:40	75	12.8	9/21/2006 10:08
22.2	10.7	9/21/2006 9:40	138	12.8	9/21/2006 10:08
22.5	10.7	9/21/2006 9:40	1488	12.8	9/21/2006 10:08
31	10.7	9/21/2006 9:40	1156	12.8	9/21/2006 10:08
33.1	10.7	9/21/2006 9:40	757	12.8	9/21/2006 10:08

Path Measurement Data Site 4 Path 1			Path Measurement Data Site 4 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
36.8	10.7	9/21/2006 9:40	800	12.8	9/21/2006 10:08
27.8	10.7	9/21/2006 9:40	346	12.8	9/21/2006 10:08
23.6	10.7	9/21/2006 9:40	324	12.8	9/21/2006 10:08
24	10.7	9/21/2006 9:40	335	12.8	9/21/2006 10:08
35.8	10.7	9/21/2006 9:40	495	12.8	9/21/2006 10:08
30	10.7	9/21/2006 9:40	224	12.8	9/21/2006 10:08
27.7	10.7	9/21/2006 9:40	190	12.8	9/21/2006 10:08
39.2	10.7	9/21/2006 9:40	216	12.8	9/21/2006 10:08
34.7	10.7	9/21/2006 9:40	276	12.8	9/21/2006 10:08
29.5	10.7	9/21/2006 9:40	885	12.8	9/21/2006 10:08
30.5	10.7	9/21/2006 9:40	496	12.8	9/21/2006 10:08
30.7	10.7	9/21/2006 9:40	626	12.8	9/21/2006 10:08
30.6	10.7	9/21/2006 9:40	415	12.8	9/21/2006 10:09
33.3	10.7	9/21/2006 9:40	956	12.8	9/21/2006 10:09
30.3	10.7	9/21/2006 9:40	1019	12.8	9/21/2006 10:09
46.9	10.7	9/21/2006 9:40	901	12.8	9/21/2006 10:09
41.4	10.7	9/21/2006 9:40	850	12.8	9/21/2006 10:09
37.6	10.7	9/21/2006 9:40	494	12.8	9/21/2006 10:09
30.6	10.7	9/21/2006 9:40	1801	12.8	9/21/2006 10:09
35.6	10.7	9/21/2006 9:40	1579	12.8	9/21/2006 10:09
35.9	10.7	9/21/2006 9:40	1175	12.8	9/21/2006 10:09
33.9	10.7	9/21/2006 9:40	991	12.8	9/21/2006 10:09
36.6	10.7	9/21/2006 9:41	801	12.8	9/21/2006 10:09
38.5	10.7	9/21/2006 9:41	634	12.8	9/21/2006 10:09
43.6	10.7	9/21/2006 9:41	558	12.8	9/21/2006 10:09
43.2	10.7	9/21/2006 9:41	490	12.8	9/21/2006 10:09
36.4	10.7	9/21/2006 9:41	411	12.8	9/21/2006 10:09
35.7	10.7	9/21/2006 9:41	327	12.8	9/21/2006 10:09
38.4	10.7	9/21/2006 9:41	331	12.8	9/21/2006 10:09
72.8	10.7	9/21/2006 9:41	376	12.8	9/21/2006 10:09
31.9	10.7	9/21/2006 9:41	295	12.8	9/21/2006 10:09
24.9	10.7	9/21/2006 9:41	327	12.8	9/21/2006 10:09
25	10.7	9/21/2006 9:41	377	12.8	9/21/2006 10:09
45.5	10.7	9/21/2006 9:41	361	12.8	9/21/2006 10:09
23.8	10.7	9/21/2006 9:41	382	12.8	9/21/2006 10:09
36.7	10.7	9/21/2006 9:41	313	12.8	9/21/2006 10:09
26.3	10.7	9/21/2006 9:41	253	12.8	9/21/2006 10:09
34.9	10.7	9/21/2006 9:41	279	12.8	9/21/2006 10:09
32.2	10.7	9/21/2006 9:41	312	12.8	9/21/2006 10:09
51.5	10.7	9/21/2006 9:41	243	12.8	9/21/2006 10:09
24.4	10.7	9/21/2006 9:41	122	12.8	9/21/2006 10:09
36.5	10.7	9/21/2006 9:41	91.2	12.8	9/21/2006 10:09
25.8	10.7	9/21/2006 9:41	83.1	12.8	9/21/2006 10:09
30.4	10.7	9/21/2006 9:41	51.3	12.8	9/21/2006 10:09
35	10.7	9/21/2006 9:41	33.3	12.8	9/21/2006 10:10
33.4	10.7	9/21/2006 9:41	42.8	12.8	9/21/2006 10:10
32.6	10.7	9/21/2006 9:41	39.1	12.8	9/21/2006 10:10
33.4	10.7	9/21/2006 9:41	115	12.8	9/21/2006 10:10
55.4	10.7	9/21/2006 9:41	158	12.8	9/21/2006 10:10
41.8	10.7	9/21/2006 9:41	45.4	12.8	9/21/2006 10:10
40.6	10.7	9/21/2006 9:41	30.1	12.8	9/21/2006 10:10
35.2	10.7	9/21/2006 9:41	75.6	12.8	9/21/2006 10:10
50.8	10.7	9/21/2006 9:41	146	12.8	9/21/2006 10:10
34.2	10.7	9/21/2006 9:41	294	12.8	9/21/2006 10:10
24.3	10.7	9/21/2006 9:41	640	12.8	9/21/2006 10:10
22.1	10.7	9/21/2006 9:41	1476	12.8	9/21/2006 10:10
22	10.7	9/21/2006 9:41	879	12.8	9/21/2006 10:10
21.7	10.7	9/21/2006 9:42	182	12.8	9/21/2006 10:10
22	10.7	9/21/2006 9:42	105	12.8	9/21/2006 10:10
31.1	10.7	9/21/2006 9:42	40.7	12.8	9/21/2006 10:10

Path Measurement Data Site 4 Path 1			Path Measurement Data Site 4 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
30.9	10.7	9/21/2006 9:42	115	12.8	9/21/2006 10:10
32.2	10.7	9/21/2006 9:42	1098	12.8	9/21/2006 10:10
49	10.7	9/21/2006 9:42	122	12.8	9/21/2006 10:10
45.6	10.7	9/21/2006 9:42	119	12.8	9/21/2006 10:10
29.2	10.7	9/21/2006 9:42	1097	12.8	9/21/2006 10:10
25.9	10.7	9/21/2006 9:42	1052	12.8	9/21/2006 10:10
26.4	10.7	9/21/2006 9:42	426	12.8	9/21/2006 10:10
27.7	10.7	9/21/2006 9:42	1011	12.8	9/21/2006 10:10
31.6	10.7	9/21/2006 9:42	156	12.8	9/21/2006 10:10
26.7	10.7	9/21/2006 9:42	80	12.8	9/21/2006 10:10
70.4	10.7	9/21/2006 9:42	94.2	12.8	9/21/2006 10:10
90.9	10.7	9/21/2006 9:42	124	12.8	9/21/2006 10:10
36.7	10.7	9/21/2006 9:42	114	12.8	9/21/2006 10:10
32.5	10.7	9/21/2006 9:42	58.3	12.8	9/21/2006 10:10
23.3	10.7	9/21/2006 9:42	53.4	12.8	9/21/2006 10:10
21.4	10.7	9/21/2006 9:42	43.2	12.8	9/21/2006 10:10
37.3	10.7	9/21/2006 9:42	37.1	12.8	9/21/2006 10:10
32.5	10.7	9/21/2006 9:42	34.6	12.8	9/21/2006 10:11
26.8	10.7	9/21/2006 9:42	179	12.8	9/21/2006 10:11
25.4	10.7	9/21/2006 9:42	532	12.8	9/21/2006 10:11
21.9	10.7	9/21/2006 9:42	468	12.8	9/21/2006 10:11
25.5	10.7	9/21/2006 9:42	559	12.8	9/21/2006 10:11
24.7	10.7	9/21/2006 9:42	283	12.8	9/21/2006 10:11
23.5	10.7	9/21/2006 9:42	232	12.8	9/21/2006 10:11
21.7	10.7	9/21/2006 9:42	184	12.8	9/21/2006 10:11
25	10.7	9/21/2006 9:42	190	12.8	9/21/2006 10:11
31.2	10.7	9/21/2006 9:42	220	12.8	9/21/2006 10:11
26.1	10.7	9/21/2006 9:42	239	12.8	9/21/2006 10:11
23.7	10.7	9/21/2006 9:42	272	12.8	9/21/2006 10:11
23.4	10.7	9/21/2006 9:42	274	12.8	9/21/2006 10:11
23.9	10.7	9/21/2006 9:42	235	12.8	9/21/2006 10:11
24	10.7	9/21/2006 9:43	209	12.8	9/21/2006 10:11
25.8	10.7	9/21/2006 9:43	151	12.8	9/21/2006 10:11
31.1	10.7	9/21/2006 9:43	142	12.8	9/21/2006 10:11
29.2	10.7	9/21/2006 9:43	122	12.8	9/21/2006 10:11
31.8	10.7	9/21/2006 9:43	207	12.8	9/21/2006 10:11
40.2	10.7	9/21/2006 9:43	75.8	12.8	9/21/2006 10:11
34.1	10.7	9/21/2006 9:43	49.2	12.8	9/21/2006 10:11
29.9	10.7	9/21/2006 9:43	52.5	12.8	9/21/2006 10:11
25.8	10.7	9/21/2006 9:43	51.5	12.8	9/21/2006 10:11
27.3	10.7	9/21/2006 9:43	64.9	12.8	9/21/2006 10:11
28.7	10.7	9/21/2006 9:43	70.1	12.8	9/21/2006 10:11
28.4	10.7	9/21/2006 9:43	71.4	12.8	9/21/2006 10:11
26.4	10.7	9/21/2006 9:43	43.9	12.8	9/21/2006 10:11
26.9	10.7	9/21/2006 9:43	63.6	12.8	9/21/2006 10:11
27.4	10.7	9/21/2006 9:43	49	12.8	9/21/2006 10:11
25.8	10.7	9/21/2006 9:43	58.4	12.8	9/21/2006 10:11
26.5	10.7	9/21/2006 9:43	60.8	12.8	9/21/2006 10:11
26	10.7	9/21/2006 9:43	45.6	12.8	9/21/2006 10:11
26.5	10.7	9/21/2006 9:43	56.9	12.8	9/21/2006 10:11
24.7	10.7	9/21/2006 9:43	55.2	12.8	9/21/2006 10:11
22.2	10.7	9/21/2006 9:43	44.6	12.8	9/21/2006 10:12
24.1	10.7	9/21/2006 9:43	62.8	12.8	9/21/2006 10:12
27.4	10.7	9/21/2006 9:43	52.1	12.8	9/21/2006 10:12
25.4	10.7	9/21/2006 9:43	54.7	12.8	9/21/2006 10:12
23.5	10.7	9/21/2006 9:43	67.6	12.8	9/21/2006 10:12
23.7	10.7	9/21/2006 9:43	82.9	12.8	9/21/2006 10:12
22.7	10.7	9/21/2006 9:43	49.2	12.8	9/21/2006 10:12
23.4	10.7	9/21/2006 9:43	44.9	12.8	9/21/2006 10:12
27.5	10.7	9/21/2006 9:43	51.1	12.8	9/21/2006 10:12

Path Measurement Data Site 4 Path 1			Path Measurement Data Site 4 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
26.7	10.7	9/21/2006 9:43	38.8	12.8	9/21/2006 10:12
26.7	10.7	9/21/2006 9:43	29.9	12.8	9/21/2006 10:12
23.2	10.7	9/21/2006 9:43	46.4	12.8	9/21/2006 10:12
26.3	10.7	9/21/2006 9:43	47	12.8	9/21/2006 10:12
83.8	10.7	9/21/2006 9:43	42.5	12.8	9/21/2006 10:12
40	10.7	9/21/2006 9:44	37.8	12.8	9/21/2006 10:12
118	10.7	9/21/2006 9:44	53	12.8	9/21/2006 10:12
284	10.7	9/21/2006 9:44	111	12.8	9/21/2006 10:12
94.8	10.7	9/21/2006 9:44	138	12.8	9/21/2006 10:12
22.9	10.7	9/21/2006 9:44	104	12.8	9/21/2006 10:12
21.9	10.7	9/21/2006 9:44	43.8	12.8	9/21/2006 10:12
25.9	10.7	9/21/2006 9:44	86	12.8	9/21/2006 10:12
23.9	10.7	9/21/2006 9:44	53.1	12.8	9/21/2006 10:12
25.8	10.7	9/21/2006 9:44	116	12.8	9/21/2006 10:12
32.3	10.7	9/21/2006 9:44	51.1	12.8	9/21/2006 10:12
31.2	10.7	9/21/2006 9:44	49.9	12.8	9/21/2006 10:12
27.2	10.7	9/21/2006 9:44	101	12.8	9/21/2006 10:12
27.6	10.7	9/21/2006 9:44	44.2	12.8	9/21/2006 10:12
24.3	10.7	9/21/2006 9:44	30.8	12.8	9/21/2006 10:12
27.1	10.7	9/21/2006 9:44	34.2	12.8	9/21/2006 10:12
25.3	10.7	9/21/2006 9:44	44.5	12.8	9/21/2006 10:12
23.4	10.7	9/21/2006 9:44	44.1	12.8	9/21/2006 10:12
24	10.7	9/21/2006 9:44	29.7	12.8	9/21/2006 10:12
24.3	10.7	9/21/2006 9:44	27.2	12.8	9/21/2006 10:12
25.6	10.7	9/21/2006 9:44	29.2	12.8	9/21/2006 10:12
22.2	10.7	9/21/2006 9:44	40.3	12.8	9/21/2006 10:13
21.9	10.7	9/21/2006 9:44	43.1	12.8	9/21/2006 10:13
22.4	10.7	9/21/2006 9:44	45.3	12.8	9/21/2006 10:13
26.8	10.7	9/21/2006 9:44	32.1	12.8	9/21/2006 10:13
23.4	10.7	9/21/2006 9:44	40.2	12.8	9/21/2006 10:13
26	10.7	9/21/2006 9:44	45	12.8	9/21/2006 10:13
24.7	10.7	9/21/2006 9:44	47.2	12.8	9/21/2006 10:13
22.1	10.7	9/21/2006 9:44	32.6	12.8	9/21/2006 10:13
26.3	10.7	9/21/2006 9:44	30.5	12.8	9/21/2006 10:13
27.6	10.7	9/21/2006 9:44	43.3	12.8	9/21/2006 10:13
27.3	10.7	9/21/2006 9:44	59	12.8	9/21/2006 10:13
25.2	10.7	9/21/2006 9:44	43	12.8	9/21/2006 10:13
27.6	10.7	9/21/2006 9:44	28.2	12.8	9/21/2006 10:13
23.6	10.7	9/21/2006 9:44	24.7	12.8	9/21/2006 10:13
23.8	10.7	9/21/2006 9:45	29.3	12.8	9/21/2006 10:13
23.8	10.7	9/21/2006 9:45	29.3	12.8	9/21/2006 10:13
139	10.7	9/21/2006 9:45	27.1	12.8	9/21/2006 10:13
515	10.7	9/21/2006 9:45	24.5	12.8	9/21/2006 10:13
330	10.7	9/21/2006 9:45	36.5	12.8	9/21/2006 10:13
230	10.7	9/21/2006 9:45	33	12.8	9/21/2006 10:13
38.8	10.7	9/21/2006 9:45	29.7	12.8	9/21/2006 10:13
38.8	10.7	9/21/2006 9:45	29.5	12.8	9/21/2006 10:13
656	10.7	9/21/2006 9:45	37	12.8	9/21/2006 10:13
1921	10.7	9/21/2006 9:45	39.3	12.8	9/21/2006 10:13
2284	10.7	9/21/2006 9:45	33	12.8	9/21/2006 10:13
1180	10.7	9/21/2006 9:45	26.6	12.8	9/21/2006 10:13
1511	10.7	9/21/2006 9:45	24.4	12.8	9/21/2006 10:13
1648	10.7	9/21/2006 9:45	24.4	12.8	9/21/2006 10:13
2413	10.7	9/21/2006 9:45	24.6	12.8	9/21/2006 10:13
1595	10.7	9/21/2006 9:45	25.9	12.8	9/21/2006 10:13
1860	10.7	9/21/2006 9:45	37.4	12.8	9/21/2006 10:13
92.8	10.7	9/21/2006 9:45	42.6	12.8	9/21/2006 10:13
39.7	10.7	9/21/2006 9:45	39.7	12.8	9/21/2006 10:13
37.9	10.7	9/21/2006 9:45	31.6	12.8	9/21/2006 10:13
32.7	10.7	9/21/2006 9:45	27.3	12.8	9/21/2006 10:14

Path Measurement Data Site 4 Path 1			Path Measurement Data Site 4 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
57.1	10.7	9/21/2006 9:45	27.9	12.8	9/21/2006 10:14
1038	10.7	9/21/2006 9:45	29	12.8	9/21/2006 10:14
300	10.7	9/21/2006 9:45	43.5	12.8	9/21/2006 10:14
39.9	10.7	9/21/2006 9:45	29	12.8	9/21/2006 10:14
35.7	10.7	9/21/2006 9:45	24.8	12.8	9/21/2006 10:14
252	10.7	9/21/2006 9:45	24.5	12.8	9/21/2006 10:14
387	10.7	9/21/2006 9:45	24.8	12.8	9/21/2006 10:14
338	10.7	9/21/2006 9:45	29.2	12.8	9/21/2006 10:14
183	10.7	9/21/2006 9:45	41.1	12.8	9/21/2006 10:14
215	10.7	9/21/2006 9:45	60.3	12.8	9/21/2006 10:14
176	10.7	9/21/2006 9:45	36	12.8	9/21/2006 10:14
130	10.7	9/21/2006 9:45	51.2	12.8	9/21/2006 10:14
134	10.7	9/21/2006 9:46	62.2	12.8	9/21/2006 10:14
86.1	10.7	9/21/2006 9:46	43.2	12.8	9/21/2006 10:14
46.6	10.7	9/21/2006 9:46	94.3	12.8	9/21/2006 10:14
24.1	10.7	9/21/2006 9:46	89.9	12.8	9/21/2006 10:14
22.2	10.7	9/21/2006 9:46	102	12.8	9/21/2006 10:14
32.6	10.7	9/21/2006 9:46	181	12.8	9/21/2006 10:14
21.6	10.7	9/21/2006 9:46	123	12.8	9/21/2006 10:14
21.9	10.7	9/21/2006 9:46	113	12.8	9/21/2006 10:14
22.6	10.7	9/21/2006 9:46	146	12.8	9/21/2006 10:14
21.8	10.7	9/21/2006 9:46	116	12.8	9/21/2006 10:14
22.6	10.7	9/21/2006 9:46	87	12.8	9/21/2006 10:14
36.8	10.7	9/21/2006 9:46	85.9	12.8	9/21/2006 10:14
29.6	10.7	9/21/2006 9:46	83	12.8	9/21/2006 10:14
45.6	10.7	9/21/2006 9:46	79	12.8	9/21/2006 10:14
34.6	10.7	9/21/2006 9:46	77.6	12.8	9/21/2006 10:14
32.9	10.7	9/21/2006 9:46	67.7	12.8	9/21/2006 10:14
30.4	10.7	9/21/2006 9:46	66	12.8	9/21/2006 10:14
27.7	10.7	9/21/2006 9:46	64.3	12.8	9/21/2006 10:14
23.7	10.7	9/21/2006 9:46	112	12.8	9/21/2006 10:14
25.6	10.7	9/21/2006 9:46	77.3	12.8	9/21/2006 10:14
23.6	10.7	9/21/2006 9:46	45.9	12.8	9/21/2006 10:14
24	10.7	9/21/2006 9:46	54.8	12.8	9/21/2006 10:15
22.5	10.7	9/21/2006 9:46	32.9	12.8	9/21/2006 10:15
22.7	10.7	9/21/2006 9:46	38.5	12.8	9/21/2006 10:15
22.9	10.7	9/21/2006 9:46	37.7	12.8	9/21/2006 10:15
22.6	10.7	9/21/2006 9:46	39.3	12.8	9/21/2006 10:15
22.2	10.7	9/21/2006 9:46	41	12.8	9/21/2006 10:15
22.2	10.7	9/21/2006 9:46	132	12.8	9/21/2006 10:15
22	10.7	9/21/2006 9:46	61.6	12.8	9/21/2006 10:15
21.8	10.7	9/21/2006 9:46	88.6	12.8	9/21/2006 10:15
21.7	10.7	9/21/2006 9:46	121	12.8	9/21/2006 10:15
21.4	10.7	9/21/2006 9:46	605	12.8	9/21/2006 10:15
21.4	10.7	9/21/2006 9:46	407	12.8	9/21/2006 10:15
21.6	10.7	9/21/2006 9:46	46.4	12.8	9/21/2006 10:15
21.5	10.7	9/21/2006 9:47	174	12.8	9/21/2006 10:15
25.2	10.7	9/21/2006 9:47	137	12.8	9/21/2006 10:15
33.8	10.7	9/21/2006 9:47	39.1	12.8	9/21/2006 10:15
29.5	10.7	9/21/2006 9:47	37.3	12.8	9/21/2006 10:15
35	10.7	9/21/2006 9:47	37	12.8	9/21/2006 10:15
22.1	10.7	9/21/2006 9:47	37.1	12.8	9/21/2006 10:15
23.2	10.7	9/21/2006 9:47	31.6	12.8	9/21/2006 10:15
22.7	10.7	9/21/2006 9:47	41	12.8	9/21/2006 10:15
21.8	10.7	9/21/2006 9:47	59.7	12.8	9/21/2006 10:15
22.1	10.7	9/21/2006 9:47	557	12.8	9/21/2006 10:15
23.3	10.7	9/21/2006 9:47	904	12.8	9/21/2006 10:15
25.2	10.7	9/21/2006 9:47	220	12.8	9/21/2006 10:15
23.1	10.7	9/21/2006 9:47	398	12.8	9/21/2006 10:15
23.4	10.7	9/21/2006 9:47	348	12.8	9/21/2006 10:15

Path Measurement Data Site 4 Path 1			Path Measurement Data Site 4 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
22.7	10.7	9/21/2006 9:47	318	12.8	9/21/2006 10:15
22.9	10.7	9/21/2006 9:47	540	12.8	9/21/2006 10:15
22.2	10.7	9/21/2006 9:47	382	12.8	9/21/2006 10:15
23.9	10.7	9/21/2006 9:47	310	12.8	9/21/2006 10:15
23.9	10.7	9/21/2006 9:47	205	12.8	9/21/2006 10:15
25.8	10.7	9/21/2006 9:47	418	12.8	9/21/2006 10:15
27.8	10.7	9/21/2006 9:47	361	12.8	9/21/2006 10:15
			341	12.8	9/21/2006 10:16
			296	12.8	9/21/2006 10:16
			328	12.8	9/21/2006 10:16
			498	12.8	9/21/2006 10:16
			373	12.8	9/21/2006 10:16
			265	12.8	9/21/2006 10:16
			700	12.8	9/21/2006 10:16
			1624	12.8	9/21/2006 10:16
			1645	12.8	9/21/2006 10:16
			870	12.8	9/21/2006 10:16
			560	12.8	9/21/2006 10:16
			292	12.8	9/21/2006 10:16
			2308	12.8	9/21/2006 10:16
			1030	12.8	9/21/2006 10:16
			416	12.8	9/21/2006 10:16
			253	12.8	9/21/2006 10:16
			77.6	12.8	9/21/2006 10:16
			26.2	12.8	9/21/2006 10:16
			27.5	12.8	9/21/2006 10:16
			30.6	12.8	9/21/2006 10:16
			34.9	12.8	9/21/2006 10:16
			967	12.8	9/21/2006 10:16
			484	12.8	9/21/2006 10:16
			1108	12.8	9/21/2006 10:16
			1234	12.8	9/21/2006 10:16
			990	12.8	9/21/2006 10:16
			435	12.8	9/21/2006 10:16
			163	12.8	9/21/2006 10:16
			78.2	12.8	9/21/2006 10:16
			41.8	12.8	9/21/2006 10:16
			43.9	12.8	9/21/2006 10:16
			65.8	12.8	9/21/2006 10:16
			407	12.8	9/21/2006 10:16
			1302	12.8	9/21/2006 10:17
			1312	12.8	9/21/2006 10:17
			1365	12.8	9/21/2006 10:17
			840	12.8	9/21/2006 10:17
			1196	12.8	9/21/2006 10:17
			55.9	12.8	9/21/2006 10:17
			166	12.8	9/21/2006 10:17
			434	12.8	9/21/2006 10:17
			68.9	12.8	9/21/2006 10:17
			44.3	12.8	9/21/2006 10:17
			44	12.8	9/21/2006 10:17
			49.3	12.8	9/21/2006 10:17
			43.1	12.8	9/21/2006 10:17
			36.9	12.8	9/21/2006 10:17
			46.8	12.8	9/21/2006 10:17
			33.5	12.8	9/21/2006 10:17
			35.8	12.8	9/21/2006 10:17
			36	12.8	9/21/2006 10:17
			36.6	12.8	9/21/2006 10:17
			34.6	12.8	9/21/2006 10:17



Path Measurement Data Site 4 Path 1			Path Measurement Data Site 4 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
			37.5	12.8	9/21/2006 10:17
			44.9	12.8	9/21/2006 10:17
			43.4	12.8	9/21/2006 10:17
			37.9	12.8	9/21/2006 10:17
			39.3	12.8	9/21/2006 10:17
			37.5	12.8	9/21/2006 10:17
			45.7	12.8	9/21/2006 10:17
			107	12.8	9/21/2006 10:17
			280	12.8	9/21/2006 10:17
			46.6	12.8	9/21/2006 10:17
			82.6	12.8	9/21/2006 10:17
			43.9	12.8	9/21/2006 10:17
			472	12.8	9/21/2006 10:17
			80.4	12.8	9/21/2006 10:17
			34	12.8	9/21/2006 10:18
			27.1	12.8	9/21/2006 10:18
			95	12.8	9/21/2006 10:18
			128	12.8	9/21/2006 10:18
			63.3	12.8	9/21/2006 10:18
			46.8	12.8	9/21/2006 10:18
			60.1	12.8	9/21/2006 10:18
			137	12.8	9/21/2006 10:18
			110	12.8	9/21/2006 10:18
			1259	12.8	9/21/2006 10:18
			98.8	12.8	9/21/2006 10:18
			33	12.8	9/21/2006 10:18
			39	12.8	9/21/2006 10:18
			46.5	12.8	9/21/2006 10:18
			121	12.8	9/21/2006 10:18
			359	12.8	9/21/2006 10:18
			184	12.8	9/21/2006 10:18
			681	12.8	9/21/2006 10:18
			1079	12.8	9/21/2006 10:18
			482	12.8	9/21/2006 10:18
			648	12.8	9/21/2006 10:18
			619	12.8	9/21/2006 10:18
			295	12.8	9/21/2006 10:18
			1068	12.8	9/21/2006 10:18
			1517	12.8	9/21/2006 10:18
			1623	12.8	9/21/2006 10:18
			1211	12.8	9/21/2006 10:18
			1308	12.8	9/21/2006 10:18
			813	12.8	9/21/2006 10:18
			298	12.8	9/21/2006 10:18
			221	12.8	9/21/2006 10:18
			147	12.8	9/21/2006 10:18
			77.5	12.8	9/21/2006 10:18
			75.8	12.8	9/21/2006 10:19
			53.9	12.8	9/21/2006 10:19
			58.9	12.8	9/21/2006 10:19
			43.9	12.8	9/21/2006 10:19
			54.2	12.8	9/21/2006 10:19
			40.5	12.8	9/21/2006 10:19
			50.8	12.8	9/21/2006 10:19
			34.5	12.8	9/21/2006 10:19
			59.4	12.8	9/21/2006 10:19
			49	12.8	9/21/2006 10:19
			59.1	12.8	9/21/2006 10:19
			46.6	12.8	9/21/2006 10:19
			40.4	12.8	9/21/2006 10:19

Path Measurement Data Site 4 Path 1			Path Measurement Data Site 4 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
			35.8	12.8	9/21/2006 10:19
			66.4	12.8	9/21/2006 10:19
			1013	12.8	9/21/2006 10:19
			647	12.8	9/21/2006 10:19
			1212	12.8	9/21/2006 10:19
			1543	12.8	9/21/2006 10:19
			868	12.8	9/21/2006 10:19
			692	12.8	9/21/2006 10:19
			93.2	12.8	9/21/2006 10:19
			47.4	12.8	9/21/2006 10:19
			33.3	12.8	9/21/2006 10:19
			28.2	12.8	9/21/2006 10:19
			25.5	12.8	9/21/2006 10:19
			27.4	12.8	9/21/2006 10:19
			58.9	12.8	9/21/2006 10:19
			38.4	12.8	9/21/2006 10:19
			38.5	12.8	9/21/2006 10:19
			46.9	12.8	9/21/2006 10:19
			46.8	12.8	9/21/2006 10:19
			45.5	12.8	9/21/2006 10:19
			40	12.8	9/21/2006 10:20
			61.8	12.8	9/21/2006 10:20
			54.9	12.8	9/21/2006 10:20
			53.4	12.8	9/21/2006 10:20
			37	12.8	9/21/2006 10:20
			29.6	12.8	9/21/2006 10:20
			39.3	12.8	9/21/2006 10:20
			41.3	12.8	9/21/2006 10:20
			52.2	12.8	9/21/2006 10:20
			60	12.8	9/21/2006 10:20
			60.1	12.8	9/21/2006 10:20
			37.3	12.8	9/21/2006 10:20
			30.7	12.8	9/21/2006 10:20
			32.1	12.8	9/21/2006 10:20
			73.4	12.8	9/21/2006 10:20
			47.6	12.8	9/21/2006 10:20
			25.6	12.8	9/21/2006 10:20
			40.8	12.8	9/21/2006 10:20

Path Measurement Data Site 4 Path 3			Path Measurement Data Site 4 Path 4		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
57.1	18	9/21/2006 10:24	28.2	15	9/21/2006 10:52
302	18	9/21/2006 10:24	28.2	15	9/21/2006 10:52
497	18	9/21/2006 10:24	28.1	15	9/21/2006 10:52
472	18	9/21/2006 10:24	28.1	15	9/21/2006 10:52
1108	18	9/21/2006 10:24	28.3	15	9/21/2006 10:52
921	18	9/21/2006 10:24	28.1	15	9/21/2006 10:52
821	18	9/21/2006 10:24	28	15	9/21/2006 10:52
719	18	9/21/2006 10:24	28	15	9/21/2006 10:52
484	18	9/21/2006 10:24	28.2	15	9/21/2006 10:52
224	18	9/21/2006 10:24	28.2	15	9/21/2006 10:52
62.6	18	9/21/2006 10:25	28.2	15	9/21/2006 10:52
39	18	9/21/2006 10:25	28	15	9/21/2006 10:52
37.4	18	9/21/2006 10:25	28	15	9/21/2006 10:52
37.5	18	9/21/2006 10:25	28.2	15	9/21/2006 10:52
37.3	18	9/21/2006 10:25	27.9	15	9/21/2006 10:52
37.5	18	9/21/2006 10:25	28	15	9/21/2006 10:52
37.4	18	9/21/2006 10:25	28.2	15	9/21/2006 10:52
37.3	18	9/21/2006 10:25	27.9	15	9/21/2006 10:53
37.3	18	9/21/2006 10:25	27.9	15	9/21/2006 10:53
37.6	18	9/21/2006 10:25	28	15	9/21/2006 10:53
37.6	18	9/21/2006 10:25	28	15	9/21/2006 10:53
37.4	18	9/21/2006 10:25	27.9	15	9/21/2006 10:53
37.4	18	9/21/2006 10:25	28	15	9/21/2006 10:53
37.3	18	9/21/2006 10:25	28.1	15	9/21/2006 10:53
37.6	18	9/21/2006 10:25	28	15	9/21/2006 10:53
37.2	18	9/21/2006 10:25	28	15	9/21/2006 10:53
37.3	18	9/21/2006 10:25	28	15	9/21/2006 10:53
37.4	18	9/21/2006 10:25	28	15	9/21/2006 10:53
37.4	18	9/21/2006 10:25	28	15	9/21/2006 10:53
37.4	18	9/21/2006 10:25	28	15	9/21/2006 10:53
37.2	18	9/21/2006 10:25	28	15	9/21/2006 10:53
37.6	18	9/21/2006 10:25	28	15	9/21/2006 10:53
37.5	18	9/21/2006 10:25	27.9	15	9/21/2006 10:53
37.7	18	9/21/2006 10:25	27.9	15	9/21/2006 10:53
37.4	18	9/21/2006 10:25	27.9	15	9/21/2006 10:53
37.6	18	9/21/2006 10:25	28.1	15	9/21/2006 10:53
37.5	18	9/21/2006 10:25	28.2	15	9/21/2006 10:53
37.5	18	9/21/2006 10:25	28.2	15	9/21/2006 10:53
37.5	18	9/21/2006 10:25	27.8	15	9/21/2006 10:53
37.4	18	9/21/2006 10:25	27.9	15	9/21/2006 10:53
37.4	18	9/21/2006 10:25	28	15	9/21/2006 10:53
37.4	18	9/21/2006 10:25	27.9	15	9/21/2006 10:53
37.6	18	9/21/2006 10:25	28.1	15	9/21/2006 10:53
37.9	18	9/21/2006 10:25	28.1	15	9/21/2006 10:53
38	18	9/21/2006 10:26	27.9	15	9/21/2006 10:53
37.8	18	9/21/2006 10:26	28.1	15	9/21/2006 10:53
38.1	18	9/21/2006 10:26	28.1	15	9/21/2006 10:53
37.8	18	9/21/2006 10:26	29.8	15	9/21/2006 10:53
38	18	9/21/2006 10:26	30.3	15	9/21/2006 10:53
37.5	18	9/21/2006 10:26	30.5	15	9/21/2006 10:53
38.7	18	9/21/2006 10:26	29.2	15	9/21/2006 10:53
38.7	18	9/21/2006 10:26	30.4	15	9/21/2006 10:54
38.4	18	9/21/2006 10:26	31.3	15	9/21/2006 10:54
38.7	18	9/21/2006 10:26	30	15	9/21/2006 10:54
38.7	18	9/21/2006 10:26	29.3	15	9/21/2006 10:54
38.6	18	9/21/2006 10:26	28.7	15	9/21/2006 10:54
38.6	18	9/21/2006 10:26	28.5	15	9/21/2006 10:54
38.5	18	9/21/2006 10:26	28.5	15	9/21/2006 10:54

Path Measurement Data Site 4 Path 3			Path Measurement Data Site 4 Path 4		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
38.4	18	9/21/2006 10:26	28.7	15	9/21/2006 10:54
38.5	18	9/21/2006 10:26	28.6	15	9/21/2006 10:54
38.4	18	9/21/2006 10:26	28.5	15	9/21/2006 10:54
38.4	18	9/21/2006 10:26	28.6	15	9/21/2006 10:54
38.6	18	9/21/2006 10:26	28.5	15	9/21/2006 10:54
38.8	18	9/21/2006 10:26	28.8	15	9/21/2006 10:54
38.5	18	9/21/2006 10:26	29.5	15	9/21/2006 10:54
38.6	18	9/21/2006 10:26	29.4	15	9/21/2006 10:54
38.4	18	9/21/2006 10:26	28.9	15	9/21/2006 10:54
38.8	18	9/21/2006 10:26	29.3	15	9/21/2006 10:54
38.7	18	9/21/2006 10:26	28.7	15	9/21/2006 10:54
38.4	18	9/21/2006 10:26	28.7	15	9/21/2006 10:54
38.5	18	9/21/2006 10:26	28.8	15	9/21/2006 10:54
38.7	18	9/21/2006 10:26	28.8	15	9/21/2006 10:54
38.7	18	9/21/2006 10:26	28.7	15	9/21/2006 10:54
40.5	18	9/21/2006 10:26	28.6	15	9/21/2006 10:54
42.5	18	9/21/2006 10:26	28.9	15	9/21/2006 10:54
45.1	18	9/21/2006 10:26	29.5	15	9/21/2006 10:54
45.3	18	9/21/2006 10:26	28.9	15	9/21/2006 10:54
45.7	18	9/21/2006 10:26	28.8	15	9/21/2006 10:54
47.7	18	9/21/2006 10:27	28.9	15	9/21/2006 10:54
48.3	18	9/21/2006 10:27	32	15	9/21/2006 10:54
51.4	18	9/21/2006 10:27	30.2	15	9/21/2006 10:54
53.4	18	9/21/2006 10:27	29.3	15	9/21/2006 10:54
54.6	18	9/21/2006 10:27	28.8	15	9/21/2006 10:54
55.7	18	9/21/2006 10:27	28.8	15	9/21/2006 10:54
56.9	18	9/21/2006 10:27	28.7	15	9/21/2006 10:54
62.8	18	9/21/2006 10:27	28.7	15	9/21/2006 10:54
69.9	18	9/21/2006 10:27	28.5	15	9/21/2006 10:55
71.3	18	9/21/2006 10:27	28.7	15	9/21/2006 10:55
66	18	9/21/2006 10:27	28.6	15	9/21/2006 10:55
66.2	18	9/21/2006 10:27	28.7	15	9/21/2006 10:55
64.3	18	9/21/2006 10:27	28.6	15	9/21/2006 10:55
64.4	18	9/21/2006 10:27	28.7	15	9/21/2006 10:55
62.5	18	9/21/2006 10:27	28.7	15	9/21/2006 10:55
61.5	18	9/21/2006 10:27	28.7	15	9/21/2006 10:55
76.9	18	9/21/2006 10:27	28.7	15	9/21/2006 10:55
91	18	9/21/2006 10:27	28.8	15	9/21/2006 10:55
91.8	18	9/21/2006 10:27	28.6	15	9/21/2006 10:55
101	18	9/21/2006 10:27	28.6	15	9/21/2006 10:55
76.4	18	9/21/2006 10:27	28.6	15	9/21/2006 10:55
65.4	18	9/21/2006 10:27	28.8	15	9/21/2006 10:55
60	18	9/21/2006 10:27	28.2	15	9/21/2006 10:55
61.9	18	9/21/2006 10:27	28.6	15	9/21/2006 10:55
67.5	18	9/21/2006 10:27	28.3	15	9/21/2006 10:55
69.1	18	9/21/2006 10:27	28.4	15	9/21/2006 10:55
62.9	18	9/21/2006 10:27	28.4	15	9/21/2006 10:55
63.1	18	9/21/2006 10:27	28.6	15	9/21/2006 10:55
61.3	18	9/21/2006 10:27	28.4	15	9/21/2006 10:55
57.3	18	9/21/2006 10:27	28.6	15	9/21/2006 10:55
57.6	18	9/21/2006 10:27	28.5	15	9/21/2006 10:55
63.3	18	9/21/2006 10:27	28.7	15	9/21/2006 10:55
64.7	18	9/21/2006 10:27	28.5	15	9/21/2006 10:55
62.1	18	9/21/2006 10:27	28.5	15	9/21/2006 10:55
61.3	18	9/21/2006 10:28	28.3	15	9/21/2006 10:55
57.1	18	9/21/2006 10:28	28.3	15	9/21/2006 10:55
54.4	18	9/21/2006 10:28	28.5	15	9/21/2006 10:55
54.9	18	9/21/2006 10:28	28.5	15	9/21/2006 10:55
57.9	18	9/21/2006 10:28	28.5	15	9/21/2006 10:55
61	18	9/21/2006 10:28	28.8	15	9/21/2006 10:55

Path Measurement Data Site 4 Path 3			Path Measurement Data Site 4 Path 4		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
61.3	18	9/21/2006 10:28	40.9	15	9/21/2006 10:55
63.7	18	9/21/2006 10:28	133	15	9/21/2006 10:55
66.1	18	9/21/2006 10:28	37.9	15	9/21/2006 10:56
68.1	18	9/21/2006 10:28	43.4	15	9/21/2006 10:56
68.6	18	9/21/2006 10:28	33.5	15	9/21/2006 10:56
68.5	18	9/21/2006 10:28	32.1	15	9/21/2006 10:56
70.1	18	9/21/2006 10:28	30.3	15	9/21/2006 10:56
70.1	18	9/21/2006 10:28	31.1	15	9/21/2006 10:56
72.7	18	9/21/2006 10:28	31.1	15	9/21/2006 10:56
77.6	18	9/21/2006 10:28	30.5	15	9/21/2006 10:56
81.9	18	9/21/2006 10:28	29.8	15	9/21/2006 10:56
84.2	18	9/21/2006 10:28	77.9	15	9/21/2006 10:56
84.9	18	9/21/2006 10:28	68.1	15	9/21/2006 10:56
89.1	18	9/21/2006 10:28	64.2	15	9/21/2006 10:56
88.4	18	9/21/2006 10:28	55	15	9/21/2006 10:56
85.5	18	9/21/2006 10:28	29.7	15	9/21/2006 10:56
85.6	18	9/21/2006 10:28	28.5	15	9/21/2006 10:56
83.5	18	9/21/2006 10:28	28.4	15	9/21/2006 10:56
89.2	18	9/21/2006 10:28	28.5	15	9/21/2006 10:56
96.5	18	9/21/2006 10:28	28.5	15	9/21/2006 10:56
103	18	9/21/2006 10:28	28.5	15	9/21/2006 10:56
95.4	18	9/21/2006 10:28	28.4	15	9/21/2006 10:56
87.8	18	9/21/2006 10:28	28.4	15	9/21/2006 10:56
78.1	18	9/21/2006 10:28	28.5	15	9/21/2006 10:56
71.8	18	9/21/2006 10:28	28.5	15	9/21/2006 10:56
68.8	18	9/21/2006 10:28	28.3	15	9/21/2006 10:56
66.1	18	9/21/2006 10:28	28.6	15	9/21/2006 10:56
64.5	18	9/21/2006 10:28	28.4	15	9/21/2006 10:56
59.7	18	9/21/2006 10:28	28.6	15	9/21/2006 10:56
67.1	18	9/21/2006 10:29	28.5	15	9/21/2006 10:56
61.5	18	9/21/2006 10:29	28.5	15	9/21/2006 10:56
63.6	18	9/21/2006 10:29	28.5	15	9/21/2006 10:56
137	18	9/21/2006 10:29	28.6	15	9/21/2006 10:56
184	18	9/21/2006 10:29	29.2	15	9/21/2006 10:56
225	18	9/21/2006 10:29	63.3	15	9/21/2006 10:56
156	18	9/21/2006 10:29	762	15	9/21/2006 10:57
72.1	18	9/21/2006 10:29	1280	15	9/21/2006 10:57
80.1	18	9/21/2006 10:29	341	15	9/21/2006 10:57
147	18	9/21/2006 10:29	69.7	15	9/21/2006 10:57
128	18	9/21/2006 10:29	52.8	15	9/21/2006 10:57
112	18	9/21/2006 10:29	38.9	15	9/21/2006 10:57
84.9	18	9/21/2006 10:29	52.6	15	9/21/2006 10:57
71.1	18	9/21/2006 10:29	44.3	15	9/21/2006 10:57
44.5	18	9/21/2006 10:29	30.7	15	9/21/2006 10:57
45.1	18	9/21/2006 10:29	29.4	15	9/21/2006 10:57
60.2	18	9/21/2006 10:29	30	15	9/21/2006 10:57
344	18	9/21/2006 10:29	28.7	15	9/21/2006 10:57
337	18	9/21/2006 10:29	28.7	15	9/21/2006 10:57
172	18	9/21/2006 10:29	28.5	15	9/21/2006 10:57
141	18	9/21/2006 10:29	28.6	15	9/21/2006 10:57
100	18	9/21/2006 10:29	28.5	15	9/21/2006 10:57
53.1	18	9/21/2006 10:29	28.5	15	9/21/2006 10:57
107	18	9/21/2006 10:29	28.6	15	9/21/2006 10:57
152	18	9/21/2006 10:29	28.6	15	9/21/2006 10:57
77.8	18	9/21/2006 10:29	28.4	15	9/21/2006 10:57
65.2	18	9/21/2006 10:29	28.6	15	9/21/2006 10:57
59	18	9/21/2006 10:29	28.6	15	9/21/2006 10:57
80.5	18	9/21/2006 10:29	28.5	15	9/21/2006 10:57
55.7	18	9/21/2006 10:29	28.3	15	9/21/2006 10:57
60.8	18	9/21/2006 10:29	28.5	15	9/21/2006 10:57

Path Measurement Data Site 4 Path 3			Path Measurement Data Site 4 Path 4		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
149	18	9/21/2006 10:29	28.4	15	9/21/2006 10:57
149	18	9/21/2006 10:29	28.4	15	9/21/2006 10:57
363	18	9/21/2006 10:29	28.4	15	9/21/2006 10:57
467	18	9/21/2006 10:30	28.4	15	9/21/2006 10:57
70.4	18	9/21/2006 10:30	28.5	15	9/21/2006 10:57
58.4	18	9/21/2006 10:30	28.5	15	9/21/2006 10:57
74.2	18	9/21/2006 10:30	28.7	15	9/21/2006 10:57
59.1	18	9/21/2006 10:30	28.5	15	9/21/2006 10:57
73.8	18	9/21/2006 10:30	28.6	15	9/21/2006 10:57
51.8	18	9/21/2006 10:30	28.6	15	9/21/2006 10:57
113	18	9/21/2006 10:30	28.6	15	9/21/2006 10:58
330	18	9/21/2006 10:30	28.6	15	9/21/2006 10:58
141	18	9/21/2006 10:30	28.6	15	9/21/2006 10:58
871	18	9/21/2006 10:30	28.6	15	9/21/2006 10:58
207	18	9/21/2006 10:30	28.6	15	9/21/2006 10:58
305	18	9/21/2006 10:30	28.5	15	9/21/2006 10:58
366	18	9/21/2006 10:30	28.5	15	9/21/2006 10:58
174	18	9/21/2006 10:30	28.5	15	9/21/2006 10:58
892	18	9/21/2006 10:30	28.5	15	9/21/2006 10:58
1601	18	9/21/2006 10:30	28.5	15	9/21/2006 10:58
1274	18	9/21/2006 10:30	28.6	15	9/21/2006 10:58
847	18	9/21/2006 10:30	28.4	15	9/21/2006 10:58
465	18	9/21/2006 10:30	28.6	15	9/21/2006 10:58
138	18	9/21/2006 10:30	28.8	15	9/21/2006 10:58
481	18	9/21/2006 10:30	28.7	15	9/21/2006 10:58
114	18	9/21/2006 10:30	28.6	15	9/21/2006 10:58
195	18	9/21/2006 10:30	28.7	15	9/21/2006 10:58
226	18	9/21/2006 10:30	28.5	15	9/21/2006 10:58
108	18	9/21/2006 10:30	28.6	15	9/21/2006 10:58
198	18	9/21/2006 10:30	28.6	15	9/21/2006 10:58
475	18	9/21/2006 10:30	28.6	15	9/21/2006 10:58
593	18	9/21/2006 10:30	28.7	15	9/21/2006 10:58
429	18	9/21/2006 10:30	28.7	15	9/21/2006 10:58
714	18	9/21/2006 10:30	28.7	15	9/21/2006 10:58
882	18	9/21/2006 10:30	28.8	15	9/21/2006 10:58
792	18	9/21/2006 10:30	28.7	15	9/21/2006 10:58
553	18	9/21/2006 10:31	28.8	15	9/21/2006 10:58
310	18	9/21/2006 10:31	28.7	15	9/21/2006 10:58
270	18	9/21/2006 10:31	28.8	15	9/21/2006 10:58
443	18	9/21/2006 10:31	28.7	15	9/21/2006 10:58
530	18	9/21/2006 10:31	28.6	15	9/21/2006 10:58
309	18	9/21/2006 10:31	28.7	15	9/21/2006 10:58
243	18	9/21/2006 10:31	28.7	15	9/21/2006 10:58
163	18	9/21/2006 10:31	28.6	15	9/21/2006 10:58
112	18	9/21/2006 10:31	28.7	15	9/21/2006 10:59
102	18	9/21/2006 10:31	28.7	15	9/21/2006 10:59
101	18	9/21/2006 10:31	28.6	15	9/21/2006 10:59
120	18	9/21/2006 10:31	28.8	15	9/21/2006 10:59
217	18	9/21/2006 10:31	28.7	15	9/21/2006 10:59
2770	18	9/21/2006 10:31	28.6	15	9/21/2006 10:59
2157	18	9/21/2006 10:31	28.7	15	9/21/2006 10:59
1547	18	9/21/2006 10:31	28.8	15	9/21/2006 10:59
1344	18	9/21/2006 10:31	28.4	15	9/21/2006 10:59
1458	18	9/21/2006 10:31	28.6	15	9/21/2006 10:59
1158	18	9/21/2006 10:31	28.7	15	9/21/2006 10:59
738	18	9/21/2006 10:31	28.7	15	9/21/2006 10:59
608	18	9/21/2006 10:31	28.9	15	9/21/2006 10:59
655	18	9/21/2006 10:31	28.6	15	9/21/2006 10:59
569	18	9/21/2006 10:31	28.6	15	9/21/2006 10:59
440	18	9/21/2006 10:31	28.5	15	9/21/2006 10:59

Path Measurement Data Site 4 Path 3			Path Measurement Data Site 4 Path 4		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
246	18	9/21/2006 10:31	28.4	15	9/21/2006 10:59
75.1	18	9/21/2006 10:31	28.5	15	9/21/2006 10:59
52.9	18	9/21/2006 10:31	28.6	15	9/21/2006 10:59
50.9	18	9/21/2006 10:31	28.7	15	9/21/2006 10:59
48.8	18	9/21/2006 10:31	28.7	15	9/21/2006 10:59
47.6	18	9/21/2006 10:31	28.5	15	9/21/2006 10:59
167	18	9/21/2006 10:31	28.6	15	9/21/2006 10:59
265	18	9/21/2006 10:31	28.7	15	9/21/2006 10:59
1016	18	9/21/2006 10:31	28.8	15	9/21/2006 10:59
997	18	9/21/2006 10:31	28.6	15	9/21/2006 10:59
505	18	9/21/2006 10:32	28.8	15	9/21/2006 10:59
177	18	9/21/2006 10:32	28.8	15	9/21/2006 10:59
1343	18	9/21/2006 10:32	28.7	15	9/21/2006 10:59
1468	18	9/21/2006 10:32	28.6	15	9/21/2006 10:59
301	18	9/21/2006 10:32	28.5	15	9/21/2006 10:59
97.5	18	9/21/2006 10:32	28.7	15	9/21/2006 10:59
56.1	18	9/21/2006 10:32	28.6	15	9/21/2006 10:59
49	18	9/21/2006 10:32	28.7	15	9/21/2006 10:59
46.8	18	9/21/2006 10:32	28.7	15	9/21/2006 11:00
60.2	18	9/21/2006 10:32	28.6	15	9/21/2006 11:00
329	18	9/21/2006 10:32	28.7	15	9/21/2006 11:00
472	18	9/21/2006 10:32	28.8	15	9/21/2006 11:00
356	18	9/21/2006 10:32	28.8	15	9/21/2006 11:00
231	18	9/21/2006 10:32	28.7	15	9/21/2006 11:00
151	18	9/21/2006 10:32	28.8	15	9/21/2006 11:00
108	18	9/21/2006 10:32	28.8	15	9/21/2006 11:00
102	18	9/21/2006 10:32	28.5	15	9/21/2006 11:00
153	18	9/21/2006 10:32	28.7	15	9/21/2006 11:00
308	18	9/21/2006 10:32	28.7	15	9/21/2006 11:00
1526	18	9/21/2006 10:32	28.8	15	9/21/2006 11:00
1056	18	9/21/2006 10:32	28.7	15	9/21/2006 11:00
372	18	9/21/2006 10:32	28.7	15	9/21/2006 11:00
180	18	9/21/2006 10:32	28.7	15	9/21/2006 11:00
128	18	9/21/2006 10:32	28.6	15	9/21/2006 11:00
180	18	9/21/2006 10:32	28.8	15	9/21/2006 11:00
184	18	9/21/2006 10:32	28.7	15	9/21/2006 11:00
78.4	18	9/21/2006 10:32	28.6	15	9/21/2006 11:00
80.3	18	9/21/2006 10:32	28.8	15	9/21/2006 11:00
71.2	18	9/21/2006 10:32	28.9	15	9/21/2006 11:00
54.6	18	9/21/2006 10:32	28.7	15	9/21/2006 11:00
68	18	9/21/2006 10:32	28.8	15	9/21/2006 11:00
77.2	18	9/21/2006 10:32	28.8	15	9/21/2006 11:00
87.3	18	9/21/2006 10:32	28.8	15	9/21/2006 11:00
51.2	18	9/21/2006 10:33	28.8	15	9/21/2006 11:00
45.1	18	9/21/2006 10:33	28.7	15	9/21/2006 11:00
43.1	18	9/21/2006 10:33	28.8	15	9/21/2006 11:00
48.7	18	9/21/2006 10:33	28.7	15	9/21/2006 11:00
51.1	18	9/21/2006 10:33	28.9	15	9/21/2006 11:00
47.4	18	9/21/2006 10:33	28.7	15	9/21/2006 11:00
41.1	18	9/21/2006 10:33	28.8	15	9/21/2006 11:00
40.5	18	9/21/2006 10:33	28.8	15	9/21/2006 11:00
40.3	18	9/21/2006 10:33	28.7	15	9/21/2006 11:00
39	18	9/21/2006 10:33	28.6	15	9/21/2006 11:01
37.6	18	9/21/2006 10:33	28.7	15	9/21/2006 11:01
37.6	18	9/21/2006 10:33	28.5	15	9/21/2006 11:01
37.8	18	9/21/2006 10:33	28.8	15	9/21/2006 11:01
37.5	18	9/21/2006 10:33	28.7	15	9/21/2006 11:01
37.5	18	9/21/2006 10:33	28.7	15	9/21/2006 11:01
37.5	18	9/21/2006 10:33	28.8	15	9/21/2006 11:01
37.3	18	9/21/2006 10:33	28.9	15	9/21/2006 11:01

Path Measurement Data Site 4 Path 3			Path Measurement Data Site 4 Path 4		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
37.6	18	9/21/2006 10:33	28.6	15	9/21/2006 11:01
37.6	18	9/21/2006 10:33	28.8	15	9/21/2006 11:01
37.4	18	9/21/2006 10:33	28.7	15	9/21/2006 11:01
37.5	18	9/21/2006 10:33	28.6	15	9/21/2006 11:01
37.1	18	9/21/2006 10:33	28.8	15	9/21/2006 11:01
37.2	18	9/21/2006 10:33	28.7	15	9/21/2006 11:01
37.3	18	9/21/2006 10:33	28.7	15	9/21/2006 11:01
37.6	18	9/21/2006 10:33	28.8	15	9/21/2006 11:01
37.4	18	9/21/2006 10:33	28.8	15	9/21/2006 11:01
37.3	18	9/21/2006 10:33	28.7	15	9/21/2006 11:01
37.2	18	9/21/2006 10:33	28.7	15	9/21/2006 11:01
37.2	18	9/21/2006 10:33	28.8	15	9/21/2006 11:01
37.5	18	9/21/2006 10:33	28.6	15	9/21/2006 11:01
37.4	18	9/21/2006 10:33	28.8	15	9/21/2006 11:01
37.4	18	9/21/2006 10:33	28.6	15	9/21/2006 11:01
37.1	18	9/21/2006 10:33	28.7	15	9/21/2006 11:01
37.3	18	9/21/2006 10:33	28.7	15	9/21/2006 11:01
37.4	18	9/21/2006 10:33	28.7	15	9/21/2006 11:01
37.5	18	9/21/2006 10:34	28.7	15	9/21/2006 11:01
37.4	18	9/21/2006 10:34	28.7	15	9/21/2006 11:01
37.4	18	9/21/2006 10:34	28.7	15	9/21/2006 11:01
37.6	18	9/21/2006 10:34	28.8	15	9/21/2006 11:01
37.3	18	9/21/2006 10:34	28.8	15	9/21/2006 11:01
37.5	18	9/21/2006 10:34	28.7	15	9/21/2006 11:01
37.5	18	9/21/2006 10:34	28.8	15	9/21/2006 11:01
37.3	18	9/21/2006 10:34	28.8	15	9/21/2006 11:01
37.5	18	9/21/2006 10:34	28.7	15	9/21/2006 11:02
37.4	18	9/21/2006 10:34	28.9	15	9/21/2006 11:02
37.5	18	9/21/2006 10:34	28.7	15	9/21/2006 11:02
37.2	18	9/21/2006 10:34	28.7	15	9/21/2006 11:02
37.3	18	9/21/2006 10:34	28.8	15	9/21/2006 11:02
37.2	18	9/21/2006 10:34	28.7	15	9/21/2006 11:02
37.3	18	9/21/2006 10:34	28.7	15	9/21/2006 11:02
37	18	9/21/2006 10:34	28.4	15	9/21/2006 11:02
37.1	18	9/21/2006 10:34	28.7	15	9/21/2006 11:02
37.2	18	9/21/2006 10:34	28.7	15	9/21/2006 11:02
37.3	18	9/21/2006 10:34	28.8	15	9/21/2006 11:02
37.6	18	9/21/2006 10:34	28.8	15	9/21/2006 11:02
37.6	18	9/21/2006 10:34	28.6	15	9/21/2006 11:02
37.6	18	9/21/2006 10:34	28.7	15	9/21/2006 11:02
38.1	18	9/21/2006 10:34	28.9	15	9/21/2006 11:02
38.3	18	9/21/2006 10:34	28.7	15	9/21/2006 11:02
38.4	18	9/21/2006 10:34	28.6	15	9/21/2006 11:02
38.4	18	9/21/2006 10:34	28.7	15	9/21/2006 11:02
39	18	9/21/2006 10:34	28.6	15	9/21/2006 11:02
39	18	9/21/2006 10:34	28.8	15	9/21/2006 11:02
38.9	18	9/21/2006 10:34	28.7	15	9/21/2006 11:02
39	18	9/21/2006 10:34	28.6	15	9/21/2006 11:02
39.5	18	9/21/2006 10:34	28.8	15	9/21/2006 11:02
39.3	18	9/21/2006 10:34	28.8	15	9/21/2006 11:02
38.7	18	9/21/2006 10:34	28.7	15	9/21/2006 11:02
38.1	18	9/21/2006 10:34	28.6	15	9/21/2006 11:02
38.1	18	9/21/2006 10:35	28.8	15	9/21/2006 11:02
38.1	18	9/21/2006 10:35	28.6	15	9/21/2006 11:02
38	18	9/21/2006 10:35	28.7	15	9/21/2006 11:02
38	18	9/21/2006 10:35	28.7	15	9/21/2006 11:02
38	18	9/21/2006 10:35	28.6	15	9/21/2006 11:02
38	18	9/21/2006 10:35	28.7	15	9/21/2006 11:02
38	18	9/21/2006 10:35	28.6	15	9/21/2006 11:02
38	18	9/21/2006 10:35	28.5	15	9/21/2006 11:02



Path Measurement Data Site 4 Path 3			Path Measurement Data Site 4 Path 4		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
38.3	18	9/21/2006 10:35	28.5	15	9/21/2006 11:03
41	18	9/21/2006 10:35	28.7	15	9/21/2006 11:03
40.5	18	9/21/2006 10:35	28.5	15	9/21/2006 11:03
42.4	18	9/21/2006 10:35	28.6	15	9/21/2006 11:03
40.2	18	9/21/2006 10:35	28.8	15	9/21/2006 11:03
125	18	9/21/2006 10:35	28.6	15	9/21/2006 11:03
350	18	9/21/2006 10:35	28.6	15	9/21/2006 11:03
615	18	9/21/2006 10:35	28.6	15	9/21/2006 11:03
490	18	9/21/2006 10:35	28.6	15	9/21/2006 11:03
700	18	9/21/2006 10:35	28.6	15	9/21/2006 11:03
573	18	9/21/2006 10:35	28.7	15	9/21/2006 11:03
380	18	9/21/2006 10:35	28.7	15	9/21/2006 11:03
91.6	18	9/21/2006 10:35	28.8	15	9/21/2006 11:03
65.7	18	9/21/2006 10:35	28.7	15	9/21/2006 11:03
81.8	18	9/21/2006 10:35	28.8	15	9/21/2006 11:03
99.7	18	9/21/2006 10:35	28.7	15	9/21/2006 11:03
65.6	18	9/21/2006 10:35	28.8	15	9/21/2006 11:03
45.1	18	9/21/2006 10:35	28.9	15	9/21/2006 11:03
44.9	18	9/21/2006 10:35	28.7	15	9/21/2006 11:03
40.9	18	9/21/2006 10:35	28.8	15	9/21/2006 11:03
39.4	18	9/21/2006 10:35	28.6	15	9/21/2006 11:03
39.7	18	9/21/2006 10:35	28.8	15	9/21/2006 11:03
38.9	18	9/21/2006 10:35	28.9	15	9/21/2006 11:03
38.9	18	9/21/2006 10:35	28.9	15	9/21/2006 11:03
44	18	9/21/2006 10:35	28.8	15	9/21/2006 11:03
66.5	18	9/21/2006 10:35	28.8	15	9/21/2006 11:03
129	18	9/21/2006 10:36	28.9	15	9/21/2006 11:03
162	18	9/21/2006 10:36	28.7	15	9/21/2006 11:03
164	18	9/21/2006 10:36	28.8	15	9/21/2006 11:03
202	18	9/21/2006 10:36	28.8	15	9/21/2006 11:03
136	18	9/21/2006 10:36	28.8	15	9/21/2006 11:03
111	18	9/21/2006 10:36	28.9	15	9/21/2006 11:03
66.3	18	9/21/2006 10:36	28.7	15	9/21/2006 11:03
47.4	18	9/21/2006 10:36	28.8	15	9/21/2006 11:03
49.2	18	9/21/2006 10:36	28.9	15	9/21/2006 11:03
52.1	18	9/21/2006 10:36	28.9	15	9/21/2006 11:04
57.8	18	9/21/2006 10:36	28.9	15	9/21/2006 11:04
61.6	18	9/21/2006 10:36	28.9	15	9/21/2006 11:04
79.2	18	9/21/2006 10:36	29	15	9/21/2006 11:04
143	18	9/21/2006 10:36	29	15	9/21/2006 11:04
144	18	9/21/2006 10:36	28.8	15	9/21/2006 11:04
120	18	9/21/2006 10:36	28.7	15	9/21/2006 11:04
88.8	18	9/21/2006 10:36	28.9	15	9/21/2006 11:04
75.5	18	9/21/2006 10:36	28.8	15	9/21/2006 11:04
59.5	18	9/21/2006 10:36	28.9	15	9/21/2006 11:04
47.1	18	9/21/2006 10:36	28.8	15	9/21/2006 11:04
42.5	18	9/21/2006 10:36	28.7	15	9/21/2006 11:04
46.4	18	9/21/2006 10:36	28.9	15	9/21/2006 11:04
46.8	18	9/21/2006 10:36	28.9	15	9/21/2006 11:04
46.8	18	9/21/2006 10:36	29	15	9/21/2006 11:04
49	18	9/21/2006 10:36	28.7	15	9/21/2006 11:04
50.6	18	9/21/2006 10:36	28.9	15	9/21/2006 11:04
50.7	18	9/21/2006 10:36	28.8	15	9/21/2006 11:04
50.3	18	9/21/2006 10:36	28.9	15	9/21/2006 11:04
46.6	18	9/21/2006 10:36	28.9	15	9/21/2006 11:04
46.3	18	9/21/2006 10:36	28.7	15	9/21/2006 11:04
45.4	18	9/21/2006 10:36	28.7	15	9/21/2006 11:04
46.1	18	9/21/2006 10:36	28.8	15	9/21/2006 11:04
43.1	18	9/21/2006 10:36	28.6	15	9/21/2006 11:04
42.6	18	9/21/2006 10:36	28.9	15	9/21/2006 11:04

Path Measurement Data Site 4 Path 3			Path Measurement Data Site 4 Path 4		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
41.5	18	9/21/2006 10:37	28.8	15	9/21/2006 11:04
40	18	9/21/2006 10:37	28.8	15	9/21/2006 11:04
39.6	18	9/21/2006 10:37	28.6	15	9/21/2006 11:04
39.4	18	9/21/2006 10:37	28.8	15	9/21/2006 11:04
39.4	18	9/21/2006 10:37	28.9	15	9/21/2006 11:04
38.9	18	9/21/2006 10:37	28.8	15	9/21/2006 11:04
39.2	18	9/21/2006 10:37	29	15	9/21/2006 11:04
38.9	18	9/21/2006 10:37	28.7	15	9/21/2006 11:04
38.9	18	9/21/2006 10:37	28.8	15	9/21/2006 11:04
38.9	18	9/21/2006 10:37	28.7	15	9/21/2006 11:05
38.6	18	9/21/2006 10:37	28.7	15	9/21/2006 11:05
38.9	18	9/21/2006 10:37	29	15	9/21/2006 11:05
38.6	18	9/21/2006 10:37	28.6	15	9/21/2006 11:05
39	18	9/21/2006 10:37	28.8	15	9/21/2006 11:05
39	18	9/21/2006 10:37	28.7	15	9/21/2006 11:05
39.2	18	9/21/2006 10:37	28.7	15	9/21/2006 11:05
39.5	18	9/21/2006 10:37	28.8	15	9/21/2006 11:05
39.7	18	9/21/2006 10:37	28.8	15	9/21/2006 11:05
39.7	18	9/21/2006 10:37	28.9	15	9/21/2006 11:05
39.6	18	9/21/2006 10:37	28.7	15	9/21/2006 11:05
39.4	18	9/21/2006 10:37	28.8	15	9/21/2006 11:05
39.9	18	9/21/2006 10:37	29	15	9/21/2006 11:05
39.5	18	9/21/2006 10:37	28.8	15	9/21/2006 11:05
39.4	18	9/21/2006 10:37	28.7	15	9/21/2006 11:05
39.8	18	9/21/2006 10:37	28.7	15	9/21/2006 11:05
40.5	18	9/21/2006 10:37	28.9	15	9/21/2006 11:05
40.8	18	9/21/2006 10:37	28.7	15	9/21/2006 11:05
40.8	18	9/21/2006 10:37	28.7	15	9/21/2006 11:05
40.7	18	9/21/2006 10:37	28.9	15	9/21/2006 11:05
40.5	18	9/21/2006 10:37	28.8	15	9/21/2006 11:05
40.8	18	9/21/2006 10:37	28.8	15	9/21/2006 11:05
41.6	18	9/21/2006 10:37	28.7	15	9/21/2006 11:05
41.1	18	9/21/2006 10:37	28.8	15	9/21/2006 11:05
41	18	9/21/2006 10:37	28.9	15	9/21/2006 11:05
41.1	18	9/21/2006 10:38	28.7	15	9/21/2006 11:05
40.4	18	9/21/2006 10:38	28.6	15	9/21/2006 11:05
40.6	18	9/21/2006 10:38	28.5	15	9/21/2006 11:05
40.2	18	9/21/2006 10:38	28.7	15	9/21/2006 11:05
39.8	18	9/21/2006 10:38	28.8	15	9/21/2006 11:05
39.3	18	9/21/2006 10:38	28.7	15	9/21/2006 11:05
39.1	18	9/21/2006 10:38	28.6	15	9/21/2006 11:05
38.7	18	9/21/2006 10:38	28.8	15	9/21/2006 11:05
38.4	18	9/21/2006 10:38	28.7	15	9/21/2006 11:05
38.1	18	9/21/2006 10:38	28.5	15	9/21/2006 11:06
38.4	18	9/21/2006 10:38	28.7	15	9/21/2006 11:06
38.2	18	9/21/2006 10:38	28.5	15	9/21/2006 11:06
38.3	18	9/21/2006 10:38	28.6	15	9/21/2006 11:06
38.2	18	9/21/2006 10:38	28.7	15	9/21/2006 11:06
38.2	18	9/21/2006 10:38	28.7	15	9/21/2006 11:06
38.4	18	9/21/2006 10:38	28.6	15	9/21/2006 11:06
38	18	9/21/2006 10:38	28.6	15	9/21/2006 11:06
38.1	18	9/21/2006 10:38	28.7	15	9/21/2006 11:06
38.1	18	9/21/2006 10:38	28.7	15	9/21/2006 11:06
38.1	18	9/21/2006 10:38	28.7	15	9/21/2006 11:06
38.1	18	9/21/2006 10:38	28.5	15	9/21/2006 11:06
38.1	18	9/21/2006 10:38	28.7	15	9/21/2006 11:06
38.2	18	9/21/2006 10:38	28.7	15	9/21/2006 11:06
38.3	18	9/21/2006 10:38	28.7	15	9/21/2006 11:06
38.1	18	9/21/2006 10:38	28.7	15	9/21/2006 11:06
38.1	18	9/21/2006 10:38	28.8	15	9/21/2006 11:06

Path Measurement Data Site 4 Path 3			Path Measurement Data Site 4 Path 4		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
38.2	18	9/21/2006 10:38	28.8	15	9/21/2006 11:06
38	18	9/21/2006 10:38	28.8	15	9/21/2006 11:06
38.3	18	9/21/2006 10:38	28.5	15	9/21/2006 11:06
38.1	18	9/21/2006 10:38	28.7	15	9/21/2006 11:06
38	18	9/21/2006 10:38	28.6	15	9/21/2006 11:06
165	18	9/21/2006 10:38	28.7	15	9/21/2006 11:06
234	18	9/21/2006 10:38	28.6	15	9/21/2006 11:06
296	18	9/21/2006 10:38	28.7	15	9/21/2006 11:06
287	18	9/21/2006 10:38	28.7	15	9/21/2006 11:06
264	18	9/21/2006 10:39	28.6	15	9/21/2006 11:06
252	18	9/21/2006 10:39	28.8	15	9/21/2006 11:06
251	18	9/21/2006 10:39	28.6	15	9/21/2006 11:06
364	18	9/21/2006 10:39	28.8	15	9/21/2006 11:06
368	18	9/21/2006 10:39	28.6	15	9/21/2006 11:06
362	18	9/21/2006 10:39	28.8	15	9/21/2006 11:06
175	18	9/21/2006 10:39	28.7	15	9/21/2006 11:06
95.1	18	9/21/2006 10:39	28.7	15	9/21/2006 11:06
53.9	18	9/21/2006 10:39	28.5	15	9/21/2006 11:07
45	18	9/21/2006 10:39	28.6	15	9/21/2006 11:07
47.3	18	9/21/2006 10:39	28.6	15	9/21/2006 11:07
53.2	18	9/21/2006 10:39	28.7	15	9/21/2006 11:07
61.8	18	9/21/2006 10:39	28.7	15	9/21/2006 11:07
65.4	18	9/21/2006 10:39	28.1	15	9/21/2006 11:07
61.7	18	9/21/2006 10:39	28.4	15	9/21/2006 11:07
58.6	18	9/21/2006 10:39	28.1	15	9/21/2006 11:07
54	18	9/21/2006 10:39	28.4	15	9/21/2006 11:07
60.7	18	9/21/2006 10:39	28.1	15	9/21/2006 11:07
83.2	18	9/21/2006 10:39	28.1	15	9/21/2006 11:07
55.1	18	9/21/2006 10:39	28.2	15	9/21/2006 11:07
48.6	18	9/21/2006 10:39	28.4	15	9/21/2006 11:07
87.5	18	9/21/2006 10:39	28.2	15	9/21/2006 11:07
72	18	9/21/2006 10:39	28.2	15	9/21/2006 11:07
54.3	18	9/21/2006 10:39	28.2	15	9/21/2006 11:07
63.9	18	9/21/2006 10:39	28.1	15	9/21/2006 11:07
151	18	9/21/2006 10:39	28.2	15	9/21/2006 11:07
149	18	9/21/2006 10:39	28.2	15	9/21/2006 11:07
74.7	18	9/21/2006 10:39	28.1	15	9/21/2006 11:07
117	18	9/21/2006 10:39	28.2	15	9/21/2006 11:07
134	18	9/21/2006 10:39	28.1	15	9/21/2006 11:07
183	18	9/21/2006 10:39	28.2	15	9/21/2006 11:07
122	18	9/21/2006 10:39	28.2	15	9/21/2006 11:07
93.2	18	9/21/2006 10:40	28.1	15	9/21/2006 11:07
68.2	18	9/21/2006 10:40	28.2	15	9/21/2006 11:07
55.6	18	9/21/2006 10:40	28.1	15	9/21/2006 11:07
48.6	18	9/21/2006 10:40	28.1	15	9/21/2006 11:07
56.4	18	9/21/2006 10:40	28.1	15	9/21/2006 11:07
57.4	18	9/21/2006 10:40	28.2	15	9/21/2006 11:07
58	18	9/21/2006 10:40	28.2	15	9/21/2006 11:07
56.9	18	9/21/2006 10:40	28.2	15	9/21/2006 11:07
55	18	9/21/2006 10:40	28.3	15	9/21/2006 11:07
58.9	18	9/21/2006 10:40	28.1	15	9/21/2006 11:08
59.7	18	9/21/2006 10:40	28.4	15	9/21/2006 11:08
59.4	18	9/21/2006 10:40	28.3	15	9/21/2006 11:08
52.9	18	9/21/2006 10:40	28.3	15	9/21/2006 11:08
52.1	18	9/21/2006 10:40	28.1	15	9/21/2006 11:08
52.9	18	9/21/2006 10:40	28.2	15	9/21/2006 11:08
52.8	18	9/21/2006 10:40	28.3	15	9/21/2006 11:08
56.5	18	9/21/2006 10:40	28.1	15	9/21/2006 11:08
63.6	18	9/21/2006 10:40	28.1	15	9/21/2006 11:08
47.9	18	9/21/2006 10:40	28.1	15	9/21/2006 11:08

Path Measurement Data Site 4 Path 3			Path Measurement Data Site 4 Path 4		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
44.6	18	9/21/2006 10:40	28.3	15	9/21/2006 11:08
46.1	18	9/21/2006 10:40	28.1	15	9/21/2006 11:08
47	18	9/21/2006 10:40	28.3	15	9/21/2006 11:08
47.1	18	9/21/2006 10:40	28.1	15	9/21/2006 11:08
46.9	18	9/21/2006 10:40	28.2	15	9/21/2006 11:08
43.5	18	9/21/2006 10:40	28.1	15	9/21/2006 11:08
42.4	18	9/21/2006 10:40	28.2	15	9/21/2006 11:08
43.4	18	9/21/2006 10:40	28.2	15	9/21/2006 11:08
41.5	18	9/21/2006 10:40	28.1	15	9/21/2006 11:08
41	18	9/21/2006 10:40	28.2	15	9/21/2006 11:08
46.2	18	9/21/2006 10:40	28.3	15	9/21/2006 11:08
49.7	18	9/21/2006 10:40	28.2	15	9/21/2006 11:08
47.4	18	9/21/2006 10:40	28.3	15	9/21/2006 11:08
60.5	18	9/21/2006 10:40	28.5	15	9/21/2006 11:08
69.6	18	9/21/2006 10:40	28.3	15	9/21/2006 11:08
65.2	18	9/21/2006 10:41	28.3	15	9/21/2006 11:08
69.6	18	9/21/2006 10:41	28.4	15	9/21/2006 11:08
80.2	18	9/21/2006 10:41	28.2	15	9/21/2006 11:08
86.6	18	9/21/2006 10:41	28.3	15	9/21/2006 11:08
70.3	18	9/21/2006 10:41	28.2	15	9/21/2006 11:08
66.3	18	9/21/2006 10:41	28.5	15	9/21/2006 11:08
65.1	18	9/21/2006 10:41	28.2	15	9/21/2006 11:08
67	18	9/21/2006 10:41	28.3	15	9/21/2006 11:08
65.8	18	9/21/2006 10:41	28.4	15	9/21/2006 11:08
63.6	18	9/21/2006 10:41	28.5	15	9/21/2006 11:09
64	18	9/21/2006 10:41	28.3	15	9/21/2006 11:09
58.9	18	9/21/2006 10:41	28.1	15	9/21/2006 11:09
57.2	18	9/21/2006 10:41	28.3	15	9/21/2006 11:09
55.1	18	9/21/2006 10:41	28.2	15	9/21/2006 11:09
56	18	9/21/2006 10:41	28.2	15	9/21/2006 11:09
55.5	18	9/21/2006 10:41	28.3	15	9/21/2006 11:09
55.7	18	9/21/2006 10:41	28.3	15	9/21/2006 11:09
56.4	18	9/21/2006 10:41	28.2	15	9/21/2006 11:09
56.7	18	9/21/2006 10:41	28.3	15	9/21/2006 11:09
56.8	18	9/21/2006 10:41	28.2	15	9/21/2006 11:09
56.4	18	9/21/2006 10:41	28.2	15	9/21/2006 11:09
56.6	18	9/21/2006 10:41	28.4	15	9/21/2006 11:09
56.5	18	9/21/2006 10:41	28.4	15	9/21/2006 11:09
56.6	18	9/21/2006 10:41	28.2	15	9/21/2006 11:09
56.5	18	9/21/2006 10:41	28.3	15	9/21/2006 11:09
58.4	18	9/21/2006 10:41	28.2	15	9/21/2006 11:09
60.2	18	9/21/2006 10:41	28.5	15	9/21/2006 11:09
60.3	18	9/21/2006 10:41	28.1	15	9/21/2006 11:09
61.2	18	9/21/2006 10:41	28.3	15	9/21/2006 11:09
62.2	18	9/21/2006 10:41	28.4	15	9/21/2006 11:09
62.9	18	9/21/2006 10:41	28.2	15	9/21/2006 11:09
64.8	18	9/21/2006 10:41	28.3	15	9/21/2006 11:09
64.7	18	9/21/2006 10:41	28.4	15	9/21/2006 11:09
61.8	18	9/21/2006 10:41	28.4	15	9/21/2006 11:09
59.5	18	9/21/2006 10:41	28.3	15	9/21/2006 11:09
58.4	18	9/21/2006 10:42	28.1	15	9/21/2006 11:09
58	18	9/21/2006 10:42	28.4	15	9/21/2006 11:09
57.5	18	9/21/2006 10:42	28.3	15	9/21/2006 11:09
57.9	18	9/21/2006 10:42	28.2	15	9/21/2006 11:09
57.9	18	9/21/2006 10:42	28.3	15	9/21/2006 11:09
58.9	18	9/21/2006 10:42	28.3	15	9/21/2006 11:09
60.1	18	9/21/2006 10:42	28.2	15	9/21/2006 11:09
61.4	18	9/21/2006 10:42	28.4	15	9/21/2006 11:09
61.6	18	9/21/2006 10:42	28.2	15	9/21/2006 11:09
61	18	9/21/2006 10:42	28.2	15	9/21/2006 11:10

Path Measurement Data Site 4 Path 3			Path Measurement Data Site 4 Path 4		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
61.3	18	9/21/2006 10:42	28.4	15	9/21/2006 11:10
61.3	18	9/21/2006 10:42	28.3	15	9/21/2006 11:10
61.2	18	9/21/2006 10:42	28.2	15	9/21/2006 11:10
61	18	9/21/2006 10:42	28	15	9/21/2006 11:10
61.2	18	9/21/2006 10:42	28.2	15	9/21/2006 11:10
60.7	18	9/21/2006 10:42	28.3	15	9/21/2006 11:10
60.8	18	9/21/2006 10:42	28.1	15	9/21/2006 11:10
60.4	18	9/21/2006 10:42	28.1	15	9/21/2006 11:10
59.5	18	9/21/2006 10:42	28.3	15	9/21/2006 11:10
58.7	18	9/21/2006 10:42	28.1	15	9/21/2006 11:10
58.1	18	9/21/2006 10:42	28.3	15	9/21/2006 11:10
57.5	18	9/21/2006 10:42	28.1	15	9/21/2006 11:10
56.8	18	9/21/2006 10:42	28	15	9/21/2006 11:10
56.5	18	9/21/2006 10:42	28.2	15	9/21/2006 11:10
58	18	9/21/2006 10:42	28	15	9/21/2006 11:10
59.3	18	9/21/2006 10:42	28.3	15	9/21/2006 11:10
60.5	18	9/21/2006 10:42	28.2	15	9/21/2006 11:10
71	18	9/21/2006 10:42	28.2	15	9/21/2006 11:10
78.1	18	9/21/2006 10:42	28.2	15	9/21/2006 11:10
76.5	18	9/21/2006 10:42	28.1	15	9/21/2006 11:10
67	18	9/21/2006 10:42	28	15	9/21/2006 11:10
65	18	9/21/2006 10:42	28	15	9/21/2006 11:10
60.6	18	9/21/2006 10:42			
58.8	18	9/21/2006 10:42			
60.4	18	9/21/2006 10:43			
62.4	18	9/21/2006 10:43			
64.3	18	9/21/2006 10:43			
64.1	18	9/21/2006 10:43			
67.3	18	9/21/2006 10:43			
63.6	18	9/21/2006 10:43			
59.9	18	9/21/2006 10:43			
60.7	18	9/21/2006 10:43			
57.2	18	9/21/2006 10:43			
52.5	18	9/21/2006 10:43			
48	18	9/21/2006 10:43			
45.5	18	9/21/2006 10:43			
44	18	9/21/2006 10:43			
43.4	18	9/21/2006 10:43			
46.3	18	9/21/2006 10:43			
47.8	18	9/21/2006 10:43			
47.7	18	9/21/2006 10:43			
44.5	18	9/21/2006 10:43			
43.4	18	9/21/2006 10:43			
75.3	18	9/21/2006 10:43			
266	18	9/21/2006 10:43			
1318	18	9/21/2006 10:43			
1790	18	9/21/2006 10:43			
1782	18	9/21/2006 10:43			
1628	18	9/21/2006 10:43			
1258	18	9/21/2006 10:43			
1093	18	9/21/2006 10:43			
754	18	9/21/2006 10:43			
438	18	9/21/2006 10:43			
381	18	9/21/2006 10:43			
908	18	9/21/2006 10:43			
1415	18	9/21/2006 10:43			
1275	18	9/21/2006 10:43			
1045	18	9/21/2006 10:43			
1058	18	9/21/2006 10:44			
1157	18	9/21/2006 10:44			

Path Measurement Data Site 4 Path 3			Path Measurement Data Site 4 Path 4		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
975	18	9/21/2006 10:44			
858	18	9/21/2006 10:44			
544	18	9/21/2006 10:44			
412	18	9/21/2006 10:44			
195	18	9/21/2006 10:44			
76.8	18	9/21/2006 10:44			
59.3	18	9/21/2006 10:44			
53.6	18	9/21/2006 10:44			
48.1	18	9/21/2006 10:44			
45	18	9/21/2006 10:44			
86.2	18	9/21/2006 10:44			
229	18	9/21/2006 10:44			
326	18	9/21/2006 10:44			
221	18	9/21/2006 10:44			
268	18	9/21/2006 10:44			
82.3	18	9/21/2006 10:44			
56.3	18	9/21/2006 10:44			
57.7	18	9/21/2006 10:44			
63.7	18	9/21/2006 10:44			
60.6	18	9/21/2006 10:44			
74	18	9/21/2006 10:44			
89.6	18	9/21/2006 10:44			
70.9	18	9/21/2006 10:44			
71.8	18	9/21/2006 10:44			
66.1	18	9/21/2006 10:44			
64.6	18	9/21/2006 10:44			
62.4	18	9/21/2006 10:44			
62.6	18	9/21/2006 10:44			
60.6	18	9/21/2006 10:44			
57.4	18	9/21/2006 10:44			
49.4	18	9/21/2006 10:44			
60.4	18	9/21/2006 10:44			
54.5	18	9/21/2006 10:45			
69.3	18	9/21/2006 10:45			
46.1	18	9/21/2006 10:45			
51	18	9/21/2006 10:45			
41.2	18	9/21/2006 10:45			
46.2	18	9/21/2006 10:45			
45.8	18	9/21/2006 10:45			
50	18	9/21/2006 10:45			
47.6	18	9/21/2006 10:45			
48.1	18	9/21/2006 10:45			
54.9	18	9/21/2006 10:45			
60.8	18	9/21/2006 10:45			
58.5	18	9/21/2006 10:45			
54.5	18	9/21/2006 10:45			
51.6	18	9/21/2006 10:45			
58.5	18	9/21/2006 10:45			
66.9	18	9/21/2006 10:45			
48.7	18	9/21/2006 10:45			
40.9	18	9/21/2006 10:45			
38.2	18	9/21/2006 10:45			
46.9	18	9/21/2006 10:45			
43.8	18	9/21/2006 10:45			
43	18	9/21/2006 10:45			
45.9	18	9/21/2006 10:45			
38.8	18	9/21/2006 10:45			
40.4	18	9/21/2006 10:45			
43.8	18	9/21/2006 10:45			
42.4	18	9/21/2006 10:45			

Path Measurement Data Site 4 Path 3			Path Measurement Data Site 4 Path 4		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
42.6	18	9/21/2006 10:45			
40.3	18	9/21/2006 10:45			
39.6	18	9/21/2006 10:45			
39.5	18	9/21/2006 10:45			
41.3	18	9/21/2006 10:45			
42.8	18	9/21/2006 10:45			
44.4	18	9/21/2006 10:46			
50	18	9/21/2006 10:46			
50.4	18	9/21/2006 10:46			
46.7	18	9/21/2006 10:46			
44.5	18	9/21/2006 10:46			
50.5	18	9/21/2006 10:46			
52.5	18	9/21/2006 10:46			
46.7	18	9/21/2006 10:46			
43.1	18	9/21/2006 10:46			
40.4	18	9/21/2006 10:46			
44	18	9/21/2006 10:46			
50.7	18	9/21/2006 10:46			
52.8	18	9/21/2006 10:46			
50.3	18	9/21/2006 10:46			
44	18	9/21/2006 10:46			
41.4	18	9/21/2006 10:46			
39.8	18	9/21/2006 10:46			
39.1	18	9/21/2006 10:46			

Path Measurement Data Site 4 Path 5		
ppm*m	pathlength	Timestamp (mountain time)
38.6	19	9/21/2006 11:14
38.5	19	9/21/2006 11:14
38.3	19	9/21/2006 11:14
38.4	19	9/21/2006 11:14
38.3	19	9/21/2006 11:15
38.5	19	9/21/2006 11:15
38.2	19	9/21/2006 11:15
38.3	19	9/21/2006 11:15
38.3	19	9/21/2006 11:15
38.3	19	9/21/2006 11:15
38.5	19	9/21/2006 11:15
38.7	19	9/21/2006 11:15
38.5	19	9/21/2006 11:15
38.1	19	9/21/2006 11:15
38.4	19	9/21/2006 11:15
38.6	19	9/21/2006 11:15
38.6	19	9/21/2006 11:15
38.3	19	9/21/2006 11:15
38.2	19	9/21/2006 11:15
38.7	19	9/21/2006 11:15
38.7	19	9/21/2006 11:15
38.4	19	9/21/2006 11:15
38.5	19	9/21/2006 11:15
38.7	19	9/21/2006 11:15
38.7	19	9/21/2006 11:15
38.6	19	9/21/2006 11:15
38.5	19	9/21/2006 11:15
38.6	19	9/21/2006 11:15
38.9	19	9/21/2006 11:15
38.4	19	9/21/2006 11:15
38.4	19	9/21/2006 11:15
38.6	19	9/21/2006 11:15
38.8	19	9/21/2006 11:15
38.6	19	9/21/2006 11:15
38.5	19	9/21/2006 11:15
38.6	19	9/21/2006 11:15
38.4	19	9/21/2006 11:15
38.6	19	9/21/2006 11:15
38.6	19	9/21/2006 11:16
38.8	19	9/21/2006 11:16
38.8	19	9/21/2006 11:16
38.6	19	9/21/2006 11:16
38.6	19	9/21/2006 11:16
38.8	19	9/21/2006 11:16
38.8	19	9/21/2006 11:16
38.8	19	9/21/2006 11:16
38.5	19	9/21/2006 11:16
38.8	19	9/21/2006 11:16
38.5	19	9/21/2006 11:16
38.8	19	9/21/2006 11:16
38.8	19	9/21/2006 11:16
38.4	19	9/21/2006 11:16
38.1	19	9/21/2006 11:16
38.5	19	9/21/2006 11:16
38.4	19	9/21/2006 11:16
38.4	19	9/21/2006 11:16
38.1	19	9/21/2006 11:16
38.5	19	9/21/2006 11:16
38.2	19	9/21/2006 11:16
38.3	19	9/21/2006 11:16



Path Measurement Data Site 4 Path 5		
ppm*m	pathlength	Timestamp (mountain time)
38.3	19	9/21/2006 11:16
38.3	19	9/21/2006 11:16
38.4	19	9/21/2006 11:16
38.2	19	9/21/2006 11:16
38.5	19	9/21/2006 11:16
38.5	19	9/21/2006 11:16
38.4	19	9/21/2006 11:16
38.1	19	9/21/2006 11:16
38.2	19	9/21/2006 11:16
38.1	19	9/21/2006 11:16
38.1	19	9/21/2006 11:16
38.2	19	9/21/2006 11:16
38.4	19	9/21/2006 11:16
38.1	19	9/21/2006 11:16
38.3	19	9/21/2006 11:17
38.2	19	9/21/2006 11:17
38.1	19	9/21/2006 11:17
38.3	19	9/21/2006 11:17
38.2	19	9/21/2006 11:17
38.2	19	9/21/2006 11:17
38.8	19	9/21/2006 11:17
39.7	19	9/21/2006 11:17
39.5	19	9/21/2006 11:17
38.7	19	9/21/2006 11:17
38.3	19	9/21/2006 11:17
38.9	19	9/21/2006 11:17
39.2	19	9/21/2006 11:17
38.4	19	9/21/2006 11:17
40.6	19	9/21/2006 11:17
42.1	19	9/21/2006 11:17
40.2	19	9/21/2006 11:17
40	19	9/21/2006 11:17
40.6	19	9/21/2006 11:17
40.3	19	9/21/2006 11:17
41	19	9/21/2006 11:17
40.9	19	9/21/2006 11:17
39.1	19	9/21/2006 11:17
39.5	19	9/21/2006 11:17
45.1	19	9/21/2006 11:17
42	19	9/21/2006 11:17
42.5	19	9/21/2006 11:17
44.7	19	9/21/2006 11:17
50.4	19	9/21/2006 11:17
54.1	19	9/21/2006 11:17
58.7	19	9/21/2006 11:17
51.4	19	9/21/2006 11:17
162	19	9/21/2006 11:17
45.2	19	9/21/2006 11:17
595	19	9/21/2006 11:18
65	19	9/21/2006 11:18
131	19	9/21/2006 11:18
156	19	9/21/2006 11:18
51.6	19	9/21/2006 11:18
70.7	19	9/21/2006 11:18
315	19	9/21/2006 11:18
1566	19	9/21/2006 11:18
629	19	9/21/2006 11:18
275	19	9/21/2006 11:18
365	19	9/21/2006 11:18
840	19	9/21/2006 11:18
2027	19	9/21/2006 11:18

Path Measurement Data Site 4 Path 5		
ppm*m	pathlength	Timestamp (mountain time)
1400	19	9/21/2006 11:18
1222	19	9/21/2006 11:18
984	19	9/21/2006 11:18
575	19	9/21/2006 11:18
201	19	9/21/2006 11:18
101	19	9/21/2006 11:18
63.1	19	9/21/2006 11:18
61.2	19	9/21/2006 11:18
58.7	19	9/21/2006 11:18
41.6	19	9/21/2006 11:18
39.5	19	9/21/2006 11:18
38.7	19	9/21/2006 11:18
38.5	19	9/21/2006 11:18
38.8	19	9/21/2006 11:18
38.8	19	9/21/2006 11:18
38.8	19	9/21/2006 11:18
38.6	19	9/21/2006 11:18
38.8	19	9/21/2006 11:18
38.8	19	9/21/2006 11:18
38.9	19	9/21/2006 11:18
38.7	19	9/21/2006 11:18
38.7	19	9/21/2006 11:19
38.8	19	9/21/2006 11:19
38.8	19	9/21/2006 11:19
38.6	19	9/21/2006 11:19
38.8	19	9/21/2006 11:19
38.7	19	9/21/2006 11:19
38.7	19	9/21/2006 11:19
39.1	19	9/21/2006 11:19
38.9	19	9/21/2006 11:19
85.6	19	9/21/2006 11:19
159	19	9/21/2006 11:19
130	19	9/21/2006 11:19
110	19	9/21/2006 11:19
248	19	9/21/2006 11:19
426	19	9/21/2006 11:19
41	19	9/21/2006 11:19
47.3	19	9/21/2006 11:19
44.2	19	9/21/2006 11:19
42.2	19	9/21/2006 11:19
43.5	19	9/21/2006 11:19
41.7	19	9/21/2006 11:19
42.6	19	9/21/2006 11:19
44.3	19	9/21/2006 11:19
45.5	19	9/21/2006 11:19
43.4	19	9/21/2006 11:19
40.6	19	9/21/2006 11:19
39.5	19	9/21/2006 11:19
39	19	9/21/2006 11:19
39	19	9/21/2006 11:19
39	19	9/21/2006 11:19
38.8	19	9/21/2006 11:19
42.2	19	9/21/2006 11:19
39.4	19	9/21/2006 11:19
39.1	19	9/21/2006 11:20
38.7	19	9/21/2006 11:20
39.5	19	9/21/2006 11:20
39.3	19	9/21/2006 11:20
38.7	19	9/21/2006 11:20
39.2	19	9/21/2006 11:20
40	19	9/21/2006 11:20

Path Measurement Data Site 4 Path 5		
ppm*m	pathlength	Timestamp (mountain time)
40.3	19	9/21/2006 11:20
40.2	19	9/21/2006 11:20
39.9	19	9/21/2006 11:20
39.8	19	9/21/2006 11:20
38.5	19	9/21/2006 11:20
38.1	19	9/21/2006 11:20
38.4	19	9/21/2006 11:20
38.5	19	9/21/2006 11:20
38.5	19	9/21/2006 11:20
38.5	19	9/21/2006 11:20
38.4	19	9/21/2006 11:20
38.6	19	9/21/2006 11:20
38.4	19	9/21/2006 11:20
38.2	19	9/21/2006 11:20
38.4	19	9/21/2006 11:20
38.4	19	9/21/2006 11:20
38.5	19	9/21/2006 11:20
38.5	19	9/21/2006 11:20
38.4	19	9/21/2006 11:20
38.4	19	9/21/2006 11:20
38.3	19	9/21/2006 11:20
37.9	19	9/21/2006 11:20
38.4	19	9/21/2006 11:20
38.3	19	9/21/2006 11:20
38.2	19	9/21/2006 11:20
38.1	19	9/21/2006 11:20
38.1	19	9/21/2006 11:20
38.2	19	9/21/2006 11:21
38.3	19	9/21/2006 11:21
38.5	19	9/21/2006 11:21
38.3	19	9/21/2006 11:21
38.4	19	9/21/2006 11:21
38.3	19	9/21/2006 11:21
38.3	19	9/21/2006 11:21
38.3	19	9/21/2006 11:21
38	19	9/21/2006 11:21
38.2	19	9/21/2006 11:21
38.2	19	9/21/2006 11:21
38.1	19	9/21/2006 11:21
38.2	19	9/21/2006 11:21
38.1	19	9/21/2006 11:21
38.3	19	9/21/2006 11:21
38.3	19	9/21/2006 11:21
38.1	19	9/21/2006 11:21
38.2	19	9/21/2006 11:21
38.2	19	9/21/2006 11:21
38	19	9/21/2006 11:21
38.3	19	9/21/2006 11:21
38.4	19	9/21/2006 11:21
38.5	19	9/21/2006 11:21
38.4	19	9/21/2006 11:21
38.3	19	9/21/2006 11:21
38.3	19	9/21/2006 11:21
38.3	19	9/21/2006 11:21
38.2	19	9/21/2006 11:21
38.2	19	9/21/2006 11:21
38.4	19	9/21/2006 11:21
38.2	19	9/21/2006 11:21
38.3	19	9/21/2006 11:21
38.2	19	9/21/2006 11:21
38.2	19	9/21/2006 11:21

Path Measurement Data Site 4 Path 5		
ppm*m	pathlength	Timestamp (mountain time)
38.3	19	9/21/2006 11:21
38.3	19	9/21/2006 11:22
38.2	19	9/21/2006 11:22
38.1	19	9/21/2006 11:22
38.3	19	9/21/2006 11:22
38.1	19	9/21/2006 11:22
38.4	19	9/21/2006 11:22
38.1	19	9/21/2006 11:22
38	19	9/21/2006 11:22
37.9	19	9/21/2006 11:22
38.2	19	9/21/2006 11:22
38.2	19	9/21/2006 11:22
38.1	19	9/21/2006 11:22
38.1	19	9/21/2006 11:22
38.2	19	9/21/2006 11:22
38.1	19	9/21/2006 11:22
38.1	19	9/21/2006 11:22
38.1	19	9/21/2006 11:22
38	19	9/21/2006 11:22
38.1	19	9/21/2006 11:22
37.9	19	9/21/2006 11:22
37.9	19	9/21/2006 11:22
38.1	19	9/21/2006 11:22
38.2	19	9/21/2006 11:22
37.9	19	9/21/2006 11:22
38.1	19	9/21/2006 11:22
38	19	9/21/2006 11:22
38	19	9/21/2006 11:22
38.2	19	9/21/2006 11:22
37.9	19	9/21/2006 11:22
37.8	19	9/21/2006 11:22
37.9	19	9/21/2006 11:22
37.8	19	9/21/2006 11:22
37.8	19	9/21/2006 11:22
37.8	19	9/21/2006 11:22
38	19	9/21/2006 11:23
37.8	19	9/21/2006 11:23
38	19	9/21/2006 11:23
38.1	19	9/21/2006 11:23
38	19	9/21/2006 11:23
37.8	19	9/21/2006 11:23
38.1	19	9/21/2006 11:23
37.8	19	9/21/2006 11:23
37.8	19	9/21/2006 11:23
38.1	19	9/21/2006 11:23
37.8	19	9/21/2006 11:23
37.9	19	9/21/2006 11:23
37.8	19	9/21/2006 11:23
37.6	19	9/21/2006 11:23
37.6	19	9/21/2006 11:23
37.9	19	9/21/2006 11:23
38	19	9/21/2006 11:23
38	19	9/21/2006 11:23
38.2	19	9/21/2006 11:23
38.1	19	9/21/2006 11:23
38	19	9/21/2006 11:23
38.1	19	9/21/2006 11:23
38	19	9/21/2006 11:23
37.9	19	9/21/2006 11:23
38.1	19	9/21/2006 11:23
38.1	19	9/21/2006 11:23

Path Measurement Data Site 4 Path 5		
ppm*m	pathlength	Timestamp (mountain time)
37.9	19	9/21/2006 11:23
37.9	19	9/21/2006 11:23
38.1	19	9/21/2006 11:23
38	19	9/21/2006 11:23
38.1	19	9/21/2006 11:23
38.1	19	9/21/2006 11:23
38	19	9/21/2006 11:23
38.1	19	9/21/2006 11:23
38.3	19	9/21/2006 11:24
38.1	19	9/21/2006 11:24
38.3	19	9/21/2006 11:24
38.1	19	9/21/2006 11:24
37.9	19	9/21/2006 11:24
38	19	9/21/2006 11:24
38.1	19	9/21/2006 11:24
38	19	9/21/2006 11:24
38	19	9/21/2006 11:24
37.9	19	9/21/2006 11:24
38.2	19	9/21/2006 11:24
37.9	19	9/21/2006 11:24
38	19	9/21/2006 11:24
38.1	19	9/21/2006 11:24
37.8	19	9/21/2006 11:24
38.4	19	9/21/2006 11:24
38.1	19	9/21/2006 11:24
38.2	19	9/21/2006 11:24
38	19	9/21/2006 11:24
38.1	19	9/21/2006 11:24
38	19	9/21/2006 11:24
38.1	19	9/21/2006 11:24
37.8	19	9/21/2006 11:24
38.2	19	9/21/2006 11:24
38.4	19	9/21/2006 11:24
38.6	19	9/21/2006 11:24
38.2	19	9/21/2006 11:24
38	19	9/21/2006 11:24
38.1	19	9/21/2006 11:24
38.1	19	9/21/2006 11:24
38	19	9/21/2006 11:24
38.2	19	9/21/2006 11:24
38.1	19	9/21/2006 11:24
37.9	19	9/21/2006 11:24
38	19	9/21/2006 11:24
37.9	19	9/21/2006 11:25
37.9	19	9/21/2006 11:25
38	19	9/21/2006 11:25
38	19	9/21/2006 11:25
38.1	19	9/21/2006 11:25
37.8	19	9/21/2006 11:25
38.3	19	9/21/2006 11:25
38	19	9/21/2006 11:25
38.1	19	9/21/2006 11:25
38	19	9/21/2006 11:25
37.9	19	9/21/2006 11:25
37.6	19	9/21/2006 11:25
38.2	19	9/21/2006 11:25
38.3	19	9/21/2006 11:25
37.8	19	9/21/2006 11:25
37.9	19	9/21/2006 11:25
37.9	19	9/21/2006 11:25
38	19	9/21/2006 11:25

Path Measurement Data Site 4 Path 5		
ppm*m	pathlength	Timestamp (mountain time)
37.8	19	9/21/2006 11:25
37.9	19	9/21/2006 11:25
38	19	9/21/2006 11:25
37.9	19	9/21/2006 11:25
37.9	19	9/21/2006 11:25
38.1	19	9/21/2006 11:25
37.9	19	9/21/2006 11:25
38.2	19	9/21/2006 11:25
37.6	19	9/21/2006 11:25
38.1	19	9/21/2006 11:25
37.8	19	9/21/2006 11:25
38	19	9/21/2006 11:25
38.1	19	9/21/2006 11:25
38.2	19	9/21/2006 11:25
38	19	9/21/2006 11:25
38.2	19	9/21/2006 11:25
37.9	19	9/21/2006 11:26
37.8	19	9/21/2006 11:26
38.1	19	9/21/2006 11:26
38.1	19	9/21/2006 11:26
37.9	19	9/21/2006 11:26
38	19	9/21/2006 11:26
37.9	19	9/21/2006 11:26
38	19	9/21/2006 11:26
37.9	19	9/21/2006 11:26
38.3	19	9/21/2006 11:26
37.9	19	9/21/2006 11:26
38	19	9/21/2006 11:26
37.9	19	9/21/2006 11:26
42	19	9/21/2006 11:26
377	19	9/21/2006 11:26
649	19	9/21/2006 11:26
183	19	9/21/2006 11:26
217	19	9/21/2006 11:26
211	19	9/21/2006 11:26
230	19	9/21/2006 11:26
1253	19	9/21/2006 11:26
306	19	9/21/2006 11:26
158	19	9/21/2006 11:26
135	19	9/21/2006 11:26
114	19	9/21/2006 11:26
95.8	19	9/21/2006 11:26
90	19	9/21/2006 11:26
88.2	19	9/21/2006 11:26
330	19	9/21/2006 11:26
842	19	9/21/2006 11:26
114	19	9/21/2006 11:26
82.4	19	9/21/2006 11:26
220	19	9/21/2006 11:26
317	19	9/21/2006 11:26
231	19	9/21/2006 11:27
173	19	9/21/2006 11:27
130	19	9/21/2006 11:27
94.3	19	9/21/2006 11:27
66.4	19	9/21/2006 11:27
62.7	19	9/21/2006 11:27
62.5	19	9/21/2006 11:27
64.6	19	9/21/2006 11:27
62.6	19	9/21/2006 11:27
67.6	19	9/21/2006 11:27
63.4	19	9/21/2006 11:27

Path Measurement Data Site 4 Path 5		
ppm*m	pathlength	Timestamp (mountain time)
62.8	19	9/21/2006 11:27
70.9	19	9/21/2006 11:27
64.6	19	9/21/2006 11:27
62.7	19	9/21/2006 11:27
63.2	19	9/21/2006 11:27
59.1	19	9/21/2006 11:27
51.8	19	9/21/2006 11:27
52.6	19	9/21/2006 11:27
48.5	19	9/21/2006 11:27
43.6	19	9/21/2006 11:27
41.6	19	9/21/2006 11:27
40.5	19	9/21/2006 11:27
40.3	19	9/21/2006 11:27
40.5	19	9/21/2006 11:27
39.4	19	9/21/2006 11:27
38	19	9/21/2006 11:27
38	19	9/21/2006 11:27
38	19	9/21/2006 11:27
37.9	19	9/21/2006 11:27
37.8	19	9/21/2006 11:27
38	19	9/21/2006 11:27
38	19	9/21/2006 11:27
40.2	19	9/21/2006 11:27
40.4	19	9/21/2006 11:28
39.6	19	9/21/2006 11:28
41.2	19	9/21/2006 11:28
40	19	9/21/2006 11:28
38.3	19	9/21/2006 11:28
38	19	9/21/2006 11:28
37.9	19	9/21/2006 11:28
38.2	19	9/21/2006 11:28
38.1	19	9/21/2006 11:28
37.8	19	9/21/2006 11:28
37.8	19	9/21/2006 11:28
38	19	9/21/2006 11:28
37.9	19	9/21/2006 11:28
37.9	19	9/21/2006 11:28
38.2	19	9/21/2006 11:28
37.8	19	9/21/2006 11:28
37.8	19	9/21/2006 11:28
38	19	9/21/2006 11:28
38	19	9/21/2006 11:28
37.9	19	9/21/2006 11:28
38.2	19	9/21/2006 11:28
38	19	9/21/2006 11:28
38.1	19	9/21/2006 11:28
38.1	19	9/21/2006 11:28
38.3	19	9/21/2006 11:28
38	19	9/21/2006 11:28
38.1	19	9/21/2006 11:28
38.3	19	9/21/2006 11:28
38.1	19	9/21/2006 11:28
37.6	19	9/21/2006 11:28
38.2	19	9/21/2006 11:28
38.1	19	9/21/2006 11:28
37.8	19	9/21/2006 11:28
38.2	19	9/21/2006 11:28
38	19	9/21/2006 11:29
38	19	9/21/2006 11:29
37.8	19	9/21/2006 11:29
37.8	19	9/21/2006 11:29

Path Measurement Data Site 4 Path 5		
ppm*m	pathlength	Timestamp (mountain time)
38	19	9/21/2006 11:29
37.9	19	9/21/2006 11:29
38.1	19	9/21/2006 11:29
38.1	19	9/21/2006 11:29
38.1	19	9/21/2006 11:29
38.1	19	9/21/2006 11:29
38.1	19	9/21/2006 11:29
38	19	9/21/2006 11:29
37.7	19	9/21/2006 11:29
38.1	19	9/21/2006 11:29
37.9	19	9/21/2006 11:29
37.9	19	9/21/2006 11:29
37.9	19	9/21/2006 11:29
37.9	19	9/21/2006 11:29
38.1	19	9/21/2006 11:29
38.2	19	9/21/2006 11:29
38.4	19	9/21/2006 11:29
38.2	19	9/21/2006 11:29
38.2	19	9/21/2006 11:29
38.1	19	9/21/2006 11:29
38	19	9/21/2006 11:29
38	19	9/21/2006 11:29
38.4	19	9/21/2006 11:29
38.3	19	9/21/2006 11:29
38	19	9/21/2006 11:29
38.1	19	9/21/2006 11:29
38.3	19	9/21/2006 11:29
38	19	9/21/2006 11:29
38	19	9/21/2006 11:29
38.1	19	9/21/2006 11:30
38.1	19	9/21/2006 11:30
38.2	19	9/21/2006 11:30
38.1	19	9/21/2006 11:30
37.8	19	9/21/2006 11:30
37.9	19	9/21/2006 11:30
38.1	19	9/21/2006 11:30
38.1	19	9/21/2006 11:30
38.2	19	9/21/2006 11:30
38.1	19	9/21/2006 11:30
38.1	19	9/21/2006 11:30
38.3	19	9/21/2006 11:30
38.1	19	9/21/2006 11:30
38.1	19	9/21/2006 11:30
38.2	19	9/21/2006 11:30
38.1	19	9/21/2006 11:30
37.9	19	9/21/2006 11:30
38.1	19	9/21/2006 11:30
38.2	19	9/21/2006 11:30
38.1	19	9/21/2006 11:30
38.1	19	9/21/2006 11:30
38.1	19	9/21/2006 11:30
37.9	19	9/21/2006 11:30
37.9	19	9/21/2006 11:30
38	19	9/21/2006 11:30
38.3	19	9/21/2006 11:30
38.2	19	9/21/2006 11:30
37.9	19	9/21/2006 11:30
38.3	19	9/21/2006 11:30
38.2	19	9/21/2006 11:30
37.9	19	9/21/2006 11:30
38.3	19	9/21/2006 11:30



Path Measurement Data Site 4 Path 5		
ppm*m	pathlength	Timestamp (mountain time)
37.5	19	9/21/2006 11:30
38.2	19	9/21/2006 11:30
37.9	19	9/21/2006 11:31
38.3	19	9/21/2006 11:31
38.2	19	9/21/2006 11:31
38.4	19	9/21/2006 11:31
38.1	19	9/21/2006 11:31
38.2	19	9/21/2006 11:31
37.9	19	9/21/2006 11:31
38.2	19	9/21/2006 11:31
38.3	19	9/21/2006 11:31
38.5	19	9/21/2006 11:31
38.2	19	9/21/2006 11:31
38.4	19	9/21/2006 11:31
38.1	19	9/21/2006 11:31
38.1	19	9/21/2006 11:31
38.4	19	9/21/2006 11:31
38.1	19	9/21/2006 11:31
38	19	9/21/2006 11:31
38.1	19	9/21/2006 11:31
38.2	19	9/21/2006 11:31
38.4	19	9/21/2006 11:31
38.2	19	9/21/2006 11:31
37.7	19	9/21/2006 11:31
38	19	9/21/2006 11:31
38.4	19	9/21/2006 11:31
38.4	19	9/21/2006 11:31
37.9	19	9/21/2006 11:31
37.9	19	9/21/2006 11:31
38.1	19	9/21/2006 11:31
38.3	19	9/21/2006 11:31
38.4	19	9/21/2006 11:31
38.3	19	9/21/2006 11:31
38.4	19	9/21/2006 11:31
38.2	19	9/21/2006 11:31
38.2	19	9/21/2006 11:31
37.9	19	9/21/2006 11:31
38.4	19	9/21/2006 11:32
38	19	9/21/2006 11:32
38.2	19	9/21/2006 11:32
38.1	19	9/21/2006 11:32
38	19	9/21/2006 11:32
38.2	19	9/21/2006 11:32
38	19	9/21/2006 11:32
38.5	19	9/21/2006 11:32
38.4	19	9/21/2006 11:32
38.1	19	9/21/2006 11:32
38.1	19	9/21/2006 11:32
38	19	9/21/2006 11:32
38.1	19	9/21/2006 11:32
38.6	19	9/21/2006 11:32
38.2	19	9/21/2006 11:32
38.5	19	9/21/2006 11:32
38.3	19	9/21/2006 11:32
38.3	19	9/21/2006 11:32
37.9	19	9/21/2006 11:32
38	19	9/21/2006 11:32
38.5	19	9/21/2006 11:32
38.3	19	9/21/2006 11:32
38.5	19	9/21/2006 11:32
37.9	19	9/21/2006 11:32

Path Measurement Data Site 4 Path 5		
ppm*m	pathlength	Timestamp (mountain time)
38.4	19	9/21/2006 11:32
38.1	19	9/21/2006 11:32
37.9	19	9/21/2006 11:32
38.1	19	9/21/2006 11:32
38.2	19	9/21/2006 11:32
38.2	19	9/21/2006 11:32
38	19	9/21/2006 11:32
38	19	9/21/2006 11:32
38.4	19	9/21/2006 11:32
38.1	19	9/21/2006 11:32
38.3	19	9/21/2006 11:33
38.2	19	9/21/2006 11:33
38.1	19	9/21/2006 11:33
37.8	19	9/21/2006 11:33
38.3	19	9/21/2006 11:33
38.3	19	9/21/2006 11:33
38.2	19	9/21/2006 11:33
38	19	9/21/2006 11:33
38.2	19	9/21/2006 11:33
38.4	19	9/21/2006 11:33
38.4	19	9/21/2006 11:33
38.3	19	9/21/2006 11:33
38.2	19	9/21/2006 11:33
38.2	19	9/21/2006 11:33
38.5	19	9/21/2006 11:33
38.1	19	9/21/2006 11:33
38.5	19	9/21/2006 11:33
38.7	19	9/21/2006 11:33
38	19	9/21/2006 11:33
38	19	9/21/2006 11:33
38.2	19	9/21/2006 11:33
38	19	9/21/2006 11:33
38.2	19	9/21/2006 11:33
38.5	19	9/21/2006 11:33
38.2	19	9/21/2006 11:33
38.6	19	9/21/2006 11:33
38.2	19	9/21/2006 11:33
38.3	19	9/21/2006 11:33
38.4	19	9/21/2006 11:33
38.3	19	9/21/2006 11:33
38.2	19	9/21/2006 11:33
38.1	19	9/21/2006 11:33
38.2	19	9/21/2006 11:33
37.9	19	9/21/2006 11:33
38.6	19	9/21/2006 11:34

Path Measurement Data Site 5 Path 1			Path Measurement Data Site 5 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
79.5	15	9/21/2006 13:03	30.7	15	9/21/2006 13:22
93.5	15	9/21/2006 13:03	30.6	15	9/21/2006 13:22
68.8	15	9/21/2006 13:03	39.5	15	9/21/2006 13:22
47.3	15	9/21/2006 13:03	35.9	15	9/21/2006 13:22
36.1	15	9/21/2006 13:03	32.7	15	9/21/2006 13:22
32.5	15	9/21/2006 13:03	36.6	15	9/21/2006 13:22
30.7	15	9/21/2006 13:03	41.8	15	9/21/2006 13:22
31.2	15	9/21/2006 13:03	80.7	15	9/21/2006 13:22
30.8	15	9/21/2006 13:04	87.8	15	9/21/2006 13:22
29.8	15	9/21/2006 13:04	74.2	15	9/21/2006 13:22
29	15	9/21/2006 13:04	74.3	15	9/21/2006 13:22
29.2	15	9/21/2006 13:04	65	15	9/21/2006 13:22
29.2	15	9/21/2006 13:04	45.2	15	9/21/2006 13:22
29.1	15	9/21/2006 13:04	53	15	9/21/2006 13:22
28.4	15	9/21/2006 13:04	61.4	15	9/21/2006 13:22
28.1	15	9/21/2006 13:04	51.8	15	9/21/2006 13:23
28	15	9/21/2006 13:04	41.8	15	9/21/2006 13:23
27.9	15	9/21/2006 13:04	36.4	15	9/21/2006 13:23
27.8	15	9/21/2006 13:04	33.6	15	9/21/2006 13:23
28	15	9/21/2006 13:04	35.4	15	9/21/2006 13:23
27.8	15	9/21/2006 13:04	35.2	15	9/21/2006 13:23
27.8	15	9/21/2006 13:04	35.3	15	9/21/2006 13:23
27.8	15	9/21/2006 13:04	33.2	15	9/21/2006 13:23
27.8	15	9/21/2006 13:04	32.4	15	9/21/2006 13:23
27.7	15	9/21/2006 13:04	34.3	15	9/21/2006 13:23
27.6	15	9/21/2006 13:04	36.5	15	9/21/2006 13:23
27.6	15	9/21/2006 13:04	34	15	9/21/2006 13:23
27.4	15	9/21/2006 13:04	33.5	15	9/21/2006 13:23
27.7	15	9/21/2006 13:04	34.3	15	9/21/2006 13:23
27.5	15	9/21/2006 13:04	35	15	9/21/2006 13:23
27.5	15	9/21/2006 13:04	37.1	15	9/21/2006 13:23
27.6	15	9/21/2006 13:04	35.4	15	9/21/2006 13:23
27.6	15	9/21/2006 13:04	35.7	15	9/21/2006 13:23
27.6	15	9/21/2006 13:04	37.9	15	9/21/2006 13:23
27.5	15	9/21/2006 13:04	36.7	15	9/21/2006 13:23
27.7	15	9/21/2006 13:04	41.3	15	9/21/2006 13:23
27.5	15	9/21/2006 13:04	39.8	15	9/21/2006 13:23
27.5	15	9/21/2006 13:04	36.4	15	9/21/2006 13:23
27.4	15	9/21/2006 13:04	33.8	15	9/21/2006 13:23
27.6	15	9/21/2006 13:04	34.1	15	9/21/2006 13:23
27.6	15	9/21/2006 13:04	33.1	15	9/21/2006 13:23
27.7	15	9/21/2006 13:04	32.4	15	9/21/2006 13:23
27.7	15	9/21/2006 13:04	31.1	15	9/21/2006 13:23
27.6	15	9/21/2006 13:05	30.5	15	9/21/2006 13:23
27.6	15	9/21/2006 13:05	30.4	15	9/21/2006 13:23
28.9	15	9/21/2006 13:05	30.5	15	9/21/2006 13:23
50	15	9/21/2006 13:05	30.4	15	9/21/2006 13:23
60.7	15	9/21/2006 13:05	30.5	15	9/21/2006 13:23
44.3	15	9/21/2006 13:05	30.5	15	9/21/2006 13:23
48.6	15	9/21/2006 13:05	30.5	15	9/21/2006 13:23
76	15	9/21/2006 13:05	30.5	15	9/21/2006 13:24
79.7	15	9/21/2006 13:05	30.7	15	9/21/2006 13:24
58.9	15	9/21/2006 13:05	30.8	15	9/21/2006 13:24
56.9	15	9/21/2006 13:05	30.9	15	9/21/2006 13:24
36.7	15	9/21/2006 13:05	30.8	15	9/21/2006 13:24

Path Measurement Data Site 5 Path 1			Path Measurement Data Site 5 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
63.9	15	9/21/2006 13:05	30.6	15	9/21/2006 13:24
87.5	15	9/21/2006 13:05	30.6	15	9/21/2006 13:24
90.9	15	9/21/2006 13:05	30.6	15	9/21/2006 13:24
55.2	15	9/21/2006 13:05	30.7	15	9/21/2006 13:24
56.7	15	9/21/2006 13:05	30.6	15	9/21/2006 13:24
98.1	15	9/21/2006 13:05	30.6	15	9/21/2006 13:24
60.3	15	9/21/2006 13:05	30.8	15	9/21/2006 13:24
55.7	15	9/21/2006 13:05	30.7	15	9/21/2006 13:24
53.9	15	9/21/2006 13:05	30.6	15	9/21/2006 13:24
55.2	15	9/21/2006 13:05	30.4	15	9/21/2006 13:24
44.1	15	9/21/2006 13:05	30.5	15	9/21/2006 13:24
111	15	9/21/2006 13:05	30.7	15	9/21/2006 13:24
79.6	15	9/21/2006 13:05	30.5	15	9/21/2006 13:24
96.9	15	9/21/2006 13:05	30.6	15	9/21/2006 13:24
92.8	15	9/21/2006 13:05	57.8	15	9/21/2006 13:24
53	15	9/21/2006 13:05	124	15	9/21/2006 13:24
36.7	15	9/21/2006 13:05	45.4	15	9/21/2006 13:24
82.8	15	9/21/2006 13:05	39	15	9/21/2006 13:24
54.6	15	9/21/2006 13:05	36.9	15	9/21/2006 13:24
41.5	15	9/21/2006 13:05	32.6	15	9/21/2006 13:24
35.2	15	9/21/2006 13:05	35.9	15	9/21/2006 13:24
31.2	15	9/21/2006 13:06	32.8	15	9/21/2006 13:24
31.8	15	9/21/2006 13:06	30.6	15	9/21/2006 13:24
30.7	15	9/21/2006 13:06	31	15	9/21/2006 13:24
30.7	15	9/21/2006 13:06	31.4	15	9/21/2006 13:24
28.2	15	9/21/2006 13:06	34.5	15	9/21/2006 13:24
28.2	15	9/21/2006 13:06	53	15	9/21/2006 13:24
27.8	15	9/21/2006 13:06	48.3	15	9/21/2006 13:24
28.4	15	9/21/2006 13:06	45	15	9/21/2006 13:24
27.9	15	9/21/2006 13:06	51	15	9/21/2006 13:25
27.8	15	9/21/2006 13:06	50	15	9/21/2006 13:25
28.8	15	9/21/2006 13:06	54.3	15	9/21/2006 13:25
28.8	15	9/21/2006 13:06	37.3	15	9/21/2006 13:25
28.3	15	9/21/2006 13:06	31.1	15	9/21/2006 13:25
30.1	15	9/21/2006 13:06	30.6	15	9/21/2006 13:25
40.8	15	9/21/2006 13:06	30.9	15	9/21/2006 13:25
44.6	15	9/21/2006 13:06	32	15	9/21/2006 13:25
75.6	15	9/21/2006 13:06	32.8	15	9/21/2006 13:25
124	15	9/21/2006 13:06	30.9	15	9/21/2006 13:25
103	15	9/21/2006 13:06	30.6	15	9/21/2006 13:25
75.5	15	9/21/2006 13:06	30.8	15	9/21/2006 13:25
83.3	15	9/21/2006 13:06	30.6	15	9/21/2006 13:25
62.5	15	9/21/2006 13:06	30.4	15	9/21/2006 13:25
43.2	15	9/21/2006 13:06	30.4	15	9/21/2006 13:25
51.5	15	9/21/2006 13:06	30.4	15	9/21/2006 13:25
33.5	15	9/21/2006 13:06	30.9	15	9/21/2006 13:25
33.4	15	9/21/2006 13:06	30.7	15	9/21/2006 13:25
42.6	15	9/21/2006 13:06	30.9	15	9/21/2006 13:25
42.8	15	9/21/2006 13:06	30.8	15	9/21/2006 13:25
51.2	15	9/21/2006 13:06	30.8	15	9/21/2006 13:25
54.1	15	9/21/2006 13:06	30.9	15	9/21/2006 13:25
47.2	15	9/21/2006 13:06	30.7	15	9/21/2006 13:25
38.5	15	9/21/2006 13:06	30.9	15	9/21/2006 13:25
40.1	15	9/21/2006 13:06	30.7	15	9/21/2006 13:25
43.7	15	9/21/2006 13:06	30.9	15	9/21/2006 13:25

Path Measurement Data Site 5 Path 1			Path Measurement Data Site 5 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
53.9	15	9/21/2006 13:07	30.8	15	9/21/2006 13:25
74.6	15	9/21/2006 13:07	31	15	9/21/2006 13:25
81.7	15	9/21/2006 13:07	30.6	15	9/21/2006 13:25
45.6	15	9/21/2006 13:07	30.9	15	9/21/2006 13:25
31.3	15	9/21/2006 13:07	30.8	15	9/21/2006 13:25
48.1	15	9/21/2006 13:07	30.6	15	9/21/2006 13:25
36.8	15	9/21/2006 13:07	30.9	15	9/21/2006 13:25
35	15	9/21/2006 13:07	30.7	15	9/21/2006 13:25
50.6	15	9/21/2006 13:07	30.9	15	9/21/2006 13:26
107	15	9/21/2006 13:07	30.7	15	9/21/2006 13:26
99.5	15	9/21/2006 13:07	30.8	15	9/21/2006 13:26
78.5	15	9/21/2006 13:07	31	15	9/21/2006 13:26
54.3	15	9/21/2006 13:07	53.1	15	9/21/2006 13:26
55.8	15	9/21/2006 13:07	64	15	9/21/2006 13:26
34.8	15	9/21/2006 13:07	47.4	15	9/21/2006 13:26
33.5	15	9/21/2006 13:07	31.7	15	9/21/2006 13:26
54.1	15	9/21/2006 13:07	31.2	15	9/21/2006 13:26
41.4	15	9/21/2006 13:07	30.7	15	9/21/2006 13:26
36.8	15	9/21/2006 13:07	30.7	15	9/21/2006 13:26
41.6	15	9/21/2006 13:07	30.9	15	9/21/2006 13:26
38.5	15	9/21/2006 13:07	30.6	15	9/21/2006 13:26
33.6	15	9/21/2006 13:07	30.6	15	9/21/2006 13:26
36.9	15	9/21/2006 13:07	30.7	15	9/21/2006 13:26
32	15	9/21/2006 13:07	30.8	15	9/21/2006 13:26
28.3	15	9/21/2006 13:07	30.8	15	9/21/2006 13:26
28	15	9/21/2006 13:07	30.7	15	9/21/2006 13:26
28.1	15	9/21/2006 13:07	30.7	15	9/21/2006 13:26
29.5	15	9/21/2006 13:07	30.8	15	9/21/2006 13:26
33.9	15	9/21/2006 13:07	30.9	15	9/21/2006 13:26
46.1	15	9/21/2006 13:07	30.7	15	9/21/2006 13:26
32.4	15	9/21/2006 13:07	30.9	15	9/21/2006 13:26
35.7	15	9/21/2006 13:07	30.9	15	9/21/2006 13:26
36.7	15	9/21/2006 13:07	30.8	15	9/21/2006 13:26
40.5	15	9/21/2006 13:07	30.8	15	9/21/2006 13:26
32.2	15	9/21/2006 13:07	30.9	15	9/21/2006 13:26
40.1	15	9/21/2006 13:08	30.8	15	9/21/2006 13:26
36.2	15	9/21/2006 13:08	30.9	15	9/21/2006 13:26
32.5	15	9/21/2006 13:08	30.7	15	9/21/2006 13:26
33.4	15	9/21/2006 13:08	30.9	15	9/21/2006 13:26
31.7	15	9/21/2006 13:08	30.9	15	9/21/2006 13:26
33.3	15	9/21/2006 13:08	31	15	9/21/2006 13:26
34.3	15	9/21/2006 13:08	30.9	15	9/21/2006 13:26
31.6	15	9/21/2006 13:08	30.8	15	9/21/2006 13:27
29.3	15	9/21/2006 13:08	30.8	15	9/21/2006 13:27
30.1	15	9/21/2006 13:08	31	15	9/21/2006 13:27
30.5	15	9/21/2006 13:08	30.9	15	9/21/2006 13:27
32.9	15	9/21/2006 13:08	31.1	15	9/21/2006 13:27
31	15	9/21/2006 13:08	31.2	15	9/21/2006 13:27
30.6	15	9/21/2006 13:08	31	15	9/21/2006 13:27
27.9	15	9/21/2006 13:08	31	15	9/21/2006 13:27
27.8	15	9/21/2006 13:08	31.1	15	9/21/2006 13:27
29.5	15	9/21/2006 13:08	31	15	9/21/2006 13:27
31.5	15	9/21/2006 13:08	31	15	9/21/2006 13:27
35.3	15	9/21/2006 13:08	31.1	15	9/21/2006 13:27
41	15	9/21/2006 13:08	31.2	15	9/21/2006 13:27

Path Measurement Data Site 5 Path 1			Path Measurement Data Site 5 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
41.2	15	9/21/2006 13:08	31.2	15	9/21/2006 13:27
39.7	15	9/21/2006 13:08	30.9	15	9/21/2006 13:27
38.3	15	9/21/2006 13:08	31	15	9/21/2006 13:27
50.1	15	9/21/2006 13:08	31	15	9/21/2006 13:27
42.8	15	9/21/2006 13:08	30.8	15	9/21/2006 13:27
44.4	15	9/21/2006 13:08	31	15	9/21/2006 13:27
36	15	9/21/2006 13:08	31	15	9/21/2006 13:27
36.8	15	9/21/2006 13:08	31	15	9/21/2006 13:27
32.8	15	9/21/2006 13:08	30.7	15	9/21/2006 13:27
45.4	15	9/21/2006 13:08	31	15	9/21/2006 13:27
28.8	15	9/21/2006 13:09	31	15	9/21/2006 13:27
31.6	15	9/21/2006 13:10	30.9	15	9/21/2006 13:27
31.1	15	9/21/2006 13:10	31	15	9/21/2006 13:27
31.5	15	9/21/2006 13:10	30.9	15	9/21/2006 13:27
33.4	15	9/21/2006 13:10	31	15	9/21/2006 13:27
30.4	15	9/21/2006 13:10	31.1	15	9/21/2006 13:27
32	15	9/21/2006 13:10	30.9	15	9/21/2006 13:27
32.2	15	9/21/2006 13:10	31	15	9/21/2006 13:27
29.8	15	9/21/2006 13:10	30.8	15	9/21/2006 13:27
30.5	15	9/21/2006 13:10	30.8	15	9/21/2006 13:27
28.6	15	9/21/2006 13:10	31.1	15	9/21/2006 13:27
30.3	15	9/21/2006 13:10	31	15	9/21/2006 13:27
32	15	9/21/2006 13:10	31	15	9/21/2006 13:28
32.5	15	9/21/2006 13:10	31.1	15	9/21/2006 13:28
31.3	15	9/21/2006 13:10	31	15	9/21/2006 13:28
29.5	15	9/21/2006 13:10	31	15	9/21/2006 13:28
32.2	15	9/21/2006 13:10	30.9	15	9/21/2006 13:28
32.4	15	9/21/2006 13:10	31.2	15	9/21/2006 13:28
31.6	15	9/21/2006 13:10	31	15	9/21/2006 13:28
29.6	15	9/21/2006 13:10	31.1	15	9/21/2006 13:28
29.3	15	9/21/2006 13:10	30.9	15	9/21/2006 13:28
28.9	15	9/21/2006 13:10	30.9	15	9/21/2006 13:28
31.7	15	9/21/2006 13:10	30.9	15	9/21/2006 13:28
30	15	9/21/2006 13:10	31	15	9/21/2006 13:28
27.8	15	9/21/2006 13:10	31	15	9/21/2006 13:28
27.7	15	9/21/2006 13:10	30.9	15	9/21/2006 13:28
27.8	15	9/21/2006 13:10	30.9	15	9/21/2006 13:28
29.7	15	9/21/2006 13:10	30.7	15	9/21/2006 13:28
39.9	15	9/21/2006 13:10	30.8	15	9/21/2006 13:28
36.3	15	9/21/2006 13:10	31	15	9/21/2006 13:28
41.6	15	9/21/2006 13:10	30.9	15	9/21/2006 13:28
69.2	15	9/21/2006 13:10	30.7	15	9/21/2006 13:28
89.6	15	9/21/2006 13:10	30.8	15	9/21/2006 13:28
89.6	15	9/21/2006 13:10	30.8	15	9/21/2006 13:28
59.8	15	9/21/2006 13:10	30.9	15	9/21/2006 13:28
29.5	15	9/21/2006 13:11	30.9	15	9/21/2006 13:28
30	15	9/21/2006 13:11	30.8	15	9/21/2006 13:28
30.1	15	9/21/2006 13:11	31	15	9/21/2006 13:28
38.6	15	9/21/2006 13:11	31.2	15	9/21/2006 13:28
28.6	15	9/21/2006 13:11	33.6	15	9/21/2006 13:28
29.3	15	9/21/2006 13:11	54.5	15	9/21/2006 13:28
29.7	15	9/21/2006 13:11	65.9	15	9/21/2006 13:28
31	15	9/21/2006 13:11	74.5	15	9/21/2006 13:28
29.6	15	9/21/2006 13:11	100	15	9/21/2006 13:28
30.3	15	9/21/2006 13:11	109	15	9/21/2006 13:28

Path Measurement Data Site 5 Path 1			Path Measurement Data Site 5 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
30	15	9/21/2006 13:11	88.3	15	9/21/2006 13:28
31.8	15	9/21/2006 13:11	141	15	9/21/2006 13:29
32.2	15	9/21/2006 13:11	171	15	9/21/2006 13:29
30.5	15	9/21/2006 13:11	157	15	9/21/2006 13:29
32.3	15	9/21/2006 13:11	72.9	15	9/21/2006 13:29
28.5	15	9/21/2006 13:11	91.3	15	9/21/2006 13:29
28.5	15	9/21/2006 13:11	62.5	15	9/21/2006 13:29
29.4	15	9/21/2006 13:11	67.5	15	9/21/2006 13:29
31	15	9/21/2006 13:11	90.8	15	9/21/2006 13:29
31.9	15	9/21/2006 13:11	104	15	9/21/2006 13:29
30.1	15	9/21/2006 13:11	82.4	15	9/21/2006 13:29
28.5	15	9/21/2006 13:11	65.3	15	9/21/2006 13:29
27.7	15	9/21/2006 13:11	56.1	15	9/21/2006 13:29
28.2	15	9/21/2006 13:11	40.2	15	9/21/2006 13:29
31.4	15	9/21/2006 13:11	50.6	15	9/21/2006 13:29
32.4	15	9/21/2006 13:11	67.9	15	9/21/2006 13:29
31	15	9/21/2006 13:11	134	15	9/21/2006 13:29
32.6	15	9/21/2006 13:11	109	15	9/21/2006 13:29
30.3	15	9/21/2006 13:11	122	15	9/21/2006 13:29
30.3	15	9/21/2006 13:11	110	15	9/21/2006 13:29
31.4	15	9/21/2006 13:11	116	15	9/21/2006 13:29
29	15	9/21/2006 13:11	125	15	9/21/2006 13:29
31.2	15	9/21/2006 13:11	173	15	9/21/2006 13:29
28.4	15	9/21/2006 13:11	172	15	9/21/2006 13:29
31.2	15	9/21/2006 13:12	129	15	9/21/2006 13:29
31.4	15	9/21/2006 13:12	96.6	15	9/21/2006 13:29
31.3	15	9/21/2006 13:12	84.5	15	9/21/2006 13:29
31.4	15	9/21/2006 13:12	91.7	15	9/21/2006 13:29
30.5	15	9/21/2006 13:12	91.4	15	9/21/2006 13:29
29.5	15	9/21/2006 13:12	182	15	9/21/2006 13:29
30.3	15	9/21/2006 13:12	110	15	9/21/2006 13:29
31.3	15	9/21/2006 13:12	109	15	9/21/2006 13:29
28.4	15	9/21/2006 13:12	73.8	15	9/21/2006 13:29
29.7	15	9/21/2006 13:12	80	15	9/21/2006 13:29
27.7	15	9/21/2006 13:12	83.1	15	9/21/2006 13:29
28.3	15	9/21/2006 13:12	154	15	9/21/2006 13:30
31.5	15	9/21/2006 13:12	67.6	15	9/21/2006 13:30
30.5	15	9/21/2006 13:12	85.2	15	9/21/2006 13:30
30.5	15	9/21/2006 13:12	106	15	9/21/2006 13:30
30.5	15	9/21/2006 13:12	38.1	15	9/21/2006 13:30
30.4	15	9/21/2006 13:12	46.9	15	9/21/2006 13:30
30.1	15	9/21/2006 13:12	49.8	15	9/21/2006 13:30
31.2	15	9/21/2006 13:12	69.4	15	9/21/2006 13:30
29.8	15	9/21/2006 13:12	36.2	15	9/21/2006 13:30
30.2	15	9/21/2006 13:12	45.7	15	9/21/2006 13:30
30.1	15	9/21/2006 13:12	33.5	15	9/21/2006 13:30
29.5	15	9/21/2006 13:12	44	15	9/21/2006 13:30
30.4	15	9/21/2006 13:12	40.4	15	9/21/2006 13:30
28.2	15	9/21/2006 13:12	54.8	15	9/21/2006 13:30
27.6	15	9/21/2006 13:12	85.1	15	9/21/2006 13:30
28.2	15	9/21/2006 13:12	86.8	15	9/21/2006 13:30
32.5	15	9/21/2006 13:12	55.8	15	9/21/2006 13:30
56.5	15	9/21/2006 13:12	39.4	15	9/21/2006 13:30
48.3	15	9/21/2006 13:12	40.4	15	9/21/2006 13:30
35.1	15	9/21/2006 13:12	37.7	15	9/21/2006 13:30

Path Measurement Data Site 5 Path 1			Path Measurement Data Site 5 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
39.2	15	9/21/2006 13:12	76.1	15	9/21/2006 13:30
37.4	15	9/21/2006 13:12	80.8	15	9/21/2006 13:30
30.4	15	9/21/2006 13:12	48.2	15	9/21/2006 13:30
29.3	15	9/21/2006 13:13	60.3	15	9/21/2006 13:30
33.1	15	9/21/2006 13:13	82.5	15	9/21/2006 13:30
29.9	15	9/21/2006 13:13			
28.6	15	9/21/2006 13:13			
28.1	15	9/21/2006 13:13			
27.7	15	9/21/2006 13:13			
28.3	15	9/21/2006 13:13			
35.4	15	9/21/2006 13:13			
37.4	15	9/21/2006 13:13			
36.4	15	9/21/2006 13:13			
52.4	15	9/21/2006 13:13			
76.2	15	9/21/2006 13:13			
36.6	15	9/21/2006 13:13			
29.7	15	9/21/2006 13:13			
90.9	15	9/21/2006 13:13			
55.5	15	9/21/2006 13:13			
28.9	15	9/21/2006 13:13			
28.9	15	9/21/2006 13:13			
30.1	15	9/21/2006 13:13			
38.8	15	9/21/2006 13:13			
80.4	15	9/21/2006 13:13			
66.8	15	9/21/2006 13:13			
62.5	15	9/21/2006 13:13			
36.4	15	9/21/2006 13:13			
38.4	15	9/21/2006 13:13			
45.8	15	9/21/2006 13:13			
33.7	15	9/21/2006 13:13			
37	15	9/21/2006 13:13			
108	15	9/21/2006 13:13			
40.5	15	9/21/2006 13:13			
34	15	9/21/2006 13:13			
33.1	15	9/21/2006 13:13			
43.4	15	9/21/2006 13:13			
37.3	15	9/21/2006 13:13			
33.4	15	9/21/2006 13:14			
33.9	15	9/21/2006 13:14			
35.9	15	9/21/2006 13:14			
30.5	15	9/21/2006 13:14			
31.8	15	9/21/2006 13:14			
28.9	15	9/21/2006 13:14			
29.5	15	9/21/2006 13:14			
29.2	15	9/21/2006 13:14			
30.7	15	9/21/2006 13:14			
31.2	15	9/21/2006 13:14			
31.7	15	9/21/2006 13:14			
29.4	15	9/21/2006 13:14			
39.8	15	9/21/2006 13:14			
130	15	9/21/2006 13:14			
39.7	15	9/21/2006 13:14			
48.7	15	9/21/2006 13:14			
30	15	9/21/2006 13:14			
30	15	9/21/2006 13:14			



Path Measurement Data Site 5 Path 1			Path Measurement Data Site 5 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
29.8	15	9/21/2006 13:14			
29.8	15	9/21/2006 13:14			
35.4	15	9/21/2006 13:14			
40.1	15	9/21/2006 13:14			
36.4	15	9/21/2006 13:14			
44.8	15	9/21/2006 13:14			
49.4	15	9/21/2006 13:14			
40.6	15	9/21/2006 13:14			
54.4	15	9/21/2006 13:14			
70.6	15	9/21/2006 13:14			
174	15	9/21/2006 13:14			
231	15	9/21/2006 13:14			
214	15	9/21/2006 13:14			
269	15	9/21/2006 13:14			
132	15	9/21/2006 13:14			
126	15	9/21/2006 13:14			
117	15	9/21/2006 13:15			
93	15	9/21/2006 13:15			
65.8	15	9/21/2006 13:15			
107	15	9/21/2006 13:15			
109	15	9/21/2006 13:15			
83.3	15	9/21/2006 13:15			
80.6	15	9/21/2006 13:15			
56	15	9/21/2006 13:15			
66.4	15	9/21/2006 13:15			
73.3	15	9/21/2006 13:15			
57.7	15	9/21/2006 13:15			
39.4	15	9/21/2006 13:15			
36.7	15	9/21/2006 13:15			
44.2	15	9/21/2006 13:15			
45.7	15	9/21/2006 13:15			
37.4	15	9/21/2006 13:15			
43.7	15	9/21/2006 13:15			
53.3	15	9/21/2006 13:15			
41	15	9/21/2006 13:15			
40.3	15	9/21/2006 13:15			
36.7	15	9/21/2006 13:15			
39.8	15	9/21/2006 13:15			
38.3	15	9/21/2006 13:15			
41.8	15	9/21/2006 13:15			
78.2	15	9/21/2006 13:15			
180	15	9/21/2006 13:15			
59.2	15	9/21/2006 13:15			
32.2	15	9/21/2006 13:15			
35.3	15	9/21/2006 13:15			
34.5	15	9/21/2006 13:15			
31.6	15	9/21/2006 13:15			
31.3	15	9/21/2006 13:15			
31.2	15	9/21/2006 13:15			
61.1	15	9/21/2006 13:15			
42.4	15	9/21/2006 13:16			
62.4	15	9/21/2006 13:16			
54.7	15	9/21/2006 13:16			
50.6	15	9/21/2006 13:16			
39.2	15	9/21/2006 13:16			

Path Measurement Data Site 5 Path 1			Path Measurement Data Site 5 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
32.7	15	9/21/2006 13:16			
33.9	15	9/21/2006 13:16			
33.3	15	9/21/2006 13:16			
29.3	15	9/21/2006 13:16			
29.3	15	9/21/2006 13:16			
28.9	15	9/21/2006 13:16			
28.8	15	9/21/2006 13:16			
28.5	15	9/21/2006 13:16			
28.7	15	9/21/2006 13:16			
28.9	15	9/21/2006 13:16			
31.6	15	9/21/2006 13:16			
32.2	15	9/21/2006 13:16			
30.2	15	9/21/2006 13:16			
35.6	15	9/21/2006 13:16			
44.3	15	9/21/2006 13:16			
97.6	15	9/21/2006 13:16			
62.3	15	9/21/2006 13:16			
141	15	9/21/2006 13:16			
186	15	9/21/2006 13:16			
299	15	9/21/2006 13:16			
162	15	9/21/2006 13:16			
59.7	15	9/21/2006 13:16			
51.7	15	9/21/2006 13:16			
42.1	15	9/21/2006 13:16			
130	15	9/21/2006 13:16			
96	15	9/21/2006 13:16			
43.2	15	9/21/2006 13:16			
48.9	15	9/21/2006 13:16			
51.3	15	9/21/2006 13:16			
57.1	15	9/21/2006 13:16			
69.7	15	9/21/2006 13:17			
82.3	15	9/21/2006 13:17			
99.5	15	9/21/2006 13:17			
118	15	9/21/2006 13:17			
119	15	9/21/2006 13:17			
104	15	9/21/2006 13:17			
108	15	9/21/2006 13:17			
126	15	9/21/2006 13:17			
114	15	9/21/2006 13:17			
96	15	9/21/2006 13:17			
118	15	9/21/2006 13:17			
116	15	9/21/2006 13:17			
107	15	9/21/2006 13:17			
80.5	15	9/21/2006 13:17			
60.4	15	9/21/2006 13:17			
44.5	15	9/21/2006 13:17			
75.8	15	9/21/2006 13:17			
107	15	9/21/2006 13:17			
97.4	15	9/21/2006 13:17			
73.5	15	9/21/2006 13:17			
50.2	15	9/21/2006 13:17			
44	15	9/21/2006 13:17			
42.2	15	9/21/2006 13:17			
49.7	15	9/21/2006 13:17			
69.7	15	9/21/2006 13:17			

Path Measurement Data Site 5 Path 1			Path Measurement Data Site 5 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
78.4	15	9/21/2006 13:17			
63.9	15	9/21/2006 13:17			
57.8	15	9/21/2006 13:17			
71.2	15	9/21/2006 13:17			
53.3	15	9/21/2006 13:17			
37.1	15	9/21/2006 13:17			
32.5	15	9/21/2006 13:17			
34.1	15	9/21/2006 13:17			
35.2	15	9/21/2006 13:17			
45	15	9/21/2006 13:18			
85.4	15	9/21/2006 13:18			
107	15	9/21/2006 13:18			
96.3	15	9/21/2006 13:18			
41.2	15	9/21/2006 13:18			
32.2	15	9/21/2006 13:18			
32.6	15	9/21/2006 13:18			
34.2	15	9/21/2006 13:18			
28.9	15	9/21/2006 13:18			
28.2	15	9/21/2006 13:18			
28	15	9/21/2006 13:18			
28.1	15	9/21/2006 13:18			
27.9	15	9/21/2006 13:18			
28.1	15	9/21/2006 13:18			
28.2	15	9/21/2006 13:18			
28.2	15	9/21/2006 13:18			
28.3	15	9/21/2006 13:18			
28.1	15	9/21/2006 13:18			
28.2	15	9/21/2006 13:18			
28.1	15	9/21/2006 13:18			
28.2	15	9/21/2006 13:18			
28	15	9/21/2006 13:18			
28	15	9/21/2006 13:18			
28.3	15	9/21/2006 13:18			
31.9	15	9/21/2006 13:18			
28.3	15	9/21/2006 13:18			
28.6	15	9/21/2006 13:18			
28.5	15	9/21/2006 13:18			
28.5	15	9/21/2006 13:18			
28.8	15	9/21/2006 13:18			
31.1	15	9/21/2006 13:18			
29.4	15	9/21/2006 13:18			
28.7	15	9/21/2006 13:18			
28.4	15	9/21/2006 13:18			
28.4	15	9/21/2006 13:19			
28.4	15	9/21/2006 13:19			
28.5	15	9/21/2006 13:19			
28.6	15	9/21/2006 13:19			
28.6	15	9/21/2006 13:19			
28.6	15	9/21/2006 13:19			
30.1	15	9/21/2006 13:19			
30.5	15	9/21/2006 13:19			
29.2	15	9/21/2006 13:19			
28.8	15	9/21/2006 13:19			
28.5	15	9/21/2006 13:19			
29.2	15	9/21/2006 13:19			

Path Measurement Data Site 5 Path 1			Path Measurement Data Site 5 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
29.9	15	9/21/2006 13:19			
32.4	15	9/21/2006 13:19			
62.6	15	9/21/2006 13:19			
105	15	9/21/2006 13:19			
104	15	9/21/2006 13:19			
61	15	9/21/2006 13:19			
48.9	15	9/21/2006 13:19			
50.3	15	9/21/2006 13:19			
83.3	15	9/21/2006 13:19			
94	15	9/21/2006 13:19			
89.9	15	9/21/2006 13:19			
82.1	15	9/21/2006 13:19			
75.8	15	9/21/2006 13:19			
78.4	15	9/21/2006 13:19			
70	15	9/21/2006 13:19			
51	15	9/21/2006 13:19			
40.5	15	9/21/2006 13:19			
61.9	15	9/21/2006 13:19			
112	15	9/21/2006 13:19			
81.8	15	9/21/2006 13:19			
84.7	15	9/21/2006 13:19			
108	15	9/21/2006 13:19			
100	15	9/21/2006 13:20			
87.5	15	9/21/2006 13:20			
95.1	15	9/21/2006 13:20			
128	15	9/21/2006 13:20			
118	15	9/21/2006 13:20			
84.3	15	9/21/2006 13:20			
61.2	15	9/21/2006 13:20			
52.7	15	9/21/2006 13:20			
45.8	15	9/21/2006 13:20			
48.9	15	9/21/2006 13:20			
83	15	9/21/2006 13:20			
100	15	9/21/2006 13:20			
50.7	15	9/21/2006 13:20			
32.7	15	9/21/2006 13:20			
30.5	15	9/21/2006 13:20			
29.2	15	9/21/2006 13:20			
29	15	9/21/2006 13:20			
28.5	15	9/21/2006 13:20			
28.4	15	9/21/2006 13:20			
28.6	15	9/21/2006 13:20			
28.5	15	9/21/2006 13:20			

Path Measurement Data Site 5 Path 3		
ppm*m	pathlength	Timestamp (mountain time)
54.3	16	9/21/2006 13:33
83.2	16	9/21/2006 13:33
44.6	16	9/21/2006 13:33
58.8	16	9/21/2006 13:34
84.7	16	9/21/2006 13:34
72.3	16	9/21/2006 13:34
56.1	16	9/21/2006 13:34
54.6	16	9/21/2006 13:34
53.1	16	9/21/2006 13:34
48.4	16	9/21/2006 13:34
49.7	16	9/21/2006 13:34
46.5	16	9/21/2006 13:34
42	16	9/21/2006 13:34
33.9	16	9/21/2006 13:34
34.1	16	9/21/2006 13:34
34.1	16	9/21/2006 13:34
33.8	16	9/21/2006 13:34
36.6	16	9/21/2006 13:34
39.5	16	9/21/2006 13:34
37.2	16	9/21/2006 13:34
37.2	16	9/21/2006 13:34
41.9	16	9/21/2006 13:34
61.6	16	9/21/2006 13:34
55.7	16	9/21/2006 13:34
75.4	16	9/21/2006 13:34
84.7	16	9/21/2006 13:34
65.3	16	9/21/2006 13:34
58.2	16	9/21/2006 13:34
63.9	16	9/21/2006 13:34
55.5	16	9/21/2006 13:34
41.2	16	9/21/2006 13:34
38.4	16	9/21/2006 13:34
37.9	16	9/21/2006 13:34
32.5	16	9/21/2006 13:34
31.5	16	9/21/2006 13:34
31.4	16	9/21/2006 13:34
31.5	16	9/21/2006 13:34
31.5	16	9/21/2006 13:34
31.6	16	9/21/2006 13:35
31.3	16	9/21/2006 13:35
31.5	16	9/21/2006 13:35
31.1	16	9/21/2006 13:35
31.3	16	9/21/2006 13:35
31.3	16	9/21/2006 13:35
31.5	16	9/21/2006 13:35
31.3	16	9/21/2006 13:35
31.3	16	9/21/2006 13:35
31.3	16	9/21/2006 13:35
31.5	16	9/21/2006 13:35
31.3	16	9/21/2006 13:35
31	16	9/21/2006 13:35
31.2	16	9/21/2006 13:35
31.3	16	9/21/2006 13:35
31.2	16	9/21/2006 13:35

Path Measurement Data Site 5 Path 3		
ppm*m	pathlength	Timestamp (mountain time)
31.3	16	9/21/2006 13:35
31.2	16	9/21/2006 13:35
31.3	16	9/21/2006 13:35
31.6	16	9/21/2006 13:35
31.3	16	9/21/2006 13:35
31.4	16	9/21/2006 13:35
32	16	9/21/2006 13:35
36.7	16	9/21/2006 13:35
46.4	16	9/21/2006 13:35
40.2	16	9/21/2006 13:35
46.2	16	9/21/2006 13:35
56.1	16	9/21/2006 13:35
81.2	16	9/21/2006 13:35
83.2	16	9/21/2006 13:35
88.4	16	9/21/2006 13:35
70.3	16	9/21/2006 13:35
60.2	16	9/21/2006 13:35
65.2	16	9/21/2006 13:35
59	16	9/21/2006 13:36
65	16	9/21/2006 13:36
67	16	9/21/2006 13:36
48.8	16	9/21/2006 13:36
40.1	16	9/21/2006 13:36
37	16	9/21/2006 13:36
34.1	16	9/21/2006 13:36
33.1	16	9/21/2006 13:36
33.6	16	9/21/2006 13:36
34.3	16	9/21/2006 13:36
33.3	16	9/21/2006 13:36
32.9	16	9/21/2006 13:36
32.7	16	9/21/2006 13:36
33	16	9/21/2006 13:36
34	16	9/21/2006 13:36
34.9	16	9/21/2006 13:36
35.1	16	9/21/2006 13:36
36.6	16	9/21/2006 13:36
37.1	16	9/21/2006 13:36
36.2	16	9/21/2006 13:36
36.7	16	9/21/2006 13:36
34	16	9/21/2006 13:36
32.9	16	9/21/2006 13:36
32.7	16	9/21/2006 13:36
32.5	16	9/21/2006 13:36
33.2	16	9/21/2006 13:36
33	16	9/21/2006 13:36
32.4	16	9/21/2006 13:36
32.8	16	9/21/2006 13:36
32.5	16	9/21/2006 13:36
32.6	16	9/21/2006 13:36
35.6	16	9/21/2006 13:36
40.6	16	9/21/2006 13:36
48.8	16	9/21/2006 13:36
73.9	16	9/21/2006 13:37
86.5	16	9/21/2006 13:37
82.6	16	9/21/2006 13:37

Path Measurement Data Site 5 Path 3		
ppm*m	pathlength	Timestamp (mountain time)
74.7	16	9/21/2006 13:37
68	16	9/21/2006 13:37
62.7	16	9/21/2006 13:37
76.4	16	9/21/2006 13:37
87.3	16	9/21/2006 13:37
88.1	16	9/21/2006 13:37
77.2	16	9/21/2006 13:37
79	16	9/21/2006 13:37
68.8	16	9/21/2006 13:37
72.3	16	9/21/2006 13:37
88.3	16	9/21/2006 13:37
77.8	16	9/21/2006 13:37
63.2	16	9/21/2006 13:37
48.2	16	9/21/2006 13:37
52.5	16	9/21/2006 13:37
69.9	16	9/21/2006 13:37
82.3	16	9/21/2006 13:37
91.8	16	9/21/2006 13:37
87	16	9/21/2006 13:37
70	16	9/21/2006 13:37
56.1	16	9/21/2006 13:37
53.8	16	9/21/2006 13:37
50.7	16	9/21/2006 13:37
50.3	16	9/21/2006 13:37
48.9	16	9/21/2006 13:37
49.3	16	9/21/2006 13:37
42.7	16	9/21/2006 13:37
40.3	16	9/21/2006 13:37
36.6	16	9/21/2006 13:37
33.1	16	9/21/2006 13:37
32.7	16	9/21/2006 13:37
32.5	16	9/21/2006 13:38
31.5	16	9/21/2006 13:38
31.6	16	9/21/2006 13:38
31.6	16	9/21/2006 13:38
31.3	16	9/21/2006 13:38
31.5	16	9/21/2006 13:38
31.4	16	9/21/2006 13:38
31.5	16	9/21/2006 13:38
31.6	16	9/21/2006 13:38
31.4	16	9/21/2006 13:38
31.5	16	9/21/2006 13:38
31.6	16	9/21/2006 13:38
31.5	16	9/21/2006 13:38
31.6	16	9/21/2006 13:38
31.7	16	9/21/2006 13:38
31.6	16	9/21/2006 13:38
31.7	16	9/21/2006 13:38
31.7	16	9/21/2006 13:38
31.9	16	9/21/2006 13:38
31.7	16	9/21/2006 13:38
31.5	16	9/21/2006 13:38
31.6	16	9/21/2006 13:38
31.5	16	9/21/2006 13:38
31.4	16	9/21/2006 13:38

Path Measurement Data Site 5 Path 3		
ppm*m	pathlength	Timestamp (mountain time)
31.4	16	9/21/2006 13:38
31.6	16	9/21/2006 13:38
31.7	16	9/21/2006 13:38
31.6	16	9/21/2006 13:38
31.7	16	9/21/2006 13:38
31.6	16	9/21/2006 13:38
31.5	16	9/21/2006 13:38
31.7	16	9/21/2006 13:38
31.6	16	9/21/2006 13:38
31.4	16	9/21/2006 13:38
31.6	16	9/21/2006 13:39
31.6	16	9/21/2006 13:39
31.7	16	9/21/2006 13:39
31.7	16	9/21/2006 13:39
31.7	16	9/21/2006 13:39
31.4	16	9/21/2006 13:39
31.6	16	9/21/2006 13:39
31.7	16	9/21/2006 13:39
31.5	16	9/21/2006 13:39
31.4	16	9/21/2006 13:39
31.7	16	9/21/2006 13:39
31.6	16	9/21/2006 13:39
31.5	16	9/21/2006 13:39
31.6	16	9/21/2006 13:39
31.5	16	9/21/2006 13:39
31.4	16	9/21/2006 13:39
31.6	16	9/21/2006 13:39
31.7	16	9/21/2006 13:39
31.6	16	9/21/2006 13:39
31.6	16	9/21/2006 13:39
31.6	16	9/21/2006 13:39
31.6	16	9/21/2006 13:39
31.7	16	9/21/2006 13:39
31.6	16	9/21/2006 13:39
31.7	16	9/21/2006 13:39
31.6	16	9/21/2006 13:39
31.7	16	9/21/2006 13:39
31.7	16	9/21/2006 13:39
31.7	16	9/21/2006 13:39
31.6	16	9/21/2006 13:39
31.6	16	9/21/2006 13:39
31.6	16	9/21/2006 13:39
31.7	16	9/21/2006 13:39
31.6	16	9/21/2006 13:39
31.6	16	9/21/2006 13:39
31.6	16	9/21/2006 13:39
31.6	16	9/21/2006 13:39
31.6	16	9/21/2006 13:40
31.6	16	9/21/2006 13:40
31.6	16	9/21/2006 13:40
31.5	16	9/21/2006 13:40
31.6	16	9/21/2006 13:40
31.5	16	9/21/2006 13:40
31.5	16	9/21/2006 13:40
31.7	16	9/21/2006 13:40
31.5	16	9/21/2006 13:40
31.6	16	9/21/2006 13:40
31.7	16	9/21/2006 13:40



Path Measurement Data Site 5 Path 3		
ppm*m	pathlength	Timestamp (mountain time)
31.5	16	9/21/2006 13:40
31.5	16	9/21/2006 13:40
31.6	16	9/21/2006 13:40
31.4	16	9/21/2006 13:40
31.5	16	9/21/2006 13:40
31.4	16	9/21/2006 13:40
31.4	16	9/21/2006 13:40
31.7	16	9/21/2006 13:40
31.5	16	9/21/2006 13:40
31.5	16	9/21/2006 13:40
31.5	16	9/21/2006 13:40
31.6	16	9/21/2006 13:40
31.7	16	9/21/2006 13:40
31.6	16	9/21/2006 13:40
31.6	16	9/21/2006 13:40
31.5	16	9/21/2006 13:40
31.4	16	9/21/2006 13:40
31.4	16	9/21/2006 13:40
31.6	16	9/21/2006 13:40
31.5	16	9/21/2006 13:40
31.5	16	9/21/2006 13:40
31.6	16	9/21/2006 13:40
31.5	16	9/21/2006 13:40
31.6	16	9/21/2006 13:40
31.5	16	9/21/2006 13:41
31.6	16	9/21/2006 13:41
31.8	16	9/21/2006 13:41
31.6	16	9/21/2006 13:41
31.5	16	9/21/2006 13:41
31.7	16	9/21/2006 13:41
31.4	16	9/21/2006 13:41
31.6	16	9/21/2006 13:41
31.6	16	9/21/2006 13:41
31.5	16	9/21/2006 13:41
31.7	16	9/21/2006 13:41
31.6	16	9/21/2006 13:41
31.7	16	9/21/2006 13:41
31.5	16	9/21/2006 13:41
31.9	16	9/21/2006 13:41
31.7	16	9/21/2006 13:41
31.9	16	9/21/2006 13:41
33	16	9/21/2006 13:41
34.4	16	9/21/2006 13:41
37.1	16	9/21/2006 13:41
41.1	16	9/21/2006 13:41
60.1	16	9/21/2006 13:41
70.8	16	9/21/2006 13:41
63.1	16	9/21/2006 13:41
50.2	16	9/21/2006 13:41
54.9	16	9/21/2006 13:41
55.1	16	9/21/2006 13:41
55.3	16	9/21/2006 13:41
50.8	16	9/21/2006 13:41
43.9	16	9/21/2006 13:41
40.2	16	9/21/2006 13:41

Path Measurement Data Site 5 Path 3		
ppm*m	pathlength	Timestamp (mountain time)
38	16	9/21/2006 13:41
36.7	16	9/21/2006 13:41
33.5	16	9/21/2006 13:41
32.2	16	9/21/2006 13:42
32	16	9/21/2006 13:42
31.7	16	9/21/2006 13:42
31.7	16	9/21/2006 13:42
31.8	16	9/21/2006 13:42
32	16	9/21/2006 13:42
32	16	9/21/2006 13:42
31.8	16	9/21/2006 13:42
31.7	16	9/21/2006 13:42
31.8	16	9/21/2006 13:42
31.7	16	9/21/2006 13:42
31.5	16	9/21/2006 13:42
31.6	16	9/21/2006 13:42
31.7	16	9/21/2006 13:42
31.7	16	9/21/2006 13:42
31.5	16	9/21/2006 13:42
31.6	16	9/21/2006 13:42
31.6	16	9/21/2006 13:42
31.6	16	9/21/2006 13:42
31.6	16	9/21/2006 13:42
31.6	16	9/21/2006 13:42
31.5	16	9/21/2006 13:42
31.5	16	9/21/2006 13:42
31.4	16	9/21/2006 13:42
31.4	16	9/21/2006 13:42
31.3	16	9/21/2006 13:42
31.6	16	9/21/2006 13:42
31.7	16	9/21/2006 13:42
31.8	16	9/21/2006 13:42
31.6	16	9/21/2006 13:42
32	16	9/21/2006 13:42
33.9	16	9/21/2006 13:42
36.5	16	9/21/2006 13:42
41.6	16	9/21/2006 13:42
45.6	16	9/21/2006 13:43
42.1	16	9/21/2006 13:43
37.5	16	9/21/2006 13:43
34.8	16	9/21/2006 13:43
38	16	9/21/2006 13:43
52	16	9/21/2006 13:43
48.9	16	9/21/2006 13:43
92.6	16	9/21/2006 13:43
97.7	16	9/21/2006 13:43
105	16	9/21/2006 13:43
63.6	16	9/21/2006 13:43
54.2	16	9/21/2006 13:43
71	16	9/21/2006 13:43
80.1	16	9/21/2006 13:43
70.5	16	9/21/2006 13:43
92.2	16	9/21/2006 13:43
67.5	16	9/21/2006 13:43
63.7	16	9/21/2006 13:43

Path Measurement Data Site 5 Path 3		
ppm*m	pathlength	Timestamp (mountain time)
62.8	16	9/21/2006 13:43
56.7	16	9/21/2006 13:43
60.9	16	9/21/2006 13:43
52.6	16	9/21/2006 13:43
46.7	16	9/21/2006 13:43
43.6	16	9/21/2006 13:43
42.5	16	9/21/2006 13:43
41.6	16	9/21/2006 13:43
44.6	16	9/21/2006 13:43
43.8	16	9/21/2006 13:43
42.2	16	9/21/2006 13:43
41.8	16	9/21/2006 13:43
41.5	16	9/21/2006 13:43
41.2	16	9/21/2006 13:43
44.5	16	9/21/2006 13:43
50.3	16	9/21/2006 13:43
45.1	16	9/21/2006 13:44
46.5	16	9/21/2006 13:44
43.6	16	9/21/2006 13:44
39.1	16	9/21/2006 13:44
37.8	16	9/21/2006 13:44
39.6	16	9/21/2006 13:44
52.8	16	9/21/2006 13:44
54.5	16	9/21/2006 13:44
60	16	9/21/2006 13:44
58	16	9/21/2006 13:44
55.3	16	9/21/2006 13:44
53.5	16	9/21/2006 13:44
54.2	16	9/21/2006 13:44
51.5	16	9/21/2006 13:44
46.9	16	9/21/2006 13:44
38.7	16	9/21/2006 13:44
34.3	16	9/21/2006 13:44
33.5	16	9/21/2006 13:44
43.9	16	9/21/2006 13:44
45.1	16	9/21/2006 13:44
44.2	16	9/21/2006 13:44
58.5	16	9/21/2006 13:44
97.8	16	9/21/2006 13:44
111	16	9/21/2006 13:44
81.8	16	9/21/2006 13:44
65.3	16	9/21/2006 13:44
53.6	16	9/21/2006 13:44
43.6	16	9/21/2006 13:44
35	16	9/21/2006 13:44
34.6	16	9/21/2006 13:44
39.9	16	9/21/2006 13:44
40.4	16	9/21/2006 13:44
44.6	16	9/21/2006 13:44
115	16	9/21/2006 13:44
173	16	9/21/2006 13:45
118	16	9/21/2006 13:45
75.1	16	9/21/2006 13:45
89.1	16	9/21/2006 13:45
110	16	9/21/2006 13:45

Path Measurement Data Site 5 Path 3		
ppm*m	pathlength	Timestamp (mountain time)
69	16	9/21/2006 13:45
90.6	16	9/21/2006 13:45
121	16	9/21/2006 13:45
72.8	16	9/21/2006 13:45
41.5	16	9/21/2006 13:45
38.6	16	9/21/2006 13:45
59.3	16	9/21/2006 13:45
55	16	9/21/2006 13:45
44.2	16	9/21/2006 13:45
43.5	16	9/21/2006 13:45
43.8	16	9/21/2006 13:45
50.7	16	9/21/2006 13:45
47.8	16	9/21/2006 13:45
50.6	16	9/21/2006 13:45
57.8	16	9/21/2006 13:45
59.9	16	9/21/2006 13:45
55.7	16	9/21/2006 13:45
52.6	16	9/21/2006 13:45
46.3	16	9/21/2006 13:45
41.5	16	9/21/2006 13:45
39.6	16	9/21/2006 13:45
35.8	16	9/21/2006 13:45
35.5	16	9/21/2006 13:45
35.5	16	9/21/2006 13:45
37.7	16	9/21/2006 13:45
43	16	9/21/2006 13:45
48.5	16	9/21/2006 13:45
56.2	16	9/21/2006 13:45
55.8	16	9/21/2006 13:45
46.3	16	9/21/2006 13:46
48	16	9/21/2006 13:46
48.4	16	9/21/2006 13:46
44.7	16	9/21/2006 13:46
53.4	16	9/21/2006 13:46
74.5	16	9/21/2006 13:46
80.5	16	9/21/2006 13:46
81.4	16	9/21/2006 13:46
96.7	16	9/21/2006 13:46
94	16	9/21/2006 13:46
79.3	16	9/21/2006 13:46
67	16	9/21/2006 13:46
64.9	16	9/21/2006 13:46
56.5	16	9/21/2006 13:46
56.6	16	9/21/2006 13:46
50.8	16	9/21/2006 13:46
43.8	16	9/21/2006 13:46
40.5	16	9/21/2006 13:46
41.9	16	9/21/2006 13:46
40.4	16	9/21/2006 13:46
38.9	16	9/21/2006 13:46
37.5	16	9/21/2006 13:46
35.4	16	9/21/2006 13:46
34.8	16	9/21/2006 13:46
33.6	16	9/21/2006 13:46
33.1	16	9/21/2006 13:46

Path Measurement Data Site 5 Path 3		
ppm*m	pathlength	Timestamp (mountain time)
32.2	16	9/21/2006 13:46
32.1	16	9/21/2006 13:46
32	16	9/21/2006 13:46
32.3	16	9/21/2006 13:46
32.2	16	9/21/2006 13:46
32.1	16	9/21/2006 13:46
32	16	9/21/2006 13:46
32	16	9/21/2006 13:46
32.2	16	9/21/2006 13:47
31.9	16	9/21/2006 13:47
36.5	16	9/21/2006 13:47
54.1	16	9/21/2006 13:47
56.6	16	9/21/2006 13:47
58.1	16	9/21/2006 13:47
66.2	16	9/21/2006 13:47
75.8	16	9/21/2006 13:47
109	16	9/21/2006 13:47
73.3	16	9/21/2006 13:47
55.1	16	9/21/2006 13:47
58.9	16	9/21/2006 13:47
55.8	16	9/21/2006 13:47
54.2	16	9/21/2006 13:47
47	16	9/21/2006 13:47
35.4	16	9/21/2006 13:47
34.7	16	9/21/2006 13:47
36.9	16	9/21/2006 13:47
40.7	16	9/21/2006 13:47
43.2	16	9/21/2006 13:47
38.3	16	9/21/2006 13:47
40.4	16	9/21/2006 13:47
41.6	16	9/21/2006 13:47
43.4	16	9/21/2006 13:47
48.5	16	9/21/2006 13:47
52.9	16	9/21/2006 13:47
65.2	16	9/21/2006 13:47
69.9	16	9/21/2006 13:47
57.9	16	9/21/2006 13:47
44.2	16	9/21/2006 13:47
44	16	9/21/2006 13:47
41.9	16	9/21/2006 13:47
45.2	16	9/21/2006 13:47
44.2	16	9/21/2006 13:47
36.8	16	9/21/2006 13:48
36.9	16	9/21/2006 13:48
36.8	16	9/21/2006 13:48
34.5	16	9/21/2006 13:48
34.6	16	9/21/2006 13:48
34.3	16	9/21/2006 13:48
34.5	16	9/21/2006 13:48
37.8	16	9/21/2006 13:48
47.5	16	9/21/2006 13:48
59.6	16	9/21/2006 13:48
56.8	16	9/21/2006 13:48
60.5	16	9/21/2006 13:48
105	16	9/21/2006 13:48

Path Measurement Data Site 5 Path 3		
ppm*m	pathlength	Timestamp (mountain time)
73.6	16	9/21/2006 13:48
37	16	9/21/2006 13:48
62.9	16	9/21/2006 13:48
55.4	16	9/21/2006 13:48
56.8	16	9/21/2006 13:48
37.9	16	9/21/2006 13:48
34.6	16	9/21/2006 13:48
40.6	16	9/21/2006 13:48
70.9	16	9/21/2006 13:48
53.4	16	9/21/2006 13:48
41.5	16	9/21/2006 13:48
41	16	9/21/2006 13:48
54.1	16	9/21/2006 13:48
59.5	16	9/21/2006 13:48
69.5	16	9/21/2006 13:48
64.1	16	9/21/2006 13:48
50.5	16	9/21/2006 13:48
51.4	16	9/21/2006 13:48
68.5	16	9/21/2006 13:48
71.1	16	9/21/2006 13:48
67.4	16	9/21/2006 13:49
62.8	16	9/21/2006 13:49
52.3	16	9/21/2006 13:49
48.5	16	9/21/2006 13:49
50.8	16	9/21/2006 13:49
52.3	16	9/21/2006 13:49
51.8	16	9/21/2006 13:49
49.2	16	9/21/2006 13:49
46.1	16	9/21/2006 13:49
41.2	16	9/21/2006 13:49
38.4	16	9/21/2006 13:49
38.4	16	9/21/2006 13:49

Path Measurement Data Site 6 Path 1			Path Measurement Data Site 6 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
39.8	10	9/22/2006 8:09	23.9	11	9/22/2006 8:39
86.8	10	9/22/2006 8:09	24.1	11	9/22/2006 8:39
317	10	9/22/2006 8:09	23.8	11	9/22/2006 8:39
191	10	9/22/2006 8:09	23.9	11	9/22/2006 8:39
102	10	9/22/2006 8:09	26.2	11	9/22/2006 8:39
30.7	10	9/22/2006 8:10	29.5	11	9/22/2006 8:39
21.8	10	9/22/2006 8:10	30.3	11	9/22/2006 8:39
22.2	10	9/22/2006 8:10	28	11	9/22/2006 8:39
22	10	9/22/2006 8:10	27.5	11	9/22/2006 8:39
25.2	10	9/22/2006 8:10	31.1	11	9/22/2006 8:39
23.2	10	9/22/2006 8:10	37	11	9/22/2006 8:40
22.3	10	9/22/2006 8:10	30.8	11	9/22/2006 8:40
21.5	10	9/22/2006 8:10	29	11	9/22/2006 8:40
21.4	10	9/22/2006 8:10	26.9	11	9/22/2006 8:40
20.4	10	9/22/2006 8:11	27.1	11	9/22/2006 8:40
20.4	10	9/22/2006 8:11	27.6	11	9/22/2006 8:40
20.3	10	9/22/2006 8:11	27.5	11	9/22/2006 8:40
20.5	10	9/22/2006 8:11	28	11	9/22/2006 8:40
20.5	10	9/22/2006 8:11	28.6	11	9/22/2006 8:40
20.5	10	9/22/2006 8:11	28.3	11	9/22/2006 8:40
20.4	10	9/22/2006 8:11	29.7	11	9/22/2006 8:40
20.3	10	9/22/2006 8:11	27.9	11	9/22/2006 8:40
21.3	10	9/22/2006 8:11	27.5	11	9/22/2006 8:40
24.1	10	9/22/2006 8:12	29.8	11	9/22/2006 8:40
25.4	10	9/22/2006 8:12	31.2	11	9/22/2006 8:40
213	10	9/22/2006 8:12	30.6	11	9/22/2006 8:40
127	10	9/22/2006 8:12	30.2	11	9/22/2006 8:40
144	10	9/22/2006 8:12	27.5	11	9/22/2006 8:40
174	10	9/22/2006 8:12	25.4	11	9/22/2006 8:40
228	10	9/22/2006 8:12	25.3	11	9/22/2006 8:40
99.3	10	9/22/2006 8:12	25.7	11	9/22/2006 8:40
49.8	10	9/22/2006 8:12	24.1	11	9/22/2006 8:40
109	10	9/22/2006 8:12	24	11	9/22/2006 8:40
36.7	10	9/22/2006 8:12	24	11	9/22/2006 8:40
30.5	10	9/22/2006 8:12	23.5	11	9/22/2006 8:40
24.4	10	9/22/2006 8:12	23.5	11	9/22/2006 8:40
23.6	10	9/22/2006 8:12	23.6	11	9/22/2006 8:40
23.1	10	9/22/2006 8:12	24.3	11	9/22/2006 8:40
23.4	10	9/22/2006 8:12	24.4	11	9/22/2006 8:40
63	10	9/22/2006 8:12	24.8	11	9/22/2006 8:40
59.1	10	9/22/2006 8:12	25.5	11	9/22/2006 8:40
31.5	10	9/22/2006 8:12	21.8	11	9/22/2006 8:41
35.3	10	9/22/2006 8:12	22	11	9/22/2006 8:41
37.5	10	9/22/2006 8:12	21.9	11	9/22/2006 8:41
20.1	10	9/22/2006 8:12	21.7	11	9/22/2006 8:42
20.3	10	9/22/2006 8:12	21.7	11	9/22/2006 8:42
20	10	9/22/2006 8:12	21.7	11	9/22/2006 8:42
20.2	10	9/22/2006 8:12	21.6	11	9/22/2006 8:42
20.1	10	9/22/2006 8:12	21.5	11	9/22/2006 8:42
20.2	10	9/22/2006 8:12	21.5	11	9/22/2006 8:42
20.1	10	9/22/2006 8:12	21.5	11	9/22/2006 8:42
20.1	10	9/22/2006 8:12	21.4	11	9/22/2006 8:42
20	10	9/22/2006 8:12	21.5	11	9/22/2006 8:42
20.7	10	9/22/2006 8:12	21.7	11	9/22/2006 8:42
24.1	10	9/22/2006 8:12	21.6	11	9/22/2006 8:42
26.5	10	9/22/2006 8:12	21.6	11	9/22/2006 8:42
23.2	10	9/22/2006 8:12	21.6	11	9/22/2006 8:42
22.6	10	9/22/2006 8:13	21.7	11	9/22/2006 8:42
22.4	10	9/22/2006 8:13	21.6	11	9/22/2006 8:42
23	10	9/22/2006 8:13	21.6	11	9/22/2006 8:42

Path Measurement Data Site 6 Path 1			Path Measurement Data Site 6 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
26.1	10	9/22/2006 8:13	21.5	11	9/22/2006 8:42
24.4	10	9/22/2006 8:13	21.7	11	9/22/2006 8:42
22.3	10	9/22/2006 8:13	22.5	11	9/22/2006 8:42
21.6	10	9/22/2006 8:13	38.3	11	9/22/2006 8:42
20.6	10	9/22/2006 8:13	186	11	9/22/2006 8:42
20.4	10	9/22/2006 8:13	102	11	9/22/2006 8:42
37.9	10	9/22/2006 8:13	148	11	9/22/2006 8:42
25.8	10	9/22/2006 8:13	109	11	9/22/2006 8:42
23.2	10	9/22/2006 8:13	137	11	9/22/2006 8:42
29.6	10	9/22/2006 8:13	75.7	11	9/22/2006 8:42
64.8	10	9/22/2006 8:13	26.5	11	9/22/2006 8:42
150	10	9/22/2006 8:13	43.9	11	9/22/2006 8:42
272	10	9/22/2006 8:13	50.1	11	9/22/2006 8:42
191	10	9/22/2006 8:13	92.9	11	9/22/2006 8:42
137	10	9/22/2006 8:13	55.6	11	9/22/2006 8:42
97.1	10	9/22/2006 8:13	26.2	11	9/22/2006 8:42
41.9	10	9/22/2006 8:13	24.2	11	9/22/2006 8:42
23.1	10	9/22/2006 8:13	36.2	11	9/22/2006 8:42
20.6	10	9/22/2006 8:13	77.5	11	9/22/2006 8:43
20.3	10	9/22/2006 8:13	45.3	11	9/22/2006 8:43
20.2	10	9/22/2006 8:13	73.9	11	9/22/2006 8:43
20.4	10	9/22/2006 8:13	24.9	11	9/22/2006 8:43
20.3	10	9/22/2006 8:13	21.6	11	9/22/2006 8:43
20.3	10	9/22/2006 8:13	30.9	11	9/22/2006 8:43
20.4	10	9/22/2006 8:13	23.5	11	9/22/2006 8:43
20.3	10	9/22/2006 8:13	42.7	11	9/22/2006 8:43
20.4	10	9/22/2006 8:13	22.5	11	9/22/2006 8:43
20.4	10	9/22/2006 8:13	33.9	11	9/22/2006 8:43
20.8	10	9/22/2006 8:13	30.1	11	9/22/2006 8:43
20.2	10	9/22/2006 8:13	63.2	11	9/22/2006 8:43
20.3	10	9/22/2006 8:13	54.3	11	9/22/2006 8:43
20.7	10	9/22/2006 8:14	29.6	11	9/22/2006 8:43
21.3	10	9/22/2006 8:14	23.2	11	9/22/2006 8:43
21.8	10	9/22/2006 8:14	26.4	11	9/22/2006 8:43
20.5	10	9/22/2006 8:14	44.8	11	9/22/2006 8:43
20.5	10	9/22/2006 8:14	55.5	11	9/22/2006 8:43
38.9	10	9/22/2006 8:14	34.7	11	9/22/2006 8:43
56.1	10	9/22/2006 8:14	27.9	11	9/22/2006 8:43
51.3	10	9/22/2006 8:14	49.9	11	9/22/2006 8:43
57.6	10	9/22/2006 8:14	41	11	9/22/2006 8:43
58.9	10	9/22/2006 8:14	31.8	11	9/22/2006 8:43
58.3	10	9/22/2006 8:14	43.5	11	9/22/2006 8:43
59.5	10	9/22/2006 8:14	76.7	11	9/22/2006 8:43
51.9	10	9/22/2006 8:14	42.1	11	9/22/2006 8:43
50.2	10	9/22/2006 8:14	74.3	11	9/22/2006 8:43
43.5	10	9/22/2006 8:14	30.6	11	9/22/2006 8:43
43.8	10	9/22/2006 8:14	29.8	11	9/22/2006 8:43
73.9	10	9/22/2006 8:14	39.7	11	9/22/2006 8:43
47.6	10	9/22/2006 8:14	31.8	11	9/22/2006 8:43
32.1	10	9/22/2006 8:14	26.5	11	9/22/2006 8:43
26.1	10	9/22/2006 8:14	24.4	11	9/22/2006 8:43
22	10	9/22/2006 8:14	23	11	9/22/2006 8:43
22.1	10	9/22/2006 8:14	22.5	11	9/22/2006 8:44
23.7	10	9/22/2006 8:14	22.1	11	9/22/2006 8:44
21	10	9/22/2006 8:14	22	11	9/22/2006 8:44
20.6	10	9/22/2006 8:14	22.2	11	9/22/2006 8:44
20.8	10	9/22/2006 8:14	22.2	11	9/22/2006 8:44
20.6	10	9/22/2006 8:14	22.4	11	9/22/2006 8:44
20.4	10	9/22/2006 8:14	22	11	9/22/2006 8:44
20.5	10	9/22/2006 8:14	21.8	11	9/22/2006 8:44



Path Measurement Data Site 6 Path 1			Path Measurement Data Site 6 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
20.2	10	9/22/2006 8:14	21.6	11	9/22/2006 8:44
20.2	10	9/22/2006 8:14	21.6	11	9/22/2006 8:44
20.2	10	9/22/2006 8:14	21.5	11	9/22/2006 8:44
20.3	10	9/22/2006 8:14	21.6	11	9/22/2006 8:44
20.2	10	9/22/2006 8:14	21.6	11	9/22/2006 8:44
20.3	10	9/22/2006 8:15	21.6	11	9/22/2006 8:44
20.2	10	9/22/2006 8:15	21.7	11	9/22/2006 8:44
20.3	10	9/22/2006 8:15	21.4	11	9/22/2006 8:44
20.2	10	9/22/2006 8:15	21.5	11	9/22/2006 8:44
20.3	10	9/22/2006 8:15	21.6	11	9/22/2006 8:44
20.3	10	9/22/2006 8:15	21.6	11	9/22/2006 8:44
20.2	10	9/22/2006 8:15	21.6	11	9/22/2006 8:44
20.2	10	9/22/2006 8:15	24.9	11	9/22/2006 8:44
20.3	10	9/22/2006 8:15	89.4	11	9/22/2006 8:44
20.2	10	9/22/2006 8:15	64	11	9/22/2006 8:44
20.8	10	9/22/2006 8:15	107	11	9/22/2006 8:44
21.8	10	9/22/2006 8:15	98.2	11	9/22/2006 8:44
22.7	10	9/22/2006 8:15	288	11	9/22/2006 8:44
21	10	9/22/2006 8:15	91.7	11	9/22/2006 8:44
21.5	10	9/22/2006 8:15	69.1	11	9/22/2006 8:44
23.4	10	9/22/2006 8:15	63.8	11	9/22/2006 8:44
53	10	9/22/2006 8:15	55	11	9/22/2006 8:44
77.3	10	9/22/2006 8:15	51.9	11	9/22/2006 8:44
109	10	9/22/2006 8:15	34.5	11	9/22/2006 8:44
52.3	10	9/22/2006 8:15	27.2	11	9/22/2006 8:44
52.5	10	9/22/2006 8:15	121	11	9/22/2006 8:44
41.4	10	9/22/2006 8:15	83.8	11	9/22/2006 8:45
46	10	9/22/2006 8:15	25.3	11	9/22/2006 8:45
29.5	10	9/22/2006 8:15	82.1	11	9/22/2006 8:45
22.1	10	9/22/2006 8:15	48.9	11	9/22/2006 8:45
20.9	10	9/22/2006 8:15	56.4	11	9/22/2006 8:45
22.2	10	9/22/2006 8:15	194	11	9/22/2006 8:45
23.5	10	9/22/2006 8:15	70.2	11	9/22/2006 8:45
22.5	10	9/22/2006 8:15	72	11	9/22/2006 8:45
21.9	10	9/22/2006 8:15	36.3	11	9/22/2006 8:45
20.4	10	9/22/2006 8:15	103	11	9/22/2006 8:45
21	10	9/22/2006 8:15	93.6	11	9/22/2006 8:45
34	10	9/22/2006 8:15	135	11	9/22/2006 8:45
79.7	10	9/22/2006 8:15	69.5	11	9/22/2006 8:45
324	10	9/22/2006 8:15	109	11	9/22/2006 8:45
83.4	10	9/22/2006 8:16	102	11	9/22/2006 8:45
20.3	10	9/22/2006 8:16	125	11	9/22/2006 8:45
20.1	10	9/22/2006 8:16	133	11	9/22/2006 8:45
20.2	10	9/22/2006 8:16	79.6	11	9/22/2006 8:45
20.7	10	9/22/2006 8:16	62.8	11	9/22/2006 8:45
21.2	10	9/22/2006 8:16	38.3	11	9/22/2006 8:45
24.8	10	9/22/2006 8:16	32.5	11	9/22/2006 8:45
23.5	10	9/22/2006 8:16	31	11	9/22/2006 8:45
30	10	9/22/2006 8:16	30.3	11	9/22/2006 8:45
27.5	10	9/22/2006 8:16	28.8	11	9/22/2006 8:45
105	10	9/22/2006 8:16	28.9	11	9/22/2006 8:45
35.1	10	9/22/2006 8:16	30.8	11	9/22/2006 8:45
79.8	10	9/22/2006 8:16	37.5	11	9/22/2006 8:45
310	10	9/22/2006 8:16	29.1	11	9/22/2006 8:45
54.4	10	9/22/2006 8:16	26.7	11	9/22/2006 8:45
37.8	10	9/22/2006 8:16	45.1	11	9/22/2006 8:45
34.1	10	9/22/2006 8:16	127	11	9/22/2006 8:45
24.4	10	9/22/2006 8:16	24.3	11	9/22/2006 8:45
22.5	10	9/22/2006 8:16	42.3	11	9/22/2006 8:45
22.1	10	9/22/2006 8:16	84.1	11	9/22/2006 8:45

Path Measurement Data Site 6 Path 1			Path Measurement Data Site 6 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
20.9	10	9/22/2006 8:16	70.9	11	9/22/2006 8:46
20.7	10	9/22/2006 8:16	45.4	11	9/22/2006 8:46
20.7	10	9/22/2006 8:16	69.8	11	9/22/2006 8:46
20.3	10	9/22/2006 8:16	45.3	11	9/22/2006 8:46
20.4	10	9/22/2006 8:16	82.6	11	9/22/2006 8:46
20.3	10	9/22/2006 8:16	86	11	9/22/2006 8:46
20.3	10	9/22/2006 8:16	71.2	11	9/22/2006 8:46
21.6	10	9/22/2006 8:16	47.1	11	9/22/2006 8:46
20.4	10	9/22/2006 8:16	38.8	11	9/22/2006 8:46
20.1	10	9/22/2006 8:16	33.8	11	9/22/2006 8:46
19.9	10	9/22/2006 8:16	30.6	11	9/22/2006 8:46
20.1	10	9/22/2006 8:16	28.9	11	9/22/2006 8:46
19.9	10	9/22/2006 8:16	30	11	9/22/2006 8:46
19.9	10	9/22/2006 8:16	32.6	11	9/22/2006 8:46
20	10	9/22/2006 8:17	31.3	11	9/22/2006 8:46
20	10	9/22/2006 8:17	31.9	11	9/22/2006 8:46
20	10	9/22/2006 8:17	30.8	11	9/22/2006 8:46
19.9	10	9/22/2006 8:17	30.3	11	9/22/2006 8:46
19.8	10	9/22/2006 8:17	30.6	11	9/22/2006 8:46
19.9	10	9/22/2006 8:17	26.6	11	9/22/2006 8:46
19.9	10	9/22/2006 8:17	25.6	11	9/22/2006 8:46
19.8	10	9/22/2006 8:17	24.7	11	9/22/2006 8:46
20	10	9/22/2006 8:17	24.1	11	9/22/2006 8:46
24.2	10	9/22/2006 8:17	26.8	11	9/22/2006 8:46
21.5	10	9/22/2006 8:17	41	11	9/22/2006 8:46
22.4	10	9/22/2006 8:17	42.5	11	9/22/2006 8:46
22.3	10	9/22/2006 8:17	43.6	11	9/22/2006 8:46
22	10	9/22/2006 8:17	31.4	11	9/22/2006 8:46
21.4	10	9/22/2006 8:17	38.9	11	9/22/2006 8:46
21.5	10	9/22/2006 8:17	73.8	11	9/22/2006 8:46
21.2	10	9/22/2006 8:17	121	11	9/22/2006 8:46
22.7	10	9/22/2006 8:17	176	11	9/22/2006 8:46
21.3	10	9/22/2006 8:17	178	11	9/22/2006 8:46
20.9	10	9/22/2006 8:17	134	11	9/22/2006 8:46
21	10	9/22/2006 8:17	129	11	9/22/2006 8:47
20.2	10	9/22/2006 8:17	108	11	9/22/2006 8:47
20.6	10	9/22/2006 8:17	77.7	11	9/22/2006 8:47
79.3	10	9/22/2006 8:17	92.4	11	9/22/2006 8:47
336	10	9/22/2006 8:17	56.9	11	9/22/2006 8:47
57.6	10	9/22/2006 8:17	33.5	11	9/22/2006 8:47
243	10	9/22/2006 8:17	27.4	11	9/22/2006 8:47
92.9	10	9/22/2006 8:17	27.3	11	9/22/2006 8:47
98.6	10	9/22/2006 8:17	26.5	11	9/22/2006 8:47
102	10	9/22/2006 8:17	43.2	11	9/22/2006 8:47
182	10	9/22/2006 8:17	27.7	11	9/22/2006 8:47
146	10	9/22/2006 8:17	27.1	11	9/22/2006 8:47
173	10	9/22/2006 8:17	25.8	11	9/22/2006 8:47
241	10	9/22/2006 8:17	33.2	11	9/22/2006 8:47
151	10	9/22/2006 8:18	24.3	11	9/22/2006 8:47
45.3	10	9/22/2006 8:18	41.6	11	9/22/2006 8:47
39.5	10	9/22/2006 8:18	59.1	11	9/22/2006 8:47
41.7	10	9/22/2006 8:18	27.7	11	9/22/2006 8:47
119	10	9/22/2006 8:18	26.4	11	9/22/2006 8:47
88.9	10	9/22/2006 8:18	24.7	11	9/22/2006 8:47
61.6	10	9/22/2006 8:18	25.9	11	9/22/2006 8:47
76.7	10	9/22/2006 8:18	38.5	11	9/22/2006 8:47
93.6	10	9/22/2006 8:18	29.5	11	9/22/2006 8:47
86.6	10	9/22/2006 8:18	32.9	11	9/22/2006 8:47
89.9	10	9/22/2006 8:18	86	11	9/22/2006 8:47
60.3	10	9/22/2006 8:18	194	11	9/22/2006 8:47

Path Measurement Data Site 6 Path 1			Path Measurement Data Site 6 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
53.8	10	9/22/2006 8:18	37.4	11	9/22/2006 8:47
49.5	10	9/22/2006 8:18	31.8	11	9/22/2006 8:47
47.2	10	9/22/2006 8:18	23.3	11	9/22/2006 8:47
45.1	10	9/22/2006 8:18	23.2	11	9/22/2006 8:47
45.9	10	9/22/2006 8:18	23.1	11	9/22/2006 8:47
59.8	10	9/22/2006 8:18	23	11	9/22/2006 8:47
142	10	9/22/2006 8:18	22.9	11	9/22/2006 8:47
90.2	10	9/22/2006 8:18	22.9	11	9/22/2006 8:47
43.9	10	9/22/2006 8:18	23.5	11	9/22/2006 8:48
25.3	10	9/22/2006 8:18	23.2	11	9/22/2006 8:48
26	10	9/22/2006 8:18	23.2	11	9/22/2006 8:48
22.9	10	9/22/2006 8:18	23.9	11	9/22/2006 8:48
21.3	10	9/22/2006 8:18	23.5	11	9/22/2006 8:48
20.8	10	9/22/2006 8:18	23.8	11	9/22/2006 8:48
24.9	10	9/22/2006 8:18	25	11	9/22/2006 8:48
29.4	10	9/22/2006 8:18	24	11	9/22/2006 8:48
63	10	9/22/2006 8:18	23.4	11	9/22/2006 8:48
23.6	10	9/22/2006 8:18	23.6	11	9/22/2006 8:48
20.5	10	9/22/2006 8:18	23.1	11	9/22/2006 8:48
20.2	10	9/22/2006 8:18	22.8	11	9/22/2006 8:48
20.2	10	9/22/2006 8:18	22.9	11	9/22/2006 8:48
21.5	10	9/22/2006 8:18	22.8	11	9/22/2006 8:48
20.7	10	9/22/2006 8:19	23	11	9/22/2006 8:48
20.4	10	9/22/2006 8:19	23.4	11	9/22/2006 8:48
21.6	10	9/22/2006 8:19	23.3	11	9/22/2006 8:48
21.7	10	9/22/2006 8:19	23.2	11	9/22/2006 8:48
23.1	10	9/22/2006 8:19	23.4	11	9/22/2006 8:48
22.8	10	9/22/2006 8:19	23.8	11	9/22/2006 8:48
22.3	10	9/22/2006 8:19	24.4	11	9/22/2006 8:48
21.5	10	9/22/2006 8:19	24.4	11	9/22/2006 8:48
21.3	10	9/22/2006 8:19	24.2	11	9/22/2006 8:48
29.8	10	9/22/2006 8:19	24.2	11	9/22/2006 8:48
20.6	10	9/22/2006 8:19	23.8	11	9/22/2006 8:48
19.9	10	9/22/2006 8:19	24.1	11	9/22/2006 8:48
20	10	9/22/2006 8:19	24.6	11	9/22/2006 8:48
20.1	10	9/22/2006 8:19	24.3	11	9/22/2006 8:48
19.9	10	9/22/2006 8:19	23.7	11	9/22/2006 8:48
20	10	9/22/2006 8:19	23.7	11	9/22/2006 8:48
21	10	9/22/2006 8:19	23.6	11	9/22/2006 8:48
21.6	10	9/22/2006 8:19	23.6	11	9/22/2006 8:48
20.7	10	9/22/2006 8:19	23.1	11	9/22/2006 8:48
20.3	10	9/22/2006 8:19	22.9	11	9/22/2006 8:48
20.2	10	9/22/2006 8:19	22.8	11	9/22/2006 8:49
19.9	10	9/22/2006 8:19	23	11	9/22/2006 8:49
31.5	10	9/22/2006 8:19	23.1	11	9/22/2006 8:49
30.7	10	9/22/2006 8:19	24.4	11	9/22/2006 8:49
21.5	10	9/22/2006 8:19	26.3	11	9/22/2006 8:49
20.3	10	9/22/2006 8:19	22.7	11	9/22/2006 8:49
19.8	10	9/22/2006 8:19	22.5	11	9/22/2006 8:49
19.8	10	9/22/2006 8:19	22.5	11	9/22/2006 8:49
20.2	10	9/22/2006 8:19	22.6	11	9/22/2006 8:49
20.1	10	9/22/2006 8:19	22.1	11	9/22/2006 8:49
19.9	10	9/22/2006 8:19	22.3	11	9/22/2006 8:49
19.8	10	9/22/2006 8:19	22	11	9/22/2006 8:49
19.9	10	9/22/2006 8:19	22.3	11	9/22/2006 8:49
20.4	10	9/22/2006 8:19	22.4	11	9/22/2006 8:49
21.2	10	9/22/2006 8:20	22.4	11	9/22/2006 8:49
20.3	10	9/22/2006 8:20	22.5	11	9/22/2006 8:49
21.4	10	9/22/2006 8:20	23.5	11	9/22/2006 8:49
21.7	10	9/22/2006 8:20	30.9	11	9/22/2006 8:49

Path Measurement Data Site 6 Path 1			Path Measurement Data Site 6 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
21.6	10	9/22/2006 8:20	47	11	9/22/2006 8:49
23.6	10	9/22/2006 8:20	24.3	11	9/22/2006 8:49
23.5	10	9/22/2006 8:20	25.3	11	9/22/2006 8:49
25.1	10	9/22/2006 8:20	26.3	11	9/22/2006 8:49
33.4	10	9/22/2006 8:20	34.4	11	9/22/2006 8:49
26.4	10	9/22/2006 8:20	35.7	11	9/22/2006 8:49
21.3	10	9/22/2006 8:20	26.4	11	9/22/2006 8:49
20.3	10	9/22/2006 8:20	58.9	11	9/22/2006 8:49
20.6	10	9/22/2006 8:20	73	11	9/22/2006 8:49
32.3	10	9/22/2006 8:20	83	11	9/22/2006 8:49
67.9	10	9/22/2006 8:20	88.1	11	9/22/2006 8:49
38.3	10	9/22/2006 8:20	108	11	9/22/2006 8:49
109	10	9/22/2006 8:20	35.2	11	9/22/2006 8:49
95.9	10	9/22/2006 8:20	44.8	11	9/22/2006 8:49
33.7	10	9/22/2006 8:20	52.2	11	9/22/2006 8:49
25	10	9/22/2006 8:20	39.8	11	9/22/2006 8:49
21.1	10	9/22/2006 8:20	53.8	11	9/22/2006 8:50
20.4	10	9/22/2006 8:20	93.6	11	9/22/2006 8:50
20.4	10	9/22/2006 8:20	62.3	11	9/22/2006 8:50
21.5	10	9/22/2006 8:20	63.7	11	9/22/2006 8:50
72.1	10	9/22/2006 8:20	100	11	9/22/2006 8:50
57.3	10	9/22/2006 8:20	35.9	11	9/22/2006 8:50
50.7	10	9/22/2006 8:20	44.9	11	9/22/2006 8:50
62.4	10	9/22/2006 8:20	53.2	11	9/22/2006 8:50
32.1	10	9/22/2006 8:20	37.7	11	9/22/2006 8:50
46.7	10	9/22/2006 8:20	90.5	11	9/22/2006 8:50
86.3	10	9/22/2006 8:20	25.8	11	9/22/2006 8:50
26.1	10	9/22/2006 8:20	23.1	11	9/22/2006 8:50
24	10	9/22/2006 8:20	22.5	11	9/22/2006 8:50
23.5	10	9/22/2006 8:20	22.7	11	9/22/2006 8:50
100	10	9/22/2006 8:21	23.1	11	9/22/2006 8:50
184	10	9/22/2006 8:21	24.1	11	9/22/2006 8:50
129	10	9/22/2006 8:21	22	11	9/22/2006 8:50
102	10	9/22/2006 8:21	21.9	11	9/22/2006 8:50
33.1	10	9/22/2006 8:21	21.9	11	9/22/2006 8:50
22.5	10	9/22/2006 8:21	22.4	11	9/22/2006 8:50
147	10	9/22/2006 8:21	22.6	11	9/22/2006 8:50
44	10	9/22/2006 8:21	22.9	11	9/22/2006 8:50
58	10	9/22/2006 8:21	23.1	11	9/22/2006 8:50
91.9	10	9/22/2006 8:21	22.7	11	9/22/2006 8:50
32.3	10	9/22/2006 8:21	22	11	9/22/2006 8:50
27.3	10	9/22/2006 8:21	22	11	9/22/2006 8:50
26	10	9/22/2006 8:21	22	11	9/22/2006 8:50
22	10	9/22/2006 8:21	22.3	11	9/22/2006 8:50
20.9	10	9/22/2006 8:21	26	11	9/22/2006 8:50
21.2	10	9/22/2006 8:21	22.2	11	9/22/2006 8:50
21.7	10	9/22/2006 8:21	21.8	11	9/22/2006 8:50
21.1	10	9/22/2006 8:21	21.8	11	9/22/2006 8:50
25.2	10	9/22/2006 8:21	22	11	9/22/2006 8:50
21.4	10	9/22/2006 8:21	21.9	11	9/22/2006 8:50
22.6	10	9/22/2006 8:21	21.9	11	9/22/2006 8:51
24.6	10	9/22/2006 8:21	23	11	9/22/2006 8:51
26.4	10	9/22/2006 8:21	23.6	11	9/22/2006 8:51
24.1	10	9/22/2006 8:21	27.1	11	9/22/2006 8:51
21.7	10	9/22/2006 8:21	30.3	11	9/22/2006 8:51
21.4	10	9/22/2006 8:21	28.9	11	9/22/2006 8:51
21.2	10	9/22/2006 8:21	27.2	11	9/22/2006 8:51
21.1	10	9/22/2006 8:21	26	11	9/22/2006 8:51
20.6	10	9/22/2006 8:21	30.2	11	9/22/2006 8:51
20.4	10	9/22/2006 8:21	38	11	9/22/2006 8:51

Path Measurement Data Site 6 Path 1			Path Measurement Data Site 6 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
20.2	10	9/22/2006 8:21	37.5	11	9/22/2006 8:51
20.2	10	9/22/2006 8:21	31.1	11	9/22/2006 8:51
20.3	10	9/22/2006 8:21	26.3	11	9/22/2006 8:51
20.5	10	9/22/2006 8:21	23.2	11	9/22/2006 8:51
22.1	10	9/22/2006 8:22	25	11	9/22/2006 8:51
28.6	10	9/22/2006 8:22	24.9	11	9/22/2006 8:51
58.8	10	9/22/2006 8:22	28.1	11	9/22/2006 8:51
43.3	10	9/22/2006 8:22	36.9	11	9/22/2006 8:51
73.1	10	9/22/2006 8:22	30.8	11	9/22/2006 8:51
44.7	10	9/22/2006 8:22	27.5	11	9/22/2006 8:51
595	10	9/22/2006 8:22	25.7	11	9/22/2006 8:51
190	10	9/22/2006 8:22	25.8	11	9/22/2006 8:51
71.1	10	9/22/2006 8:22	27.9	11	9/22/2006 8:51
56	10	9/22/2006 8:22	42.8	11	9/22/2006 8:51
58.7	10	9/22/2006 8:22	30.8	11	9/22/2006 8:51
24.4	10	9/22/2006 8:22	36	11	9/22/2006 8:51
22.6	10	9/22/2006 8:22	42.5	11	9/22/2006 8:51
22	10	9/22/2006 8:22	37.4	11	9/22/2006 8:51
26.7	10	9/22/2006 8:22	36.4	11	9/22/2006 8:51
35.9	10	9/22/2006 8:22	37.7	11	9/22/2006 8:51
114	10	9/22/2006 8:22	39.6	11	9/22/2006 8:51
118	10	9/22/2006 8:22	38.8	11	9/22/2006 8:51
505	10	9/22/2006 8:22	40.1	11	9/22/2006 8:51
235	10	9/22/2006 8:22	38.2	11	9/22/2006 8:51
102	10	9/22/2006 8:22	36.4	11	9/22/2006 8:51
36.3	10	9/22/2006 8:22	35.3	11	9/22/2006 8:52
35.7	10	9/22/2006 8:22	41.1	11	9/22/2006 8:52
23.9	10	9/22/2006 8:22	81.3	11	9/22/2006 8:52
79.7	10	9/22/2006 8:22	96.3	11	9/22/2006 8:52
103	10	9/22/2006 8:22	84	11	9/22/2006 8:52
92.5	10	9/22/2006 8:22	36.9	11	9/22/2006 8:52
139	10	9/22/2006 8:22	23	11	9/22/2006 8:52
163	10	9/22/2006 8:22	22.7	11	9/22/2006 8:52
31	10	9/22/2006 8:22	22.4	11	9/22/2006 8:52
20.7	10	9/22/2006 8:22	22.3	11	9/22/2006 8:52
20.6	10	9/22/2006 8:22	22	11	9/22/2006 8:52
21	10	9/22/2006 8:22	83.4	11	9/22/2006 8:52
20.8	10	9/22/2006 8:22	48.4	11	9/22/2006 8:52
20.8	10	9/22/2006 8:23	156	11	9/22/2006 8:52
20.9	10	9/22/2006 8:23	143	11	9/22/2006 8:52
21	10	9/22/2006 8:23	104	11	9/22/2006 8:52
21.4	10	9/22/2006 8:23	45.8	11	9/22/2006 8:52
21.5	10	9/22/2006 8:23	33	11	9/22/2006 8:52
21.8	10	9/22/2006 8:23	31.2	11	9/22/2006 8:52
21.8	10	9/22/2006 8:23	38.3	11	9/22/2006 8:52
21.5	10	9/22/2006 8:23	68.7	11	9/22/2006 8:52
21.3	10	9/22/2006 8:23	48.8	11	9/22/2006 8:52
21.2	10	9/22/2006 8:23	43.9	11	9/22/2006 8:52
21.3	10	9/22/2006 8:23	23.6	11	9/22/2006 8:52
21.3	10	9/22/2006 8:23	22.5	11	9/22/2006 8:52
21.4	10	9/22/2006 8:23	21.9	11	9/22/2006 8:52
21.2	10	9/22/2006 8:23	22.9	11	9/22/2006 8:52
22.1	10	9/22/2006 8:23	23.7	11	9/22/2006 8:52
133	10	9/22/2006 8:23	29	11	9/22/2006 8:52
481	10	9/22/2006 8:23	43.3	11	9/22/2006 8:52
269	10	9/22/2006 8:23	54.3	11	9/22/2006 8:52
167	10	9/22/2006 8:23	65.2	11	9/22/2006 8:52
121	10	9/22/2006 8:23	110	11	9/22/2006 8:52
98.7	10	9/22/2006 8:23	108	11	9/22/2006 8:53
84.8	10	9/22/2006 8:23	73.4	11	9/22/2006 8:53

Path Measurement Data Site 6 Path 1			Path Measurement Data Site 6 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
183	10	9/22/2006 8:23	54	11	9/22/2006 8:53
186	10	9/22/2006 8:23	41.5	11	9/22/2006 8:53
211	10	9/22/2006 8:23	51.6	11	9/22/2006 8:53
164	10	9/22/2006 8:23	242	11	9/22/2006 8:53
200	10	9/22/2006 8:23	132	11	9/22/2006 8:53
175	10	9/22/2006 8:23	125	11	9/22/2006 8:53
177	10	9/22/2006 8:23	135	11	9/22/2006 8:53
160	10	9/22/2006 8:23	117	11	9/22/2006 8:53
137	10	9/22/2006 8:23	132	11	9/22/2006 8:53
127	10	9/22/2006 8:23	52.3	11	9/22/2006 8:53
118	10	9/22/2006 8:23	31.6	11	9/22/2006 8:53
96.8	10	9/22/2006 8:23	26.8	11	9/22/2006 8:53
82.6	10	9/22/2006 8:24	25.7	11	9/22/2006 8:53
54.6	10	9/22/2006 8:24	29.7	11	9/22/2006 8:53
37.4	10	9/22/2006 8:24	24.8	11	9/22/2006 8:53
29.5	10	9/22/2006 8:24	26	11	9/22/2006 8:53
25.5	10	9/22/2006 8:24	27.7	11	9/22/2006 8:53
24	10	9/22/2006 8:24	27.5	11	9/22/2006 8:53
23.4	10	9/22/2006 8:24	23.5	11	9/22/2006 8:53
24	10	9/22/2006 8:24	21.7	11	9/22/2006 8:53
23.1	10	9/22/2006 8:24	21.8	11	9/22/2006 8:53
22.7	10	9/22/2006 8:24	22.4	11	9/22/2006 8:53
23.4	10	9/22/2006 8:24	22.2	11	9/22/2006 8:53
24.9	10	9/22/2006 8:24	22.3	11	9/22/2006 8:53
27.5	10	9/22/2006 8:24	22.4	11	9/22/2006 8:53
29.8	10	9/22/2006 8:24	22.4	11	9/22/2006 8:53
32.1	10	9/22/2006 8:24	22.4	11	9/22/2006 8:53
50.5	10	9/22/2006 8:24	22.3	11	9/22/2006 8:53
780	10	9/22/2006 8:24	22.4	11	9/22/2006 8:53
263	10	9/22/2006 8:24	23.1	11	9/22/2006 8:53
201	10	9/22/2006 8:24	23.3	11	9/22/2006 8:53
216	10	9/22/2006 8:24	22.9	11	9/22/2006 8:53
139	10	9/22/2006 8:24	22.7	11	9/22/2006 8:54
180	10	9/22/2006 8:24	23.5	11	9/22/2006 8:54
170	10	9/22/2006 8:24	25.2	11	9/22/2006 8:54
105	10	9/22/2006 8:24	27.2	11	9/22/2006 8:54
92	10	9/22/2006 8:24	28.5	11	9/22/2006 8:54
77.1	10	9/22/2006 8:24	29.4	11	9/22/2006 8:54
56.5	10	9/22/2006 8:24	28.1	11	9/22/2006 8:54
48.5	10	9/22/2006 8:24	27	11	9/22/2006 8:54
45.3	10	9/22/2006 8:24	26.3	11	9/22/2006 8:54
46.1	10	9/22/2006 8:24	26.1	11	9/22/2006 8:54
38.7	10	9/22/2006 8:24	24.8	11	9/22/2006 8:54
32.1	10	9/22/2006 8:24	48.8	11	9/22/2006 8:54
27.3	10	9/22/2006 8:24	86.7	11	9/22/2006 8:54
26.8	10	9/22/2006 8:25	145	11	9/22/2006 8:54
27.3	10	9/22/2006 8:25	105	11	9/22/2006 8:54
27.4	10	9/22/2006 8:25	120	11	9/22/2006 8:54
32.5	10	9/22/2006 8:25	57.1	11	9/22/2006 8:54
28.2	10	9/22/2006 8:25	57.4	11	9/22/2006 8:54
21.6	10	9/22/2006 8:25	39.7	11	9/22/2006 8:54
21.4	10	9/22/2006 8:25	41	11	9/22/2006 8:54
22.1	10	9/22/2006 8:25	33.3	11	9/22/2006 8:54
23.5	10	9/22/2006 8:25	28.5	11	9/22/2006 8:54
24.2	10	9/22/2006 8:25	26.2	11	9/22/2006 8:54
24.3	10	9/22/2006 8:25	26	11	9/22/2006 8:54
22.9	10	9/22/2006 8:25	26.8	11	9/22/2006 8:54
25.5	10	9/22/2006 8:25	40.9	11	9/22/2006 8:54
27.7	10	9/22/2006 8:25	34.8	11	9/22/2006 8:54
30.3	10	9/22/2006 8:25	42.5	11	9/22/2006 8:54

Path Measurement Data Site 6 Path 1			Path Measurement Data Site 6 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
38	10	9/22/2006 8:25	39.5	11	9/22/2006 8:54
33.2	10	9/22/2006 8:25	54.2	11	9/22/2006 8:54
27.1	10	9/22/2006 8:25	37.6	11	9/22/2006 8:54
32.9	10	9/22/2006 8:25	68.3	11	9/22/2006 8:54
29.2	10	9/22/2006 8:25	104	11	9/22/2006 8:54
27.2	10	9/22/2006 8:25	51.1	11	9/22/2006 8:54
23.7	10	9/22/2006 8:25	79.8	11	9/22/2006 8:54
22.6	10	9/22/2006 8:25	109	11	9/22/2006 8:55
22.5	10	9/22/2006 8:25	82.6	11	9/22/2006 8:55
22.9	10	9/22/2006 8:25	109	11	9/22/2006 8:55
22.2	10	9/22/2006 8:25	81.9	11	9/22/2006 8:55
21.9	10	9/22/2006 8:25	49.1	11	9/22/2006 8:55
21.2	10	9/22/2006 8:25	45.7	11	9/22/2006 8:55
21	10	9/22/2006 8:25	33.9	11	9/22/2006 8:55
21.4	10	9/22/2006 8:25	29.6	11	9/22/2006 8:55
23.7	10	9/22/2006 8:25	27.6	11	9/22/2006 8:55
43.9	10	9/22/2006 8:25	25.1	11	9/22/2006 8:55
32.2	10	9/22/2006 8:25	24.5	11	9/22/2006 8:55
66.3	10	9/22/2006 8:25	24.1	11	9/22/2006 8:55
35.2	10	9/22/2006 8:25	24	11	9/22/2006 8:55
36.5	10	9/22/2006 8:26	38.9	11	9/22/2006 8:55
34.3	10	9/22/2006 8:26	25.1	11	9/22/2006 8:55
26.5	10	9/22/2006 8:26	25.1	11	9/22/2006 8:55
25.5	10	9/22/2006 8:26	23.7	11	9/22/2006 8:55
39.6	10	9/22/2006 8:26	23.7	11	9/22/2006 8:55
35.3	10	9/22/2006 8:26	31.5	11	9/22/2006 8:55
30.4	10	9/22/2006 8:26	43.8	11	9/22/2006 8:55
106	10	9/22/2006 8:26	31.1	11	9/22/2006 8:55
40.3	10	9/22/2006 8:26	43.2	11	9/22/2006 8:55
23.3	10	9/22/2006 8:26	32.4	11	9/22/2006 8:55
50.4	10	9/22/2006 8:26	75.1	11	9/22/2006 8:55
45.7	10	9/22/2006 8:26	94.3	11	9/22/2006 8:55
144	10	9/22/2006 8:26	44.4	11	9/22/2006 8:55
170	10	9/22/2006 8:26	36.7	11	9/22/2006 8:55
86.7	10	9/22/2006 8:26	54.6	11	9/22/2006 8:55
124	10	9/22/2006 8:26	96.5	11	9/22/2006 8:55
74.1	10	9/22/2006 8:26	63	11	9/22/2006 8:55
75.4	10	9/22/2006 8:26	32.2	11	9/22/2006 8:55
102	10	9/22/2006 8:26	45.8	11	9/22/2006 8:55
98.1	10	9/22/2006 8:26	25.4	11	9/22/2006 8:55
69.1	10	9/22/2006 8:26	33.6	11	9/22/2006 8:56
56.9	10	9/22/2006 8:26	36.3	11	9/22/2006 8:56
40.4	10	9/22/2006 8:26	46.7	11	9/22/2006 8:56
33.5	10	9/22/2006 8:26	24	11	9/22/2006 8:56
32.1	10	9/22/2006 8:26	23.6	11	9/22/2006 8:56
31.5	10	9/22/2006 8:26	22.3	11	9/22/2006 8:56
25.2	10	9/22/2006 8:26	69.2	11	9/22/2006 8:56
20.9	10	9/22/2006 8:26	41.4	11	9/22/2006 8:56
20.3	10	9/22/2006 8:26	81	11	9/22/2006 8:56
20.5	10	9/22/2006 8:26	43.3	11	9/22/2006 8:56
20.7	10	9/22/2006 8:26	32.5	11	9/22/2006 8:56
20.5	10	9/22/2006 8:26	35.3	11	9/22/2006 8:56
20.4	10	9/22/2006 8:26	121	11	9/22/2006 8:56
20.5	10	9/22/2006 8:27	75.5	11	9/22/2006 8:56
20.4	10	9/22/2006 8:27	59.6	11	9/22/2006 8:56
20.5	10	9/22/2006 8:27	34.9	11	9/22/2006 8:56
20.6	10	9/22/2006 8:27	27.3	11	9/22/2006 8:56
20.4	10	9/22/2006 8:27	25.7	11	9/22/2006 8:56
20.8	10	9/22/2006 8:27	22.8	11	9/22/2006 8:56
21.8	10	9/22/2006 8:27	22.6	11	9/22/2006 8:56

Path Measurement Data Site 6 Path 1			Path Measurement Data Site 6 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
23.7	10	9/22/2006 8:27	22.4	11	9/22/2006 8:56
28.2	10	9/22/2006 8:27	26.6	11	9/22/2006 8:56
30.9	10	9/22/2006 8:27	22.1	11	9/22/2006 8:56
32.3	10	9/22/2006 8:27	52.1	11	9/22/2006 8:56
33.1	10	9/22/2006 8:27	48.1	11	9/22/2006 8:56
33.3	10	9/22/2006 8:27	24.7	11	9/22/2006 8:56
34.4	10	9/22/2006 8:27	23	11	9/22/2006 8:56
33.9	10	9/22/2006 8:27	21.8	11	9/22/2006 8:56
32.8	10	9/22/2006 8:27	23.4	11	9/22/2006 8:56
31.5	10	9/22/2006 8:27	24	11	9/22/2006 8:56
31.1	10	9/22/2006 8:27	24.3	11	9/22/2006 8:56
30.2	10	9/22/2006 8:27	23.6	11	9/22/2006 8:56
31.1	10	9/22/2006 8:27	26.7	11	9/22/2006 8:56
32.2	10	9/22/2006 8:27	81	11	9/22/2006 8:57
31.3	10	9/22/2006 8:27	61.6	11	9/22/2006 8:57
29.3	10	9/22/2006 8:27	61	11	9/22/2006 8:57
28	10	9/22/2006 8:27	50.7	11	9/22/2006 8:57
27.4	10	9/22/2006 8:27	37.7	11	9/22/2006 8:57
27	10	9/22/2006 8:27	24	11	9/22/2006 8:57
26.5	10	9/22/2006 8:27	23.1	11	9/22/2006 8:57
26.2	10	9/22/2006 8:27	23.2	11	9/22/2006 8:57
25.5	10	9/22/2006 8:27	26	11	9/22/2006 8:57
25.5	10	9/22/2006 8:27	25.5	11	9/22/2006 8:57
25.6	10	9/22/2006 8:27	30.2	11	9/22/2006 8:57
26.2	10	9/22/2006 8:27	28	11	9/22/2006 8:57
26.3	10	9/22/2006 8:27	26	11	9/22/2006 8:57
25.2	10	9/22/2006 8:27	25.6	11	9/22/2006 8:57
25.1	10	9/22/2006 8:28	26.1	11	9/22/2006 8:57
25.5	10	9/22/2006 8:28	27.5	11	9/22/2006 8:57
25.4	10	9/22/2006 8:28	27.2	11	9/22/2006 8:57
25	10	9/22/2006 8:28	27.4	11	9/22/2006 8:57
24.6	10	9/22/2006 8:28	26.4	11	9/22/2006 8:57
24.5	10	9/22/2006 8:28	24.9	11	9/22/2006 8:57
24.4	10	9/22/2006 8:28	26.8	11	9/22/2006 8:57
24.6	10	9/22/2006 8:28	79.7	11	9/22/2006 8:57
24.6	10	9/22/2006 8:28	26.7	11	9/22/2006 8:57
24.9	10	9/22/2006 8:28	31.6	11	9/22/2006 8:57
24.7	10	9/22/2006 8:28	23.9	11	9/22/2006 8:57
24.8	10	9/22/2006 8:28	23.3	11	9/22/2006 8:57
25.9	10	9/22/2006 8:28	23.7	11	9/22/2006 8:57
28.2	10	9/22/2006 8:28	45.9	11	9/22/2006 8:57
32.5	10	9/22/2006 8:28	86	11	9/22/2006 8:57
40.4	10	9/22/2006 8:28	133	11	9/22/2006 8:57
39.7	10	9/22/2006 8:28	71.3	11	9/22/2006 8:57
46.2	10	9/22/2006 8:28	96.2	11	9/22/2006 8:57
95.5	10	9/22/2006 8:28	77.5	11	9/22/2006 8:57
163	10	9/22/2006 8:28	52.5	11	9/22/2006 8:57
175	10	9/22/2006 8:28	39.6	11	9/22/2006 8:58
237	10	9/22/2006 8:28	47.6	11	9/22/2006 8:58
231	10	9/22/2006 8:28	45.1	11	9/22/2006 8:58
167	10	9/22/2006 8:28	35.3	11	9/22/2006 8:58
212	10	9/22/2006 8:28	47.7	11	9/22/2006 8:58
289	10	9/22/2006 8:28	56.6	11	9/22/2006 8:58
250	10	9/22/2006 8:28	81.1	11	9/22/2006 8:58
174	10	9/22/2006 8:28	71.9	11	9/22/2006 8:58
101	10	9/22/2006 8:28	62.2	11	9/22/2006 8:58
96.1	10	9/22/2006 8:28	271	11	9/22/2006 8:58
73.1	10	9/22/2006 8:28	150	11	9/22/2006 8:58
83.5	10	9/22/2006 8:28	61.2	11	9/22/2006 8:58
74.6	10	9/22/2006 8:28	86.2	11	9/22/2006 8:58



Path Measurement Data Site 6 Path 1			Path Measurement Data Site 6 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
77.5	10	9/22/2006 8:28	68.9	11	9/22/2006 8:58
66	10	9/22/2006 8:29	60.3	11	9/22/2006 8:58
71.4	10	9/22/2006 8:29	23.5	11	9/22/2006 8:58
65.1	10	9/22/2006 8:29	23	11	9/22/2006 8:58
59	10	9/22/2006 8:29	23.7	11	9/22/2006 8:58
60.6	10	9/22/2006 8:29	23.9	11	9/22/2006 8:58
59.2	10	9/22/2006 8:29	29	11	9/22/2006 8:58
67.7	10	9/22/2006 8:29	26	11	9/22/2006 8:58
74.6	10	9/22/2006 8:29	23.9	11	9/22/2006 8:58
77.5	10	9/22/2006 8:29	25.2	11	9/22/2006 8:58
84.9	10	9/22/2006 8:29	34.6	11	9/22/2006 8:58
96.6	10	9/22/2006 8:29	130	11	9/22/2006 8:58
97.8	10	9/22/2006 8:29	34	11	9/22/2006 8:58
77.8	10	9/22/2006 8:29	52.3	11	9/22/2006 8:58
63	10	9/22/2006 8:29	103	11	9/22/2006 8:58
64.8	10	9/22/2006 8:29	23	11	9/22/2006 8:58
66.6	10	9/22/2006 8:29	52.9	11	9/22/2006 8:58
64.8	10	9/22/2006 8:29	56.8	11	9/22/2006 8:58
69.9	10	9/22/2006 8:29	21.9	11	9/22/2006 8:58
61.5	10	9/22/2006 8:29	21.6	11	9/22/2006 8:58
59.6	10	9/22/2006 8:29	22.1	11	9/22/2006 8:58
63.3	10	9/22/2006 8:29	23.2	11	9/22/2006 8:59
68	10	9/22/2006 8:29	22.1	11	9/22/2006 8:59
70.3	10	9/22/2006 8:29	23.7	11	9/22/2006 8:59
82.3	10	9/22/2006 8:29	25.6	11	9/22/2006 8:59
355	10	9/22/2006 8:29	25.8	11	9/22/2006 8:59
495	10	9/22/2006 8:29	23.9	11	9/22/2006 8:59
695	10	9/22/2006 8:29	24.6	11	9/22/2006 8:59
345	10	9/22/2006 8:29	23.2	11	9/22/2006 8:59
174	10	9/22/2006 8:29	24.1	11	9/22/2006 8:59
128	10	9/22/2006 8:29	26.8	11	9/22/2006 8:59
56.9	10	9/22/2006 8:29	26.1	11	9/22/2006 8:59
85.8	10	9/22/2006 8:29	25.1	11	9/22/2006 8:59
306	10	9/22/2006 8:29	27.7	11	9/22/2006 8:59
365	10	9/22/2006 8:29	30.3	11	9/22/2006 8:59
258	10	9/22/2006 8:30	35.5	11	9/22/2006 8:59
258	10	9/22/2006 8:30	31.2	11	9/22/2006 8:59
91.4	10	9/22/2006 8:30	26.3	11	9/22/2006 8:59
135	10	9/22/2006 8:30	24.7	11	9/22/2006 8:59
52.8	10	9/22/2006 8:30	25.5	11	9/22/2006 8:59
42.7	10	9/22/2006 8:30	26.3	11	9/22/2006 8:59
38.9	10	9/22/2006 8:30	23.6	11	9/22/2006 8:59
34.2	10	9/22/2006 8:30	24.1	11	9/22/2006 8:59
38.8	10	9/22/2006 8:30	24.8	11	9/22/2006 8:59
56.2	10	9/22/2006 8:30	30.3	11	9/22/2006 8:59
86.2	10	9/22/2006 8:30	25.9	11	9/22/2006 8:59
103	10	9/22/2006 8:30	25.5	11	9/22/2006 8:59
112	10	9/22/2006 8:30	26.9	11	9/22/2006 8:59
121	10	9/22/2006 8:30	27.5	11	9/22/2006 8:59
97.9	10	9/22/2006 8:30	26.9	11	9/22/2006 8:59
81.3	10	9/22/2006 8:30	26	11	9/22/2006 8:59
76	10	9/22/2006 8:30	27.3	11	9/22/2006 8:59
69.4	10	9/22/2006 8:30	27.4	11	9/22/2006 8:59
59.3	10	9/22/2006 8:30	27.6	11	9/22/2006 8:59
81.4	10	9/22/2006 8:30	28.6	11	9/22/2006 8:59
65.6	10	9/22/2006 8:30	27.7	11	9/22/2006 9:00
68.4	10	9/22/2006 8:30	28.6	11	9/22/2006 9:00
28.6	10	9/22/2006 8:30	31	11	9/22/2006 9:00
23.5	10	9/22/2006 8:30	31.8	11	9/22/2006 9:00
24.1	10	9/22/2006 8:30	31.6	11	9/22/2006 9:00

Path Measurement Data Site 6 Path 1			Path Measurement Data Site 6 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
24.8	10	9/22/2006 8:30	28.8	11	9/22/2006 9:00
21.4	10	9/22/2006 8:30	27.7	11	9/22/2006 9:00
21.1	10	9/22/2006 8:30	27.6	11	9/22/2006 9:00
21.3	10	9/22/2006 8:30	29	11	9/22/2006 9:00
21	10	9/22/2006 8:30	31.6	11	9/22/2006 9:00
21.8	10	9/22/2006 8:30	33.8	11	9/22/2006 9:00
21.3	10	9/22/2006 8:30	33.7	11	9/22/2006 9:00
21.5	10	9/22/2006 8:30	42.6	11	9/22/2006 9:00
21.6	10	9/22/2006 8:31	402	11	9/22/2006 9:00
22.1	10	9/22/2006 8:31	375	11	9/22/2006 9:00
22.4	10	9/22/2006 8:31	44.3	11	9/22/2006 9:00
23.2	10	9/22/2006 8:31	70.2	11	9/22/2006 9:00
23.7	10	9/22/2006 8:31	258	11	9/22/2006 9:00
22.6	10	9/22/2006 8:31	44	11	9/22/2006 9:00
22.3	10	9/22/2006 8:31	36.4	11	9/22/2006 9:00
22.1	10	9/22/2006 8:31	35.6	11	9/22/2006 9:00
22.4	10	9/22/2006 8:31	29.3	11	9/22/2006 9:00
22.7	10	9/22/2006 8:31	30.6	11	9/22/2006 9:00
22.4	10	9/22/2006 8:31	33.2	11	9/22/2006 9:00
22.4	10	9/22/2006 8:31	22.2	11	9/22/2006 9:00
23.1	10	9/22/2006 8:31	21.4	11	9/22/2006 9:00
23.9	10	9/22/2006 8:31	21.2	11	9/22/2006 9:00
28.2	10	9/22/2006 8:31	21.2	11	9/22/2006 9:00
43.5	10	9/22/2006 8:31	61.2	11	9/22/2006 9:00
130	10	9/22/2006 8:31	365	11	9/22/2006 9:00
83.6	10	9/22/2006 8:31	580	11	9/22/2006 9:00
86.5	10	9/22/2006 8:31	444	11	9/22/2006 9:00
96.6	10	9/22/2006 8:31	208	11	9/22/2006 9:00
78.7	10	9/22/2006 8:31	88.1	11	9/22/2006 9:00
54.7	10	9/22/2006 8:31	88	11	9/22/2006 9:01
44.9	10	9/22/2006 8:31	30.1	11	9/22/2006 9:01
91.2	10	9/22/2006 8:31	74.8	11	9/22/2006 9:01
55.4	10	9/22/2006 8:31	56.4	11	9/22/2006 9:01
328	10	9/22/2006 8:31	92.2	11	9/22/2006 9:01
86.7	10	9/22/2006 8:31	51.4	11	9/22/2006 9:01
45.4	10	9/22/2006 8:31	82.2	11	9/22/2006 9:01
33.1	10	9/22/2006 8:31	79.4	11	9/22/2006 9:01
140	10	9/22/2006 8:31	42.5	11	9/22/2006 9:01
106	10	9/22/2006 8:31	30.1	11	9/22/2006 9:01
61.8	10	9/22/2006 8:31	38.9	11	9/22/2006 9:01
31.2	10	9/22/2006 8:31	46.4	11	9/22/2006 9:01
29.3	10	9/22/2006 8:31	22.3	11	9/22/2006 9:01
29.6	10	9/22/2006 8:31	22	11	9/22/2006 9:01
29.6	10	9/22/2006 8:32	21.4	11	9/22/2006 9:01
34.1	10	9/22/2006 8:32	21.5	11	9/22/2006 9:01
36.6	10	9/22/2006 8:32	21.8	11	9/22/2006 9:01
32.8	10	9/22/2006 8:32	22.9	11	9/22/2006 9:01
27	10	9/22/2006 8:32	28.8	11	9/22/2006 9:01
27	10	9/22/2006 8:32	27.7	11	9/22/2006 9:01
25.3	10	9/22/2006 8:32	25.2	11	9/22/2006 9:01
28.3	10	9/22/2006 8:32	24.3	11	9/22/2006 9:01
107	10	9/22/2006 8:32			
34.5	10	9/22/2006 8:32			
31.5	10	9/22/2006 8:32			
94.4	10	9/22/2006 8:32			
198	10	9/22/2006 8:32			
141	10	9/22/2006 8:32			
448	10	9/22/2006 8:32			
113	10	9/22/2006 8:32			
159	10	9/22/2006 8:32			

Path Measurement Data Site 6 Path 1			Path Measurement Data Site 6 Path 2		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
65.7	10	9/22/2006 8:32			
199	10	9/22/2006 8:32			
72.8	10	9/22/2006 8:32			
25.1	10	9/22/2006 8:32			
31.5	10	9/22/2006 8:32			
223	10	9/22/2006 8:32			
299	10	9/22/2006 8:32			
80	10	9/22/2006 8:32			
29.5	10	9/22/2006 8:32			
25.8	10	9/22/2006 8:32			
29.1	10	9/22/2006 8:32			
26.9	10	9/22/2006 8:32			
27.2	10	9/22/2006 8:32			
31.1	10	9/22/2006 8:32			
24.9	10	9/22/2006 8:32			
52.7	10	9/22/2006 8:32			
39.2	10	9/22/2006 8:33			
33.8	10	9/22/2006 8:33			
35.4	10	9/22/2006 8:33			
42.6	10	9/22/2006 8:33			
43.3	10	9/22/2006 8:33			
61.5	10	9/22/2006 8:33			
86.9	10	9/22/2006 8:33			
68.2	10	9/22/2006 8:33			
76.1	10	9/22/2006 8:33			
78.4	10	9/22/2006 8:33			
65.8	10	9/22/2006 8:33			
60.5	10	9/22/2006 8:33			
55	10	9/22/2006 8:33			
60.9	10	9/22/2006 8:33			
81.5	10	9/22/2006 8:33			
58.1	10	9/22/2006 8:33			
44.8	10	9/22/2006 8:33			
61.5	10	9/22/2006 8:33			
65.9	10	9/22/2006 8:33			
112	10	9/22/2006 8:33			
112	10	9/22/2006 8:33			
78.5	10	9/22/2006 8:33			
92	10	9/22/2006 8:33			
89.6	10	9/22/2006 8:33			
47.2	10	9/22/2006 8:33			
33.1	10	9/22/2006 8:33			
48.9	10	9/22/2006 8:33			
78	10	9/22/2006 8:33			
136	10	9/22/2006 8:33			
168	10	9/22/2006 8:33			
216	10	9/22/2006 8:33			
186	10	9/22/2006 8:33			

Path Measurement Data Site 6 Path 3			Path Measurement Data Site 6 Path 4		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
30.4	11	9/22/2006 9:04	28.3	11	9/22/2006 9:30
26	11	9/22/2006 9:04	41.1	11	9/22/2006 9:30
58.1	11	9/22/2006 9:04	72.5	11	9/22/2006 9:30
89.5	11	9/22/2006 9:04	73.9	11	9/22/2006 9:30
279	11	9/22/2006 9:04	195	11	9/22/2006 9:30
42.1	11	9/22/2006 9:04	27.3	11	9/22/2006 9:30
47.6	11	9/22/2006 9:04	25.8	11	9/22/2006 9:30
38.8	11	9/22/2006 9:04	28.1	11	9/22/2006 9:30
34.4	11	9/22/2006 9:04	26.9	11	9/22/2006 9:30
29	11	9/22/2006 9:04	24.7	11	9/22/2006 9:30
25.2	11	9/22/2006 9:04	25	11	9/22/2006 9:30
25.5	11	9/22/2006 9:04	25.1	11	9/22/2006 9:30
27.5	11	9/22/2006 9:04	23.4	11	9/22/2006 9:30
28	11	9/22/2006 9:04	23.9	11	9/22/2006 9:30
26.3	11	9/22/2006 9:05	22.8	11	9/22/2006 9:30
23.9	11	9/22/2006 9:05	23.7	11	9/22/2006 9:30
24.7	11	9/22/2006 9:05	24.5	11	9/22/2006 9:30
24.3	11	9/22/2006 9:05	22.8	11	9/22/2006 9:30
34.6	11	9/22/2006 9:05	22.6	11	9/22/2006 9:30
43.8	11	9/22/2006 9:05	22.8	11	9/22/2006 9:30
31.9	11	9/22/2006 9:05	22.8	11	9/22/2006 9:30
41.8	11	9/22/2006 9:05	23	11	9/22/2006 9:30
28.8	11	9/22/2006 9:05	22.8	11	9/22/2006 9:30
29.5	11	9/22/2006 9:05	22.7	11	9/22/2006 9:30
25.8	11	9/22/2006 9:05	22.6	11	9/22/2006 9:30
23.8	11	9/22/2006 9:05	22.6	11	9/22/2006 9:30
23.7	11	9/22/2006 9:05	22.7	11	9/22/2006 9:30
22.1	11	9/22/2006 9:05	22.6	11	9/22/2006 9:30
21.3	11	9/22/2006 9:05	29.6	11	9/22/2006 9:30
21.3	11	9/22/2006 9:05	62.8	11	9/22/2006 9:30
21.5	11	9/22/2006 9:05	138	11	9/22/2006 9:31
21.7	11	9/22/2006 9:05	192	11	9/22/2006 9:31
21.9	11	9/22/2006 9:05	88.2	11	9/22/2006 9:31
22.1	11	9/22/2006 9:05	127	11	9/22/2006 9:31
22.2	11	9/22/2006 9:05	119	11	9/22/2006 9:31
22.3	11	9/22/2006 9:05	105	11	9/22/2006 9:31
22	11	9/22/2006 9:05	227	11	9/22/2006 9:31
22	11	9/22/2006 9:05	328	11	9/22/2006 9:31
22.1	11	9/22/2006 9:05	256	11	9/22/2006 9:31
21.7	11	9/22/2006 9:05	127	11	9/22/2006 9:31
21.3	11	9/22/2006 9:05	88.1	11	9/22/2006 9:31
21.3	11	9/22/2006 9:05	42	11	9/22/2006 9:31
21.3	11	9/22/2006 9:05	22.8	11	9/22/2006 9:31
21.2	11	9/22/2006 9:05	22.8	11	9/22/2006 9:31
21.2	11	9/22/2006 9:05	22.7	11	9/22/2006 9:31
21.2	11	9/22/2006 9:05	23.8	11	9/22/2006 9:31
22.4	11	9/22/2006 9:05	70.5	11	9/22/2006 9:31
21.9	11	9/22/2006 9:05	372	11	9/22/2006 9:31
22.4	11	9/22/2006 9:06	682	11	9/22/2006 9:31
29.3	11	9/22/2006 9:06	348	11	9/22/2006 9:31
23.9	11	9/22/2006 9:06	365	11	9/22/2006 9:31
23.9	11	9/22/2006 9:06	214	11	9/22/2006 9:31
24.1	11	9/22/2006 9:06	67.3	11	9/22/2006 9:31
24.8	11	9/22/2006 9:06	46.3	11	9/22/2006 9:31
33.4	11	9/22/2006 9:06	44	11	9/22/2006 9:31
62.2	11	9/22/2006 9:06	45.2	11	9/22/2006 9:31
21.9	11	9/22/2006 9:06	60.9	11	9/22/2006 9:31
21.6	11	9/22/2006 9:06	89.7	11	9/22/2006 9:31

Path Measurement Data Site 6 Path 3			Path Measurement Data Site 6 Path 4		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
21.5	11	9/22/2006 9:06	32.8	11	9/22/2006 9:31
21.6	11	9/22/2006 9:06	40	11	9/22/2006 9:31
21.5	11	9/22/2006 9:06	42.6	11	9/22/2006 9:31
21.5	11	9/22/2006 9:06	41.2	11	9/22/2006 9:31
21.5	11	9/22/2006 9:06	42.1	11	9/22/2006 9:31
21.6	11	9/22/2006 9:06	42.6	11	9/22/2006 9:32
21.5	11	9/22/2006 9:06	43.8	11	9/22/2006 9:32
21.4	11	9/22/2006 9:06	31.1	11	9/22/2006 9:32
21.6	11	9/22/2006 9:06	27.7	11	9/22/2006 9:32
21.7	11	9/22/2006 9:06	32.9	11	9/22/2006 9:32
21.6	11	9/22/2006 9:06	28.4	11	9/22/2006 9:32
21.5	11	9/22/2006 9:06	24.4	11	9/22/2006 9:32
21.8	11	9/22/2006 9:06	28.5	11	9/22/2006 9:32
21.6	11	9/22/2006 9:06	25.1	11	9/22/2006 9:32
21.8	11	9/22/2006 9:06	23.9	11	9/22/2006 9:32
21.7	11	9/22/2006 9:06	23	11	9/22/2006 9:32
21.6	11	9/22/2006 9:06	22.6	11	9/22/2006 9:32
21.7	11	9/22/2006 9:06	22.4	11	9/22/2006 9:32
21.5	11	9/22/2006 9:06	22.2	11	9/22/2006 9:32
21.6	11	9/22/2006 9:06	22.1	11	9/22/2006 9:32
21.5	11	9/22/2006 9:06	22.2	11	9/22/2006 9:32
21.5	11	9/22/2006 9:06	22.1	11	9/22/2006 9:32
21.4	11	9/22/2006 9:06	22.2	11	9/22/2006 9:32
21.6	11	9/22/2006 9:06	22.3	11	9/22/2006 9:32
21.4	11	9/22/2006 9:07	22.1	11	9/22/2006 9:32
21.5	11	9/22/2006 9:07	22.2	11	9/22/2006 9:32
21.5	11	9/22/2006 9:07	22.2	11	9/22/2006 9:32
21.6	11	9/22/2006 9:07	22.2	11	9/22/2006 9:32
21.5	11	9/22/2006 9:07	26.3	11	9/22/2006 9:32
21.6	11	9/22/2006 9:07	24.1	11	9/22/2006 9:32
32.5	11	9/22/2006 9:07	34.6	11	9/22/2006 9:32
27.2	11	9/22/2006 9:07	62	11	9/22/2006 9:32
25.6	11	9/22/2006 9:07	79	11	9/22/2006 9:32
27.4	11	9/22/2006 9:07	215	11	9/22/2006 9:32
24.7	11	9/22/2006 9:07	247	11	9/22/2006 9:32
26.9	11	9/22/2006 9:07	179	11	9/22/2006 9:32
26.9	11	9/22/2006 9:07	273	11	9/22/2006 9:32
26.5	11	9/22/2006 9:07	108	11	9/22/2006 9:32
27.6	11	9/22/2006 9:07	58.2	11	9/22/2006 9:32
24.1	11	9/22/2006 9:07	97.4	11	9/22/2006 9:32
22.9	11	9/22/2006 9:07	103	11	9/22/2006 9:33
21.9	11	9/22/2006 9:07	120	11	9/22/2006 9:33
32.8	11	9/22/2006 9:07	193	11	9/22/2006 9:33
56.5	11	9/22/2006 9:07	151	11	9/22/2006 9:33
37.3	11	9/22/2006 9:07	119	11	9/22/2006 9:33
25.7	11	9/22/2006 9:07	86.4	11	9/22/2006 9:33
29.4	11	9/22/2006 9:07	58.1	11	9/22/2006 9:33
38.4	11	9/22/2006 9:07	75.3	11	9/22/2006 9:33
29.8	11	9/22/2006 9:07	208	11	9/22/2006 9:33
29.1	11	9/22/2006 9:07	68.6	11	9/22/2006 9:33
30.4	11	9/22/2006 9:07	31.3	11	9/22/2006 9:33
32.6	11	9/22/2006 9:07	29.5	11	9/22/2006 9:33
25.2	11	9/22/2006 9:07	47.5	11	9/22/2006 9:33
33.4	11	9/22/2006 9:07	49	11	9/22/2006 9:33
24.2	11	9/22/2006 9:07	33.9	11	9/22/2006 9:33
21.9	11	9/22/2006 9:07	29.7	11	9/22/2006 9:33
22.7	11	9/22/2006 9:07	29.1	11	9/22/2006 9:33
25.8	11	9/22/2006 9:07	28	11	9/22/2006 9:33
24.1	11	9/22/2006 9:08	26.3	11	9/22/2006 9:33
32.2	11	9/22/2006 9:08	31.6	11	9/22/2006 9:33

Path Measurement Data Site 6 Path 3			Path Measurement Data Site 6 Path 4		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
23.9	11	9/22/2006 9:08	30	11	9/22/2006 9:33
23.4	11	9/22/2006 9:08	28.6	11	9/22/2006 9:33
25.7	11	9/22/2006 9:08	29.1	11	9/22/2006 9:33
26.4	11	9/22/2006 9:08	32	11	9/22/2006 9:33
23.8	11	9/22/2006 9:08	33.5	11	9/22/2006 9:33
25.2	11	9/22/2006 9:08	30.9	11	9/22/2006 9:33
27.4	11	9/22/2006 9:08	26.3	11	9/22/2006 9:33
25.2	11	9/22/2006 9:08	29.7	11	9/22/2006 9:33
28.6	11	9/22/2006 9:08	34.4	11	9/22/2006 9:33
29.3	11	9/22/2006 9:08	28.8	11	9/22/2006 9:33
28.7	11	9/22/2006 9:08	29.9	11	9/22/2006 9:33
26.9	11	9/22/2006 9:08	27.7	11	9/22/2006 9:33
22.8	11	9/22/2006 9:08	25.9	11	9/22/2006 9:33
23.1	11	9/22/2006 9:08	23.5	11	9/22/2006 9:34
23.2	11	9/22/2006 9:08	25.4	11	9/22/2006 9:34
26.1	11	9/22/2006 9:08	23.5	11	9/22/2006 9:34
23.1	11	9/22/2006 9:08	24.2	11	9/22/2006 9:34
21.3	11	9/22/2006 9:08	23.4	11	9/22/2006 9:34
21.2	11	9/22/2006 9:08	23.6	11	9/22/2006 9:34
21.3	11	9/22/2006 9:08	25	11	9/22/2006 9:34
21.3	11	9/22/2006 9:08	24.4	11	9/22/2006 9:34
21.1	11	9/22/2006 9:08	24.7	11	9/22/2006 9:34
21.3	11	9/22/2006 9:08	24	11	9/22/2006 9:34
21.4	11	9/22/2006 9:08	23.2	11	9/22/2006 9:34
21.8	11	9/22/2006 9:08	23.3	11	9/22/2006 9:34
21.6	11	9/22/2006 9:08	22.9	11	9/22/2006 9:34
21.4	11	9/22/2006 9:08	22.7	11	9/22/2006 9:34
21.2	11	9/22/2006 9:08	23.8	11	9/22/2006 9:34
21.2	11	9/22/2006 9:08	32.5	11	9/22/2006 9:34
21	11	9/22/2006 9:08	26.1	11	9/22/2006 9:34
21.2	11	9/22/2006 9:08	24.8	11	9/22/2006 9:34
21.2	11	9/22/2006 9:08	24.6	11	9/22/2006 9:34
21.1	11	9/22/2006 9:09	31.9	11	9/22/2006 9:34
21	11	9/22/2006 9:09	77.4	11	9/22/2006 9:34
21.1	11	9/22/2006 9:09	65.9	11	9/22/2006 9:34
21	11	9/22/2006 9:09	120	11	9/22/2006 9:34
21.2	11	9/22/2006 9:09	299	11	9/22/2006 9:34
21.1	11	9/22/2006 9:09	760	11	9/22/2006 9:34
21	11	9/22/2006 9:09	900	11	9/22/2006 9:34
21.3	11	9/22/2006 9:09	883	11	9/22/2006 9:34
21	11	9/22/2006 9:09	101	11	9/22/2006 9:34
21.2	11	9/22/2006 9:09	50.6	11	9/22/2006 9:34
21.1	11	9/22/2006 9:09	46.4	11	9/22/2006 9:34
24.1	11	9/22/2006 9:09	31.3	11	9/22/2006 9:34
24.1	11	9/22/2006 9:09	41	11	9/22/2006 9:34
26.6	11	9/22/2006 9:09	66.9	11	9/22/2006 9:34
26.3	11	9/22/2006 9:09	63	11	9/22/2006 9:34
26.3	11	9/22/2006 9:09	29.9	11	9/22/2006 9:35
27.3	11	9/22/2006 9:09	31	11	9/22/2006 9:35
26	11	9/22/2006 9:09	26.8	11	9/22/2006 9:35
23.9	11	9/22/2006 9:09	26.1	11	9/22/2006 9:35
25.2	11	9/22/2006 9:09	29	11	9/22/2006 9:35
30.7	11	9/22/2006 9:09	36.7	11	9/22/2006 9:35
24.3	11	9/22/2006 9:09	32.1	11	9/22/2006 9:35
24.7	11	9/22/2006 9:09	51.1	11	9/22/2006 9:35
21.6	11	9/22/2006 9:09	38.9	11	9/22/2006 9:35
23.3	11	9/22/2006 9:09	35.2	11	9/22/2006 9:35
24	11	9/22/2006 9:09	33.6	11	9/22/2006 9:35
21	11	9/22/2006 9:09	31.3	11	9/22/2006 9:35
21.1	11	9/22/2006 9:09	28.6	11	9/22/2006 9:35

Path Measurement Data Site 6 Path 3			Path Measurement Data Site 6 Path 4		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
26.7	11	9/22/2006 9:09	27.3	11	9/22/2006 9:35
22.7	11	9/22/2006 9:09	35.4	11	9/22/2006 9:35
21.9	11	9/22/2006 9:09	31.3	11	9/22/2006 9:35
60.8	11	9/22/2006 9:09	29.8	11	9/22/2006 9:35
27.2	11	9/22/2006 9:09	29	11	9/22/2006 9:35
25.4	11	9/22/2006 9:09	26	11	9/22/2006 9:35
23.8	11	9/22/2006 9:09	25.5	11	9/22/2006 9:35
24.7	11	9/22/2006 9:10	25.5	11	9/22/2006 9:35
23.2	11	9/22/2006 9:10	26.9	11	9/22/2006 9:35
27.3	11	9/22/2006 9:10	44.4	11	9/22/2006 9:35
28.6	11	9/22/2006 9:10	286	11	9/22/2006 9:35
21.3	11	9/22/2006 9:10	574	11	9/22/2006 9:35
21.4	11	9/22/2006 9:10	315	11	9/22/2006 9:35
21.2	11	9/22/2006 9:10	88.6	11	9/22/2006 9:35
21.5	11	9/22/2006 9:10	100	11	9/22/2006 9:35
22	11	9/22/2006 9:10	195	11	9/22/2006 9:35
24	11	9/22/2006 9:10	37.8	11	9/22/2006 9:35
23.8	11	9/22/2006 9:10	36.2	11	9/22/2006 9:35
24.2	11	9/22/2006 9:10	143	11	9/22/2006 9:35
37.3	11	9/22/2006 9:10	205	11	9/22/2006 9:35
95.1	11	9/22/2006 9:10	209	11	9/22/2006 9:35
45.9	11	9/22/2006 9:10	172	11	9/22/2006 9:36
24.5	11	9/22/2006 9:10	53.5	11	9/22/2006 9:36
25.1	11	9/22/2006 9:10	36.6	11	9/22/2006 9:36
23.3	11	9/22/2006 9:10	37.5	11	9/22/2006 9:36
23	11	9/22/2006 9:10	34.3	11	9/22/2006 9:36
23.2	11	9/22/2006 9:10	26	11	9/22/2006 9:36
27.4	11	9/22/2006 9:10	28.6	11	9/22/2006 9:36
26.9	11	9/22/2006 9:10	40.1	11	9/22/2006 9:36
25.7	11	9/22/2006 9:10	40.7	11	9/22/2006 9:36
23.5	11	9/22/2006 9:10	39	11	9/22/2006 9:36
23.3	11	9/22/2006 9:10	39.8	11	9/22/2006 9:36
22.6	11	9/22/2006 9:10	36.8	11	9/22/2006 9:36
22.5	11	9/22/2006 9:10	34.7	11	9/22/2006 9:36
24.1	11	9/22/2006 9:10	32.2	11	9/22/2006 9:36
96.6	11	9/22/2006 9:10	28.5	11	9/22/2006 9:36
284	11	9/22/2006 9:10	30.7	11	9/22/2006 9:36
82.9	11	9/22/2006 9:10	28.1	11	9/22/2006 9:36
95.2	11	9/22/2006 9:10	25.9	11	9/22/2006 9:36
29.5	11	9/22/2006 9:10	31.3	11	9/22/2006 9:36
23	11	9/22/2006 9:10	27.1	11	9/22/2006 9:36
25.7	11	9/22/2006 9:11	26.9	11	9/22/2006 9:36
28	11	9/22/2006 9:11	25.7	11	9/22/2006 9:36
52.5	11	9/22/2006 9:11	25.2	11	9/22/2006 9:36
37.7	11	9/22/2006 9:11	25.9	11	9/22/2006 9:36
22	11	9/22/2006 9:11	26.6	11	9/22/2006 9:36
22.8	11	9/22/2006 9:11	29	11	9/22/2006 9:36
25.3	11	9/22/2006 9:11	42.6	11	9/22/2006 9:36
25.3	11	9/22/2006 9:11	94.6	11	9/22/2006 9:36
22.5	11	9/22/2006 9:11	146	11	9/22/2006 9:36
23	11	9/22/2006 9:11	176	11	9/22/2006 9:36
24.6	11	9/22/2006 9:11	112	11	9/22/2006 9:36
25.2	11	9/22/2006 9:11	100	11	9/22/2006 9:36
26.3	11	9/22/2006 9:11	99.9	11	9/22/2006 9:36
26.4	11	9/22/2006 9:11	103	11	9/22/2006 9:36
34.7	11	9/22/2006 9:11	114	11	9/22/2006 9:37
93.9	11	9/22/2006 9:11	128	11	9/22/2006 9:37
214	11	9/22/2006 9:11	138	11	9/22/2006 9:37
133	11	9/22/2006 9:11	141	11	9/22/2006 9:37
93.6	11	9/22/2006 9:11	141	11	9/22/2006 9:37

Path Measurement Data Site 6 Path 3			Path Measurement Data Site 6 Path 4		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
59.1	11	9/22/2006 9:11	137	11	9/22/2006 9:37
40.2	11	9/22/2006 9:11	129	11	9/22/2006 9:37
27.1	11	9/22/2006 9:11	106	11	9/22/2006 9:37
21.9	11	9/22/2006 9:11	94.7	11	9/22/2006 9:37
21.8	11	9/22/2006 9:11	89.1	11	9/22/2006 9:37
21.7	11	9/22/2006 9:11	58.9	11	9/22/2006 9:37
21.6	11	9/22/2006 9:11	39.2	11	9/22/2006 9:37
21.5	11	9/22/2006 9:11	34	11	9/22/2006 9:37
21.4	11	9/22/2006 9:11	32.4	11	9/22/2006 9:37
21.5	11	9/22/2006 9:11	27.1	11	9/22/2006 9:37
21.3	11	9/22/2006 9:11	42.7	11	9/22/2006 9:37
25.7	11	9/22/2006 9:11	93	11	9/22/2006 9:37
23	11	9/22/2006 9:11	105	11	9/22/2006 9:37
23.6	11	9/22/2006 9:11	109	11	9/22/2006 9:37
40.6	11	9/22/2006 9:12	115	11	9/22/2006 9:37
26.8	11	9/22/2006 9:12	69.1	11	9/22/2006 9:37
25.4	11	9/22/2006 9:12	62.6	11	9/22/2006 9:37
27	11	9/22/2006 9:12	41.7	11	9/22/2006 9:37
25.5	11	9/22/2006 9:12	34.8	11	9/22/2006 9:37
27	11	9/22/2006 9:12	36.8	11	9/22/2006 9:37
31.7	11	9/22/2006 9:12	33.6	11	9/22/2006 9:37
37.4	11	9/22/2006 9:12	29.3	11	9/22/2006 9:37
31.7	11	9/22/2006 9:12	30.2	11	9/22/2006 9:37
31.5	11	9/22/2006 9:12	27.9	11	9/22/2006 9:37
36.4	11	9/22/2006 9:12	24.8	11	9/22/2006 9:37
37.8	11	9/22/2006 9:12	22.5	11	9/22/2006 9:37
41.3	11	9/22/2006 9:12	22.4	11	9/22/2006 9:37
60.5	11	9/22/2006 9:12	22.4	11	9/22/2006 9:37
47.5	11	9/22/2006 9:12	22.5	11	9/22/2006 9:38
37.1	11	9/22/2006 9:12	22.4	11	9/22/2006 9:38
25.5	11	9/22/2006 9:12	22.6	11	9/22/2006 9:38
22.5	11	9/22/2006 9:12	22.5	11	9/22/2006 9:38
24.3	11	9/22/2006 9:12	22.6	11	9/22/2006 9:38
25.7	11	9/22/2006 9:12	22.5	11	9/22/2006 9:38
32.6	11	9/22/2006 9:12	22.4	11	9/22/2006 9:38
37.4	11	9/22/2006 9:12	22.5	11	9/22/2006 9:38
39	11	9/22/2006 9:12	22.6	11	9/22/2006 9:38
37.2	11	9/22/2006 9:12	22.5	11	9/22/2006 9:38
40.2	11	9/22/2006 9:12	22.6	11	9/22/2006 9:38
38.4	11	9/22/2006 9:12	22.9	11	9/22/2006 9:38
35	11	9/22/2006 9:12	23.1	11	9/22/2006 9:38
38.3	11	9/22/2006 9:12	23	11	9/22/2006 9:38
45.1	11	9/22/2006 9:12	23.4	11	9/22/2006 9:38
56.6	11	9/22/2006 9:12	23.5	11	9/22/2006 9:38
73.4	11	9/22/2006 9:12	23.6	11	9/22/2006 9:38
92.3	11	9/22/2006 9:12	23.4	11	9/22/2006 9:38
52.6	11	9/22/2006 9:12	23.2	11	9/22/2006 9:38
50.5	11	9/22/2006 9:12	22.9	11	9/22/2006 9:38
49	11	9/22/2006 9:12	23	11	9/22/2006 9:38
53.5	11	9/22/2006 9:13	22.7	11	9/22/2006 9:38
44.6	11	9/22/2006 9:13	22.8	11	9/22/2006 9:38
35.2	11	9/22/2006 9:13	23.3	11	9/22/2006 9:38
34.4	11	9/22/2006 9:13	23.3	11	9/22/2006 9:38
36.1	11	9/22/2006 9:13	23.9	11	9/22/2006 9:38
32.1	11	9/22/2006 9:13	24.1	11	9/22/2006 9:38
33.8	11	9/22/2006 9:13	24.7	11	9/22/2006 9:38
30.6	11	9/22/2006 9:13	25	11	9/22/2006 9:38
28.5	11	9/22/2006 9:13	25	11	9/22/2006 9:38
28	11	9/22/2006 9:13	24.8	11	9/22/2006 9:38
92.7	11	9/22/2006 9:13	24.3	11	9/22/2006 9:38



Path Measurement Data Site 6 Path 3			Path Measurement Data Site 6 Path 4		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
393	11	9/22/2006 9:13	24	11	9/22/2006 9:38
222	11	9/22/2006 9:13	23.5	11	9/22/2006 9:38
435	11	9/22/2006 9:13	22.8	11	9/22/2006 9:38
519	11	9/22/2006 9:13	22.7	11	9/22/2006 9:39
372	11	9/22/2006 9:13	22.5	11	9/22/2006 9:39
296	11	9/22/2006 9:13	22.6	11	9/22/2006 9:39
74.7	11	9/22/2006 9:13	22.5	11	9/22/2006 9:39
56.2	11	9/22/2006 9:13	22.7	11	9/22/2006 9:39
51.2	11	9/22/2006 9:13	22.7	11	9/22/2006 9:39
48.1	11	9/22/2006 9:13	22.6	11	9/22/2006 9:39
36.5	11	9/22/2006 9:13	22.8	11	9/22/2006 9:39
30.3	11	9/22/2006 9:13	22.5	11	9/22/2006 9:39
27	11	9/22/2006 9:13	22.5	11	9/22/2006 9:39
23.3	11	9/22/2006 9:13	22.7	11	9/22/2006 9:39
22	11	9/22/2006 9:13	22.9	11	9/22/2006 9:39
21.7	11	9/22/2006 9:13	22.3	11	9/22/2006 9:39
21.7	11	9/22/2006 9:13	22.7	11	9/22/2006 9:39
21.6	11	9/22/2006 9:13	22.6	11	9/22/2006 9:39
21.8	11	9/22/2006 9:13	22.7	11	9/22/2006 9:39
22.5	11	9/22/2006 9:13	22.9	11	9/22/2006 9:39
30.9	11	9/22/2006 9:13	23	11	9/22/2006 9:39
32.1	11	9/22/2006 9:13	23	11	9/22/2006 9:39
34.6	11	9/22/2006 9:13	22.9	11	9/22/2006 9:39
37.2	11	9/22/2006 9:14	22.8	11	9/22/2006 9:39
34.1	11	9/22/2006 9:14	23	11	9/22/2006 9:39
34.7	11	9/22/2006 9:14	22.8	11	9/22/2006 9:39
35.1	11	9/22/2006 9:14	22.7	11	9/22/2006 9:39
30.9	11	9/22/2006 9:14	22.7	11	9/22/2006 9:39
28.5	11	9/22/2006 9:14	22.6	11	9/22/2006 9:39
29.1	11	9/22/2006 9:14	22.8	11	9/22/2006 9:39
30.8	11	9/22/2006 9:14	22.6	11	9/22/2006 9:39
28.3	11	9/22/2006 9:14	22.7	11	9/22/2006 9:39
34	11	9/22/2006 9:14	22.7	11	9/22/2006 9:39
35.1	11	9/22/2006 9:14	22.7	11	9/22/2006 9:39
49	11	9/22/2006 9:14	22.6	11	9/22/2006 9:39
40.8	11	9/22/2006 9:14	22.7	11	9/22/2006 9:39
31.5	11	9/22/2006 9:14	22.7	11	9/22/2006 9:39
35.9	11	9/22/2006 9:14	22.8	11	9/22/2006 9:40
37.9	11	9/22/2006 9:14	22.8	11	9/22/2006 9:40
34.1	11	9/22/2006 9:14	22.6	11	9/22/2006 9:40
29	11	9/22/2006 9:14	22.4	11	9/22/2006 9:40
28.8	11	9/22/2006 9:14	22.7	11	9/22/2006 9:40
27.7	11	9/22/2006 9:14	22.5	11	9/22/2006 9:40
29.1	11	9/22/2006 9:14	22.5	11	9/22/2006 9:40
26.9	11	9/22/2006 9:14	22.4	11	9/22/2006 9:40
25.7	11	9/22/2006 9:14	22.6	11	9/22/2006 9:40
24.8	11	9/22/2006 9:14	22.8	11	9/22/2006 9:40
24	11	9/22/2006 9:14	22.5	11	9/22/2006 9:40
25.9	11	9/22/2006 9:14	22.6	11	9/22/2006 9:40
335	11	9/22/2006 9:14	22.7	11	9/22/2006 9:40
1220	11	9/22/2006 9:14	24	11	9/22/2006 9:40
2012	11	9/22/2006 9:14	31.1	11	9/22/2006 9:40
2312	11	9/22/2006 9:14	28.4	11	9/22/2006 9:40
2151	11	9/22/2006 9:14	30.9	11	9/22/2006 9:40
1273	11	9/22/2006 9:14	33.6	11	9/22/2006 9:40
551	11	9/22/2006 9:14	37.5	11	9/22/2006 9:40
320	11	9/22/2006 9:14	35.8	11	9/22/2006 9:40
207	11	9/22/2006 9:15	34.9	11	9/22/2006 9:40
93.7	11	9/22/2006 9:15	32	11	9/22/2006 9:40
28.6	11	9/22/2006 9:15	34.5	11	9/22/2006 9:40

Path Measurement Data Site 6 Path 3			Path Measurement Data Site 6 Path 4		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
29.6	11	9/22/2006 9:15	31.2	11	9/22/2006 9:40
29.3	11	9/22/2006 9:15	40.6	11	9/22/2006 9:40
27.2	11	9/22/2006 9:15	45.2	11	9/22/2006 9:40
28.7	11	9/22/2006 9:15	152	11	9/22/2006 9:40
29.6	11	9/22/2006 9:15	575	11	9/22/2006 9:40
34.2	11	9/22/2006 9:15	85.8	11	9/22/2006 9:40
35.2	11	9/22/2006 9:15	37.1	11	9/22/2006 9:40
32.2	11	9/22/2006 9:15	51.8	11	9/22/2006 9:40
34.3	11	9/22/2006 9:15	43	11	9/22/2006 9:40
33.1	11	9/22/2006 9:15	40.2	11	9/22/2006 9:40
32	11	9/22/2006 9:15	103	11	9/22/2006 9:40
35.7	11	9/22/2006 9:15	86.7	11	9/22/2006 9:41
34.8	11	9/22/2006 9:15	73.6	11	9/22/2006 9:41
86.4	11	9/22/2006 9:15	405	11	9/22/2006 9:41
40.4	11	9/22/2006 9:15	212	11	9/22/2006 9:41
35.4	11	9/22/2006 9:15	234	11	9/22/2006 9:41
35.6	11	9/22/2006 9:15	282	11	9/22/2006 9:41
35.6	11	9/22/2006 9:15	259	11	9/22/2006 9:41
30.5	11	9/22/2006 9:15	258	11	9/22/2006 9:41
25.9	11	9/22/2006 9:15	360	11	9/22/2006 9:41
23	11	9/22/2006 9:15	180	11	9/22/2006 9:41
22.7	11	9/22/2006 9:15	146	11	9/22/2006 9:41
24.6	11	9/22/2006 9:15	438	11	9/22/2006 9:41
34.7	11	9/22/2006 9:15	471	11	9/22/2006 9:41
30.5	11	9/22/2006 9:15	342	11	9/22/2006 9:41
24.3	11	9/22/2006 9:15	185	11	9/22/2006 9:41
24.4	11	9/22/2006 9:15	43.6	11	9/22/2006 9:41
28.9	11	9/22/2006 9:15	37	11	9/22/2006 9:41
25.5	11	9/22/2006 9:15	33.6	11	9/22/2006 9:41
25.4	11	9/22/2006 9:15	42	11	9/22/2006 9:41
22.7	11	9/22/2006 9:15	32.9	11	9/22/2006 9:41
22.5	11	9/22/2006 9:16	31.4	11	9/22/2006 9:41
22.8	11	9/22/2006 9:16	33.3	11	9/22/2006 9:41
22	11	9/22/2006 9:16	36	11	9/22/2006 9:41
22	11	9/22/2006 9:16	45.3	11	9/22/2006 9:41
22.8	11	9/22/2006 9:16	41.3	11	9/22/2006 9:41
24.1	11	9/22/2006 9:16	38.8	11	9/22/2006 9:41
26	11	9/22/2006 9:16	39.2	11	9/22/2006 9:41
38.7	11	9/22/2006 9:16	67.4	11	9/22/2006 9:41
37.7	11	9/22/2006 9:16	101	11	9/22/2006 9:41
109	11	9/22/2006 9:16	120	11	9/22/2006 9:41
83.1	11	9/22/2006 9:16	217	11	9/22/2006 9:41
371	11	9/22/2006 9:16	161	11	9/22/2006 9:41
434	11	9/22/2006 9:16	66.8	11	9/22/2006 9:41
266	11	9/22/2006 9:16	29.3	11	9/22/2006 9:42
173	11	9/22/2006 9:16	26.7	11	9/22/2006 9:42
460	11	9/22/2006 9:16	25.9	11	9/22/2006 9:42
554	11	9/22/2006 9:16	25	11	9/22/2006 9:42
289	11	9/22/2006 9:16	25.1	11	9/22/2006 9:42
276	11	9/22/2006 9:16	27.1	11	9/22/2006 9:42
264	11	9/22/2006 9:16	26.8	11	9/22/2006 9:42
358	11	9/22/2006 9:16	28.8	11	9/22/2006 9:42
733	11	9/22/2006 9:16	33	11	9/22/2006 9:42
610	11	9/22/2006 9:16	30.1	11	9/22/2006 9:42
995	11	9/22/2006 9:16	31.8	11	9/22/2006 9:42
408	11	9/22/2006 9:16	32.7	11	9/22/2006 9:42
166	11	9/22/2006 9:16	32.9	11	9/22/2006 9:42
134	11	9/22/2006 9:16	32.2	11	9/22/2006 9:42
125	11	9/22/2006 9:16	30.3	11	9/22/2006 9:42
131	11	9/22/2006 9:16	28.5	11	9/22/2006 9:42

Path Measurement Data Site 6 Path 3			Path Measurement Data Site 6 Path 4		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
187	11	9/22/2006 9:16	27.8	11	9/22/2006 9:42
104	11	9/22/2006 9:16	27.2	11	9/22/2006 9:42
481	11	9/22/2006 9:16	27.1	11	9/22/2006 9:42
394	11	9/22/2006 9:16	27.5	11	9/22/2006 9:42
130	11	9/22/2006 9:17	29.3	11	9/22/2006 9:42
203	11	9/22/2006 9:17	26.2	11	9/22/2006 9:42
181	11	9/22/2006 9:17	25.2	11	9/22/2006 9:42
150	11	9/22/2006 9:17	24.4	11	9/22/2006 9:42
137	11	9/22/2006 9:17	24.1	11	9/22/2006 9:42
95.4	11	9/22/2006 9:17	24.2	11	9/22/2006 9:42
54.2	11	9/22/2006 9:17	23.6	11	9/22/2006 9:42
51.1	11	9/22/2006 9:17	23.1	11	9/22/2006 9:42
48.9	11	9/22/2006 9:17	23.1	11	9/22/2006 9:42
47.2	11	9/22/2006 9:17	23.2	11	9/22/2006 9:42
50.6	11	9/22/2006 9:17	24	11	9/22/2006 9:42
54.4	11	9/22/2006 9:17	23.9	11	9/22/2006 9:42
45.7	11	9/22/2006 9:17	24.3	11	9/22/2006 9:42
44.4	11	9/22/2006 9:17	24.7	11	9/22/2006 9:42
43.1	11	9/22/2006 9:17	26	11	9/22/2006 9:42
40.6	11	9/22/2006 9:17	105	11	9/22/2006 9:43
38.9	11	9/22/2006 9:17	162	11	9/22/2006 9:43
39.4	11	9/22/2006 9:17	57.1	11	9/22/2006 9:43
39.5	11	9/22/2006 9:17	86.7	11	9/22/2006 9:43
39.6	11	9/22/2006 9:17	74.5	11	9/22/2006 9:43
36.5	11	9/22/2006 9:17	68.6	11	9/22/2006 9:43
34.1	11	9/22/2006 9:17	47.9	11	9/22/2006 9:43
31.8	11	9/22/2006 9:17	42.9	11	9/22/2006 9:43
31.2	11	9/22/2006 9:17	40.2	11	9/22/2006 9:43
31.1	11	9/22/2006 9:17	33.8	11	9/22/2006 9:43
31.2	11	9/22/2006 9:17	24.2	11	9/22/2006 9:43
31.3	11	9/22/2006 9:17	23.4	11	9/22/2006 9:43
31.5	11	9/22/2006 9:17	22.9	11	9/22/2006 9:43
30.6	11	9/22/2006 9:17	23.2	11	9/22/2006 9:43
31.2	11	9/22/2006 9:17	23.3	11	9/22/2006 9:43
30.7	11	9/22/2006 9:17	23.2	11	9/22/2006 9:43
30.3	11	9/22/2006 9:17	23.4	11	9/22/2006 9:43
29.2	11	9/22/2006 9:17	23.8	11	9/22/2006 9:43
27.7	11	9/22/2006 9:17	23.5	11	9/22/2006 9:43
37	11	9/22/2006 9:18	23.2	11	9/22/2006 9:43
40.4	11	9/22/2006 9:18	23.3	11	9/22/2006 9:43
35.1	11	9/22/2006 9:18	23	11	9/22/2006 9:43
33.5	11	9/22/2006 9:18	23.3	11	9/22/2006 9:43
28.8	11	9/22/2006 9:18	23.3	11	9/22/2006 9:43
38.6	11	9/22/2006 9:18	23.2	11	9/22/2006 9:43
126	11	9/22/2006 9:18	23.1	11	9/22/2006 9:43
167	11	9/22/2006 9:18	23.3	11	9/22/2006 9:43
81.4	11	9/22/2006 9:18	23.4	11	9/22/2006 9:43
151	11	9/22/2006 9:18	23.3	11	9/22/2006 9:43
203	11	9/22/2006 9:18	23.1	11	9/22/2006 9:43
88.7	11	9/22/2006 9:18	23.7	11	9/22/2006 9:43
44.6	11	9/22/2006 9:18	23.6	11	9/22/2006 9:43
30.9	11	9/22/2006 9:18	23.3	11	9/22/2006 9:43
36.7	11	9/22/2006 9:18	23.3	11	9/22/2006 9:44
33.7	11	9/22/2006 9:18	23.4	11	9/22/2006 9:44
34.8	11	9/22/2006 9:18	23.6	11	9/22/2006 9:44
27.8	11	9/22/2006 9:18	23.6	11	9/22/2006 9:44
270	11	9/22/2006 9:18	23.6	11	9/22/2006 9:44
663	11	9/22/2006 9:18	23.2	11	9/22/2006 9:44
103	11	9/22/2006 9:18	22.8	11	9/22/2006 9:44
32.3	11	9/22/2006 9:18	23.5	11	9/22/2006 9:44

Path Measurement Data Site 6 Path 3			Path Measurement Data Site 6 Path 4		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
30.5	11	9/22/2006 9:18	23.3	11	9/22/2006 9:44
25.6	11	9/22/2006 9:18	23.3	11	9/22/2006 9:44
27.8	11	9/22/2006 9:18	23.1	11	9/22/2006 9:44
31.1	11	9/22/2006 9:18	24	11	9/22/2006 9:44
57.7	11	9/22/2006 9:18	23	11	9/22/2006 9:44
55.3	11	9/22/2006 9:18	23.7	11	9/22/2006 9:44
45	11	9/22/2006 9:18	23.1	11	9/22/2006 9:44
41.3	11	9/22/2006 9:18	23.4	11	9/22/2006 9:44
49.7	11	9/22/2006 9:18	23.5	11	9/22/2006 9:44
51	11	9/22/2006 9:18	23.5	11	9/22/2006 9:44
54.6	11	9/22/2006 9:18	23	11	9/22/2006 9:44
49.9	11	9/22/2006 9:18	23.2	11	9/22/2006 9:44
48.3	11	9/22/2006 9:18	23.3	11	9/22/2006 9:44
45.7	11	9/22/2006 9:19	23	11	9/22/2006 9:44
53.5	11	9/22/2006 9:19	22.9	11	9/22/2006 9:44
46.1	11	9/22/2006 9:19	22.8	11	9/22/2006 9:44
43.8	11	9/22/2006 9:19	23.1	11	9/22/2006 9:44
43.1	11	9/22/2006 9:19	23.4	11	9/22/2006 9:44
46.1	11	9/22/2006 9:19	23.3	11	9/22/2006 9:44
45.4	11	9/22/2006 9:19	24.3	11	9/22/2006 9:44
47.3	11	9/22/2006 9:19	26.7	11	9/22/2006 9:44
46.5	11	9/22/2006 9:19	26.8	11	9/22/2006 9:44
43.7	11	9/22/2006 9:19	45.3	11	9/22/2006 9:44
56	11	9/22/2006 9:19	62	11	9/22/2006 9:44
118	11	9/22/2006 9:19	63.1	11	9/22/2006 9:44
459	11	9/22/2006 9:19	35.5	11	9/22/2006 9:45
383	11	9/22/2006 9:19	38.7	11	9/22/2006 9:45
385	11	9/22/2006 9:19	46.9	11	9/22/2006 9:45
1587	11	9/22/2006 9:19	31.6	11	9/22/2006 9:45
969	11	9/22/2006 9:19	26.1	11	9/22/2006 9:45
701	11	9/22/2006 9:19	23.4	11	9/22/2006 9:45
384	11	9/22/2006 9:19	23.1	11	9/22/2006 9:45
52.8	11	9/22/2006 9:19	23.2	11	9/22/2006 9:45
40.6	11	9/22/2006 9:19	23.1	11	9/22/2006 9:45
104	11	9/22/2006 9:19	22.8	11	9/22/2006 9:45
47.5	11	9/22/2006 9:19	23.5	11	9/22/2006 9:45
28.5	11	9/22/2006 9:19	22.6	11	9/22/2006 9:45
24.6	11	9/22/2006 9:19	23.1	11	9/22/2006 9:45
24.1	11	9/22/2006 9:19	23.5	11	9/22/2006 9:45
22.9	11	9/22/2006 9:19	23.2	11	9/22/2006 9:45
21.6	11	9/22/2006 9:19	23.2	11	9/22/2006 9:45
21.5	11	9/22/2006 9:19	23.3	11	9/22/2006 9:45
21.7	11	9/22/2006 9:19	23.3	11	9/22/2006 9:45
22.9	11	9/22/2006 9:19	23	11	9/22/2006 9:45
30.2	11	9/22/2006 9:19	23.1	11	9/22/2006 9:45
34.3	11	9/22/2006 9:20	23	11	9/22/2006 9:45
36.1	11	9/22/2006 9:20	23.2	11	9/22/2006 9:45
48.1	11	9/22/2006 9:20	23.1	11	9/22/2006 9:45
41	11	9/22/2006 9:20	23	11	9/22/2006 9:45
44.7	11	9/22/2006 9:20	23.1	11	9/22/2006 9:45
47.8	11	9/22/2006 9:20	22.9	11	9/22/2006 9:45
44.1	11	9/22/2006 9:20	23	11	9/22/2006 9:45
43	11	9/22/2006 9:20	23.1	11	9/22/2006 9:45
40.2	11	9/22/2006 9:20	23	11	9/22/2006 9:45
38	11	9/22/2006 9:20	23	11	9/22/2006 9:45
35.3	11	9/22/2006 9:20	22.9	11	9/22/2006 9:45
33.9	11	9/22/2006 9:20	22.8	11	9/22/2006 9:45
36.3	11	9/22/2006 9:20	23	11	9/22/2006 9:45
40.1	11	9/22/2006 9:20	23.2	11	9/22/2006 9:45
73.6	11	9/22/2006 9:20	23	11	9/22/2006 9:45

Path Measurement Data Site 6 Path 3			Path Measurement Data Site 6 Path 4		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
41.8	11	9/22/2006 9:20	23.3	11	9/22/2006 9:46
71.3	11	9/22/2006 9:20	23	11	9/22/2006 9:46
99.9	11	9/22/2006 9:20	23.1	11	9/22/2006 9:46
104	11	9/22/2006 9:20	22.7	11	9/22/2006 9:46
88.9	11	9/22/2006 9:20	22.7	11	9/22/2006 9:46
91.6	11	9/22/2006 9:20	22.9	11	9/22/2006 9:46
303	11	9/22/2006 9:20	22.9	11	9/22/2006 9:46
363	11	9/22/2006 9:20	23	11	9/22/2006 9:46
56	11	9/22/2006 9:20	23.1	11	9/22/2006 9:46
28.3	11	9/22/2006 9:20	22.9	11	9/22/2006 9:46
27.4	11	9/22/2006 9:20	22.7	11	9/22/2006 9:46
25.8	11	9/22/2006 9:20	22.9	11	9/22/2006 9:46
24.7	11	9/22/2006 9:20	22.8	11	9/22/2006 9:46
26.5	11	9/22/2006 9:20	23	11	9/22/2006 9:46
26.1	11	9/22/2006 9:20	22.7	11	9/22/2006 9:46
22.6	11	9/22/2006 9:20	23	11	9/22/2006 9:46
26.5	11	9/22/2006 9:20	23.2	11	9/22/2006 9:46
23.4	11	9/22/2006 9:20	23.4	11	9/22/2006 9:46
23.1	11	9/22/2006 9:20	27.9	11	9/22/2006 9:46
23.4	11	9/22/2006 9:21	30.2	11	9/22/2006 9:46
23.6	11	9/22/2006 9:21	37.7	11	9/22/2006 9:46
28.6	11	9/22/2006 9:21	31.9	11	9/22/2006 9:46
23.9	11	9/22/2006 9:21	28.6	11	9/22/2006 9:46
23.9	11	9/22/2006 9:21	30.3	11	9/22/2006 9:46
78.1	11	9/22/2006 9:21	29.5	11	9/22/2006 9:46
58.6	11	9/22/2006 9:21	34.1	11	9/22/2006 9:46
79.9	11	9/22/2006 9:21	27.7	11	9/22/2006 9:46
81.1	11	9/22/2006 9:21	24.6	11	9/22/2006 9:46
53.2	11	9/22/2006 9:21	23.2	11	9/22/2006 9:46
24.6	11	9/22/2006 9:21	23	11	9/22/2006 9:46
24.5	11	9/22/2006 9:21	23.1	11	9/22/2006 9:46
26.4	11	9/22/2006 9:21	23	11	9/22/2006 9:46
23.7	11	9/22/2006 9:21	23.1	11	9/22/2006 9:46
25	11	9/22/2006 9:21	23.1	11	9/22/2006 9:46
22.8	11	9/22/2006 9:21	22.9	11	9/22/2006 9:47
22.7	11	9/22/2006 9:21	23	11	9/22/2006 9:47
22.2	11	9/22/2006 9:21	23	11	9/22/2006 9:47
22.5	11	9/22/2006 9:21	23.1	11	9/22/2006 9:47
25.6	11	9/22/2006 9:21	22.9	11	9/22/2006 9:47
27.3	11	9/22/2006 9:21	23	11	9/22/2006 9:47
26.6	11	9/22/2006 9:21	23	11	9/22/2006 9:47
26.8	11	9/22/2006 9:21	23	11	9/22/2006 9:47
25.7	11	9/22/2006 9:21	22.9	11	9/22/2006 9:47
23.6	11	9/22/2006 9:21	22.9	11	9/22/2006 9:47
22.9	11	9/22/2006 9:21	23.1	11	9/22/2006 9:47
22.7	11	9/22/2006 9:21	22.8	11	9/22/2006 9:47
29.2	11	9/22/2006 9:21	23	11	9/22/2006 9:47
469	11	9/22/2006 9:21	23	11	9/22/2006 9:47
215	11	9/22/2006 9:21	22.9	11	9/22/2006 9:47
238	11	9/22/2006 9:21	23	11	9/22/2006 9:47
140	11	9/22/2006 9:21	23.1	11	9/22/2006 9:47
38.1	11	9/22/2006 9:21	23.1	11	9/22/2006 9:47
32.2	11	9/22/2006 9:21	25	11	9/22/2006 9:47
27.5	11	9/22/2006 9:22	35.7	11	9/22/2006 9:47
25.8	11	9/22/2006 9:22	35.1	11	9/22/2006 9:47
24.5	11	9/22/2006 9:22	35.9	11	9/22/2006 9:47
61.7	11	9/22/2006 9:22	30.6	11	9/22/2006 9:47
66.7	11	9/22/2006 9:22	23.8	11	9/22/2006 9:47
69.3	11	9/22/2006 9:22	22.9	11	9/22/2006 9:47
132	11	9/22/2006 9:22	22.8	11	9/22/2006 9:47

Path Measurement Data Site 6 Path 3			Path Measurement Data Site 6 Path 4		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
154	11	9/22/2006 9:22	22.8	11	9/22/2006 9:47
114	11	9/22/2006 9:22	22.9	11	9/22/2006 9:47
295	11	9/22/2006 9:22	23.2	11	9/22/2006 9:47
1130	11	9/22/2006 9:22	23.1	11	9/22/2006 9:47
863	11	9/22/2006 9:22	23.2	11	9/22/2006 9:47
718	11	9/22/2006 9:22	23.3	11	9/22/2006 9:47
326	11	9/22/2006 9:22	23.2	11	9/22/2006 9:47
295	11	9/22/2006 9:22	23.4	11	9/22/2006 9:48
440	11	9/22/2006 9:22	23.2	11	9/22/2006 9:48
1304	11	9/22/2006 9:22	23.3	11	9/22/2006 9:48
801	11	9/22/2006 9:22	23.3	11	9/22/2006 9:48
462	11	9/22/2006 9:22	77.1	11	9/22/2006 9:48
299	11	9/22/2006 9:22	36.4	11	9/22/2006 9:48
186	11	9/22/2006 9:22	23.4	11	9/22/2006 9:48
172	11	9/22/2006 9:22	23.3	11	9/22/2006 9:48
145	11	9/22/2006 9:22	23.4	11	9/22/2006 9:48
114	11	9/22/2006 9:22	23.4	11	9/22/2006 9:48
94.2	11	9/22/2006 9:22	23.2	11	9/22/2006 9:48
80.6	11	9/22/2006 9:22	23.3	11	9/22/2006 9:48
62.9	11	9/22/2006 9:22	23.2	11	9/22/2006 9:48
65.9	11	9/22/2006 9:22	23.4	11	9/22/2006 9:48
57.4	11	9/22/2006 9:22	23.1	11	9/22/2006 9:48
45.9	11	9/22/2006 9:22	23.3	11	9/22/2006 9:48
40.2	11	9/22/2006 9:22	23.2	11	9/22/2006 9:48
53.5	11	9/22/2006 9:22	23.3	11	9/22/2006 9:48
50.7	11	9/22/2006 9:22	23.2	11	9/22/2006 9:48
34.3	11	9/22/2006 9:22	23.2	11	9/22/2006 9:48
30.2	11	9/22/2006 9:23	23.3	11	9/22/2006 9:48
31.6	11	9/22/2006 9:23	23.3	11	9/22/2006 9:48
29.1	11	9/22/2006 9:23	23.3	11	9/22/2006 9:48
25.8	11	9/22/2006 9:23	23.9	11	9/22/2006 9:48
25.5	11	9/22/2006 9:23	26.3	11	9/22/2006 9:48
26.2	11	9/22/2006 9:23	24.3	11	9/22/2006 9:48
26.1	11	9/22/2006 9:23	23.4	11	9/22/2006 9:48
25.5	11	9/22/2006 9:23	23.4	11	9/22/2006 9:48
25.6	11	9/22/2006 9:23	23.5	11	9/22/2006 9:48
25.6	11	9/22/2006 9:23	23.9	11	9/22/2006 9:48
26.1	11	9/22/2006 9:23	25.6	11	9/22/2006 9:48
25.6	11	9/22/2006 9:23	28.4	11	9/22/2006 9:48
32.4	11	9/22/2006 9:23	24.4	11	9/22/2006 9:48
34.4	11	9/22/2006 9:23	24	11	9/22/2006 9:48
30.1	11	9/22/2006 9:23	23.8	11	9/22/2006 9:48
26.9	11	9/22/2006 9:23	23.8	11	9/22/2006 9:49
26.1	11	9/22/2006 9:23	24.1	11	9/22/2006 9:49
30.6	11	9/22/2006 9:23	23.8	11	9/22/2006 9:49
30.1	11	9/22/2006 9:23	24.3	11	9/22/2006 9:49
28.5	11	9/22/2006 9:23	23.9	11	9/22/2006 9:49
29.1	11	9/22/2006 9:23	23.6	11	9/22/2006 9:49
34.3	11	9/22/2006 9:23	24.3	11	9/22/2006 9:49
143	11	9/22/2006 9:23	24.8	11	9/22/2006 9:49
305	11	9/22/2006 9:23	24.8	11	9/22/2006 9:49
292	11	9/22/2006 9:23	25.6	11	9/22/2006 9:49
478	11	9/22/2006 9:23	24.5	11	9/22/2006 9:49
721	11	9/22/2006 9:23	24.1	11	9/22/2006 9:49
384	11	9/22/2006 9:23	23.7	11	9/22/2006 9:49
356	11	9/22/2006 9:23	24	11	9/22/2006 9:49
143	11	9/22/2006 9:23	23.7	11	9/22/2006 9:49
174	11	9/22/2006 9:23	23.7	11	9/22/2006 9:49
82.6	11	9/22/2006 9:23	23.9	11	9/22/2006 9:49
26.9	11	9/22/2006 9:23	24.1	11	9/22/2006 9:49

Path Measurement Data Site 6 Path 3			Path Measurement Data Site 6 Path 4		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
27.2	11	9/22/2006 9:23	24.2	11	9/22/2006 9:49
24.2	11	9/22/2006 9:24	24	11	9/22/2006 9:49
28.4	11	9/22/2006 9:24	23.8	11	9/22/2006 9:49
26	11	9/22/2006 9:24	23.7	11	9/22/2006 9:49
24.7	11	9/22/2006 9:24	23.6	11	9/22/2006 9:49
24.1	11	9/22/2006 9:24	23.7	11	9/22/2006 9:49
23.7	11	9/22/2006 9:24	23.5	11	9/22/2006 9:49
29.7	11	9/22/2006 9:24	23.6	11	9/22/2006 9:49
40.3	11	9/22/2006 9:24	23.6	11	9/22/2006 9:49
29.1	11	9/22/2006 9:24	23.6	11	9/22/2006 9:49
33	11	9/22/2006 9:24	23.7	11	9/22/2006 9:49
23.8	11	9/22/2006 9:24	23.7	11	9/22/2006 9:49
23.4	11	9/22/2006 9:24	23.6	11	9/22/2006 9:49
23.1	11	9/22/2006 9:24	23.6	11	9/22/2006 9:49
23.2	11	9/22/2006 9:24	23.7	11	9/22/2006 9:49
23.2	11	9/22/2006 9:24	23.6	11	9/22/2006 9:49
23.1	11	9/22/2006 9:24	23.6	11	9/22/2006 9:50
22.6	11	9/22/2006 9:24	23.8	11	9/22/2006 9:50
23	11	9/22/2006 9:24	23.6	11	9/22/2006 9:50
23.7	11	9/22/2006 9:24	23.8	11	9/22/2006 9:50
23.4	11	9/22/2006 9:24	23.6	11	9/22/2006 9:50
23.3	11	9/22/2006 9:24	25.7	11	9/22/2006 9:50
23.8	11	9/22/2006 9:24	26.2	11	9/22/2006 9:50
25.4	11	9/22/2006 9:24	44.7	11	9/22/2006 9:50
25.1	11	9/22/2006 9:24	122	11	9/22/2006 9:50
23.8	11	9/22/2006 9:24	154	11	9/22/2006 9:50
22.3	11	9/22/2006 9:24	38	11	9/22/2006 9:50
25	11	9/22/2006 9:24	27.2	11	9/22/2006 9:50
39.7	11	9/22/2006 9:24	28.7	11	9/22/2006 9:50
51.5	11	9/22/2006 9:24	30.1	11	9/22/2006 9:50
49.3	11	9/22/2006 9:24	36.1	11	9/22/2006 9:50
51.7	11	9/22/2006 9:24	44.5	11	9/22/2006 9:50
35.6	11	9/22/2006 9:24	29.4	11	9/22/2006 9:50
42.2	11	9/22/2006 9:24	26.4	11	9/22/2006 9:50
57.3	11	9/22/2006 9:24	24.7	11	9/22/2006 9:50
48.6	11	9/22/2006 9:25	25	11	9/22/2006 9:50
37.5	11	9/22/2006 9:25	24.6	11	9/22/2006 9:50
33.1	11	9/22/2006 9:25	24.4	11	9/22/2006 9:50
25.4	11	9/22/2006 9:25	24.3	11	9/22/2006 9:50
25.7	11	9/22/2006 9:25	23.8	11	9/22/2006 9:50
24.7	11	9/22/2006 9:25	24.1	11	9/22/2006 9:50
106	11	9/22/2006 9:25	24	11	9/22/2006 9:50
267	11	9/22/2006 9:25	23.4	11	9/22/2006 9:50
177	11	9/22/2006 9:25	23.6	11	9/22/2006 9:50
135	11	9/22/2006 9:25	23.4	11	9/22/2006 9:50
226	11	9/22/2006 9:25	24.2	11	9/22/2006 9:50
83.7	11	9/22/2006 9:25	39.9	11	9/22/2006 9:50
35.4	11	9/22/2006 9:25	87.6	11	9/22/2006 9:50
27.8	11	9/22/2006 9:25	92.4	11	9/22/2006 9:50
33.2	11	9/22/2006 9:25	67.6	11	9/22/2006 9:51
28.6	11	9/22/2006 9:25	38.7	11	9/22/2006 9:51
26.2	11	9/22/2006 9:25	34.3	11	9/22/2006 9:51
26.4	11	9/22/2006 9:25	30.4	11	9/22/2006 9:51
27.2	11	9/22/2006 9:25	25.6	11	9/22/2006 9:51
25.6	11	9/22/2006 9:25	23.9	11	9/22/2006 9:51
24.4	11	9/22/2006 9:25	24.2	11	9/22/2006 9:51
38.7	11	9/22/2006 9:25	24.5	11	9/22/2006 9:51
102	11	9/22/2006 9:25	24.6	11	9/22/2006 9:51
48.8	11	9/22/2006 9:25	23.6	11	9/22/2006 9:51
36.9	11	9/22/2006 9:25	23.3	11	9/22/2006 9:51

Path Measurement Data Site 6 Path 3			Path Measurement Data Site 6 Path 4		
ppm*m	pathlength	Timestamp (mountain time)	ppm*m	pathlength	Timestamp (mountain time)
39.1	11	9/22/2006 9:25	23.6	11	9/22/2006 9:51
31	11	9/22/2006 9:25	23.5	11	9/22/2006 9:51
27	11	9/22/2006 9:25	23.5	11	9/22/2006 9:51
29.3	11	9/22/2006 9:25	23.6	11	9/22/2006 9:51
137	11	9/22/2006 9:25	23.7	11	9/22/2006 9:51
1027	11	9/22/2006 9:25	23.8	11	9/22/2006 9:51
793	11	9/22/2006 9:25	23.7	11	9/22/2006 9:51
391	11	9/22/2006 9:25	23.6	11	9/22/2006 9:51
99.5	11	9/22/2006 9:25	23.5	11	9/22/2006 9:51
56.3	11	9/22/2006 9:26	23.5	11	9/22/2006 9:51
99.9	11	9/22/2006 9:26			
139	11	9/22/2006 9:26			
114	11	9/22/2006 9:26			
286	11	9/22/2006 9:26			
192	11	9/22/2006 9:26			
55.2	11	9/22/2006 9:26			
27.5	11	9/22/2006 9:26			
26.2	11	9/22/2006 9:26			
24.1	11	9/22/2006 9:26			
23.9	11	9/22/2006 9:26			
29.7	11	9/22/2006 9:26			
148	11	9/22/2006 9:26			
690	11	9/22/2006 9:26			
254	11	9/22/2006 9:26			
162	11	9/22/2006 9:26			
146	11	9/22/2006 9:26			
210	11	9/22/2006 9:26			
118	11	9/22/2006 9:26			
45	11	9/22/2006 9:26			
31.1	11	9/22/2006 9:26			
28.6	11	9/22/2006 9:26			
27.3	11	9/22/2006 9:26			
29.2	11	9/22/2006 9:26			
118	11	9/22/2006 9:26			
443	11	9/22/2006 9:26			
444	11	9/22/2006 9:26			
232	11	9/22/2006 9:26			
205	11	9/22/2006 9:26			



Path Measurement Data Site 6 Path 5		
ppm*m	pathlength	Timestamp (mountain time)
23.1	12	9/22/2006 9:53
23.1	12	9/22/2006 9:53
23.2	12	9/22/2006 9:53
23.2	12	9/22/2006 9:53
23.2	12	9/22/2006 9:53
23.2	12	9/22/2006 9:53
23.2	12	9/22/2006 9:53
23.2	12	9/22/2006 9:53
23.2	12	9/22/2006 9:53
23.2	12	9/22/2006 9:53
23.2	12	9/22/2006 9:53
23.2	12	9/22/2006 9:53
23.2	12	9/22/2006 9:53
23.2	12	9/22/2006 9:54
23.3	12	9/22/2006 9:54
23.2	12	9/22/2006 9:54
23.3	12	9/22/2006 9:54
23.3	12	9/22/2006 9:54
23.4	12	9/22/2006 9:54
23.4	12	9/22/2006 9:54
23.4	12	9/22/2006 9:54
23.5	12	9/22/2006 9:54
23.4	12	9/22/2006 9:54
23.4	12	9/22/2006 9:54
23.5	12	9/22/2006 9:54
23.4	12	9/22/2006 9:54
23.5	12	9/22/2006 9:54
23.6	12	9/22/2006 9:54
23.4	12	9/22/2006 9:54
23.7	12	9/22/2006 9:54
23.6	12	9/22/2006 9:54
23.5	12	9/22/2006 9:54
23.4	12	9/22/2006 9:54
23.5	12	9/22/2006 9:54
23.4	12	9/22/2006 9:54
23.5	12	9/22/2006 9:54
23.5	12	9/22/2006 9:54
23.4	12	9/22/2006 9:54
23.4	12	9/22/2006 9:54
23.3	12	9/22/2006 9:54
23.5	12	9/22/2006 9:54
23.4	12	9/22/2006 9:54
23.4	12	9/22/2006 9:54
23.2	12	9/22/2006 9:54
23.2	12	9/22/2006 9:54
23.3	12	9/22/2006 9:54
23.4	12	9/22/2006 9:55
23.2	12	9/22/2006 9:55
23.4	12	9/22/2006 9:55
23.3	12	9/22/2006 9:55
23.4	12	9/22/2006 9:55
23.3	12	9/22/2006 9:55
23.4	12	9/22/2006 9:55
23.4	12	9/22/2006 9:55
23.4	12	9/22/2006 9:55
23.3	12	9/22/2006 9:55

Path Measurement Data Site 6 Path 5		
ppm*m	pathlength	Timestamp (mountain time)
23.2	12	9/22/2006 9:55
23.4	12	9/22/2006 9:55
23.2	12	9/22/2006 9:55
23.1	12	9/22/2006 9:55
23	12	9/22/2006 9:55
23.1	12	9/22/2006 9:55
23.3	12	9/22/2006 9:55
23.2	12	9/22/2006 9:55
23.1	12	9/22/2006 9:55
23.3	12	9/22/2006 9:55
23.4	12	9/22/2006 9:55
23.9	12	9/22/2006 9:55
25.3	12	9/22/2006 9:55
27.9	12	9/22/2006 9:55
27.2	12	9/22/2006 9:55
30.2	12	9/22/2006 9:55
27.9	12	9/22/2006 9:55
24.9	12	9/22/2006 9:55
23.2	12	9/22/2006 9:55
23.2	12	9/22/2006 9:55
23.2	12	9/22/2006 9:55
23.2	12	9/22/2006 9:55
23.4	12	9/22/2006 9:55
23.2	12	9/22/2006 9:55
23.1	12	9/22/2006 9:56
23.1	12	9/22/2006 9:56
23.1	12	9/22/2006 9:56
23.1	12	9/22/2006 9:56
23.1	12	9/22/2006 9:56
23.1	12	9/22/2006 9:56
23	12	9/22/2006 9:56
23.1	12	9/22/2006 9:56
22.9	12	9/22/2006 9:56
22.9	12	9/22/2006 9:56
23.1	12	9/22/2006 9:56
23.1	12	9/22/2006 9:56
23	12	9/22/2006 9:56
22.9	12	9/22/2006 9:56
22.9	12	9/22/2006 9:56
22.9	12	9/22/2006 9:56
22.9	12	9/22/2006 9:56
23	12	9/22/2006 9:56
23	12	9/22/2006 9:56
23	12	9/22/2006 9:56
23.3	12	9/22/2006 9:56
23.3	12	9/22/2006 9:56
23.4	12	9/22/2006 9:56
23.3	12	9/22/2006 9:56
23.5	12	9/22/2006 9:56
23.6	12	9/22/2006 9:56
23.4	12	9/22/2006 9:56
23.4	12	9/22/2006 9:56
23.3	12	9/22/2006 9:56
23.4	12	9/22/2006 9:56
23.4	12	9/22/2006 9:56
23.3	12	9/22/2006 9:56
23.6	12	9/22/2006 9:56

Path Measurement Data Site 6 Path 5		
ppm*m	pathlength	Timestamp (mountain time)
23.4	12	9/22/2006 9:56
23.5	12	9/22/2006 9:56
23.5	12	9/22/2006 9:57
24	12	9/22/2006 9:57
30.1	12	9/22/2006 9:57
33.8	12	9/22/2006 9:57
32.4	12	9/22/2006 9:57
30	12	9/22/2006 9:57
33.2	12	9/22/2006 9:57
23.3	12	9/22/2006 9:57
23.4	12	9/22/2006 9:57
23.3	12	9/22/2006 9:57
23.3	12	9/22/2006 9:57
23.5	12	9/22/2006 9:57
23.3	12	9/22/2006 9:57
23.4	12	9/22/2006 9:57
23.3	12	9/22/2006 9:57
23.4	12	9/22/2006 9:57
23.5	12	9/22/2006 9:57
23.3	12	9/22/2006 9:57
24.3	12	9/22/2006 9:57
25.2	12	9/22/2006 9:57
25.5	12	9/22/2006 9:57
25.9	12	9/22/2006 9:57
26.4	12	9/22/2006 9:57
27.2	12	9/22/2006 9:57
28.8	12	9/22/2006 9:57
27.2	12	9/22/2006 9:57
27.7	12	9/22/2006 9:57
28.4	12	9/22/2006 9:57
28.2	12	9/22/2006 9:57
26.5	12	9/22/2006 9:57
25.3	12	9/22/2006 9:57
24.7	12	9/22/2006 9:57
24.6	12	9/22/2006 9:57
24.2	12	9/22/2006 9:57
23.7	12	9/22/2006 9:57
23.7	12	9/22/2006 9:58
23.5	12	9/22/2006 9:58
23.4	12	9/22/2006 9:58
23.4	12	9/22/2006 9:58
23.4	12	9/22/2006 9:58
23.3	12	9/22/2006 9:58
23.5	12	9/22/2006 9:58
23.7	12	9/22/2006 9:58
23.3	12	9/22/2006 9:58
23.3	12	9/22/2006 9:58
23.6	12	9/22/2006 9:58
24.4	12	9/22/2006 9:58
24.2	12	9/22/2006 9:58
23.8	12	9/22/2006 9:58
23.3	12	9/22/2006 9:58
23.4	12	9/22/2006 9:58
23.4	12	9/22/2006 9:58
23.7	12	9/22/2006 9:58
30.5	12	9/22/2006 9:58

Path Measurement Data Site 6 Path 5		
ppm*m	pathlength	Timestamp (mountain time)
116	12	9/22/2006 9:58
74.8	12	9/22/2006 9:58
33.7	12	9/22/2006 9:58
26	12	9/22/2006 9:58
24.2	12	9/22/2006 9:58
25	12	9/22/2006 9:58
23.6	12	9/22/2006 9:58
23.4	12	9/22/2006 9:58
23.4	12	9/22/2006 9:58
23.4	12	9/22/2006 9:58
23.3	12	9/22/2006 9:58
23.4	12	9/22/2006 9:58
23.4	12	9/22/2006 9:58
23.4	12	9/22/2006 9:58
23.4	12	9/22/2006 9:58
24.3	12	9/22/2006 9:59
26.8	12	9/22/2006 9:59
24.2	12	9/22/2006 9:59
25.1	12	9/22/2006 9:59
24.1	12	9/22/2006 9:59
24.1	12	9/22/2006 9:59
24	12	9/22/2006 9:59
27.3	12	9/22/2006 9:59
27.2	12	9/22/2006 9:59
24.6	12	9/22/2006 9:59
25.2	12	9/22/2006 9:59
28.5	12	9/22/2006 9:59
25.1	12	9/22/2006 9:59
24.2	12	9/22/2006 9:59
23.5	12	9/22/2006 9:59
23.5	12	9/22/2006 9:59
23.3	12	9/22/2006 9:59
23.3	12	9/22/2006 9:59
23.4	12	9/22/2006 9:59
23.3	12	9/22/2006 9:59
23.5	12	9/22/2006 9:59
23.7	12	9/22/2006 9:59
23.4	12	9/22/2006 9:59
23.6	12	9/22/2006 9:59
23.4	12	9/22/2006 9:59
23.6	12	9/22/2006 9:59
23.7	12	9/22/2006 9:59
23.6	12	9/22/2006 9:59
23.5	12	9/22/2006 9:59
23.7	12	9/22/2006 9:59
23.6	12	9/22/2006 9:59
23.5	12	9/22/2006 9:59
23.4	12	9/22/2006 9:59
23.4	12	9/22/2006 9:59
23.7	12	9/22/2006 10:00
23.6	12	9/22/2006 10:00
23.5	12	9/22/2006 10:00
23.7	12	9/22/2006 10:00
23.5	12	9/22/2006 10:00
23.5	12	9/22/2006 10:00
23.5	12	9/22/2006 10:00

Path Measurement Data Site 6 Path 5		
ppm*m	pathlength	Timestamp (mountain time)
23.7	12	9/22/2006 10:00
23.7	12	9/22/2006 10:00
23.6	12	9/22/2006 10:00
23.7	12	9/22/2006 10:00
23.6	12	9/22/2006 10:00
23.7	12	9/22/2006 10:00
23.7	12	9/22/2006 10:00
23.7	12	9/22/2006 10:00
23.6	12	9/22/2006 10:00
23.7	12	9/22/2006 10:00
23.7	12	9/22/2006 10:00
23.5	12	9/22/2006 10:00
23.7	12	9/22/2006 10:00
23.6	12	9/22/2006 10:00
23.7	12	9/22/2006 10:00
23.6	12	9/22/2006 10:00
23.9	12	9/22/2006 10:00
23.8	12	9/22/2006 10:00
23.8	12	9/22/2006 10:00
23.7	12	9/22/2006 10:00
23.5	12	9/22/2006 10:00
23.6	12	9/22/2006 10:00
23.7	12	9/22/2006 10:00
23.8	12	9/22/2006 10:00
23.9	12	9/22/2006 10:00
23.8	12	9/22/2006 10:00
23.9	12	9/22/2006 10:01
23.6	12	9/22/2006 10:01
23.6	12	9/22/2006 10:01
23.6	12	9/22/2006 10:01
23.4	12	9/22/2006 10:01
23.9	12	9/22/2006 10:01
23.8	12	9/22/2006 10:01
23.8	12	9/22/2006 10:01
23.7	12	9/22/2006 10:01
23.7	12	9/22/2006 10:01
23.9	12	9/22/2006 10:01
24.8	12	9/22/2006 10:01
23.8	12	9/22/2006 10:01
23.9	12	9/22/2006 10:01
23.8	12	9/22/2006 10:01
23.8	12	9/22/2006 10:01
23.8	12	9/22/2006 10:01
23.7	12	9/22/2006 10:01
24	12	9/22/2006 10:01
23.8	12	9/22/2006 10:01
23.9	12	9/22/2006 10:01
24	12	9/22/2006 10:01
24.1	12	9/22/2006 10:01
24.2	12	9/22/2006 10:01
24.3	12	9/22/2006 10:01
24.2	12	9/22/2006 10:01
25.6	12	9/22/2006 10:01
24.6	12	9/22/2006 10:01
24.4	12	9/22/2006 10:01
23.8	12	9/22/2006 10:01

Path Measurement Data Site 6 Path 5		
ppm*m	pathlength	Timestamp (mountain time)
23.8	12	9/22/2006 10:01
24.3	12	9/22/2006 10:01
24.6	12	9/22/2006 10:01
24.3	12	9/22/2006 10:01
24.1	12	9/22/2006 10:01
24.2	12	9/22/2006 10:02
24.1	12	9/22/2006 10:02
24	12	9/22/2006 10:02
24.1	12	9/22/2006 10:02
24.1	12	9/22/2006 10:02
24.1	12	9/22/2006 10:02
24	12	9/22/2006 10:02
24	12	9/22/2006 10:02
24	12	9/22/2006 10:02
24.2	12	9/22/2006 10:02
24	12	9/22/2006 10:02
23.9	12	9/22/2006 10:02
23.9	12	9/22/2006 10:02
24	12	9/22/2006 10:02
23.7	12	9/22/2006 10:02
23.7	12	9/22/2006 10:02
23.8	12	9/22/2006 10:02
23.8	12	9/22/2006 10:02
23.6	12	9/22/2006 10:02
23.5	12	9/22/2006 10:02
23.7	12	9/22/2006 10:02
23.6	12	9/22/2006 10:02
23.6	12	9/22/2006 10:02
23.6	12	9/22/2006 10:02
23.6	12	9/22/2006 10:02
23.8	12	9/22/2006 10:02
23.5	12	9/22/2006 10:02
23.6	12	9/22/2006 10:02
23.6	12	9/22/2006 10:02
23.6	12	9/22/2006 10:02
23.8	12	9/22/2006 10:02
116	12	9/22/2006 10:02
90.8	12	9/22/2006 10:02
24.6	12	9/22/2006 10:02
24.9	12	9/22/2006 10:02
25.6	12	9/22/2006 10:03
26.1	12	9/22/2006 10:03
34.4	12	9/22/2006 10:03
33.2	12	9/22/2006 10:03
27.5	12	9/22/2006 10:03
126	12	9/22/2006 10:03
268	12	9/22/2006 10:03
280	12	9/22/2006 10:03
87.8	12	9/22/2006 10:03
29.2	12	9/22/2006 10:03
45.7	12	9/22/2006 10:03
132	12	9/22/2006 10:03
111	12	9/22/2006 10:03
98.6	12	9/22/2006 10:03
65.3	12	9/22/2006 10:03
54.4	12	9/22/2006 10:03
42.5	12	9/22/2006 10:03

Path Measurement Data Site 6 Path 5		
ppm*m	pathlength	Timestamp (mountain time)
37.7	12	9/22/2006 10:03
32.5	12	9/22/2006 10:03
36.7	12	9/22/2006 10:03
40.7	12	9/22/2006 10:03
40.8	12	9/22/2006 10:03
37.7	12	9/22/2006 10:03
37.1	12	9/22/2006 10:03
33.9	12	9/22/2006 10:03
26.4	12	9/22/2006 10:03
25.8	12	9/22/2006 10:03
23.6	12	9/22/2006 10:03
23.8	12	9/22/2006 10:03
23.8	12	9/22/2006 10:03
23.8	12	9/22/2006 10:03
24	12	9/22/2006 10:03
23.7	12	9/22/2006 10:03
23.6	12	9/22/2006 10:04
23.8	12	9/22/2006 10:04
23.7	12	9/22/2006 10:04
23.7	12	9/22/2006 10:04
23.7	12	9/22/2006 10:04
23.5	12	9/22/2006 10:04
23.6	12	9/22/2006 10:04
23.6	12	9/22/2006 10:04
23.6	12	9/22/2006 10:04
23.7	12	9/22/2006 10:04
23.8	12	9/22/2006 10:04
23.8	12	9/22/2006 10:04
24	12	9/22/2006 10:04
24.6	12	9/22/2006 10:04
24	12	9/22/2006 10:04
23.7	12	9/22/2006 10:04
23.6	12	9/22/2006 10:04
23.7	12	9/22/2006 10:04
23.6	12	9/22/2006 10:04
23.5	12	9/22/2006 10:04
23.4	12	9/22/2006 10:04
23.6	12	9/22/2006 10:04
23.5	12	9/22/2006 10:04
23.5	12	9/22/2006 10:04
23.3	12	9/22/2006 10:04
23.6	12	9/22/2006 10:04
23.4	12	9/22/2006 10:04
23.6	12	9/22/2006 10:04
23.5	12	9/22/2006 10:04
23.3	12	9/22/2006 10:04
23.4	12	9/22/2006 10:04
23.4	12	9/22/2006 10:04
23.4	12	9/22/2006 10:04
23.6	12	9/22/2006 10:04
24	12	9/22/2006 10:04
120	12	9/22/2006 10:05
386	12	9/22/2006 10:05
157	12	9/22/2006 10:05
132	12	9/22/2006 10:05
183	12	9/22/2006 10:05

Path Measurement Data Site 6 Path 5		
ppm*m	pathlength	Timestamp (mountain time)
162	12	9/22/2006 10:05
111	12	9/22/2006 10:05
36.7	12	9/22/2006 10:05
32.1	12	9/22/2006 10:05
27.5	12	9/22/2006 10:05
33.4	12	9/22/2006 10:05
61.4	12	9/22/2006 10:05
48.6	12	9/22/2006 10:05
66.3	12	9/22/2006 10:05
36.8	12	9/22/2006 10:05
27.4	12	9/22/2006 10:05
24.1	12	9/22/2006 10:05
23.7	12	9/22/2006 10:05
24.2	12	9/22/2006 10:05
24.8	12	9/22/2006 10:05
24.9	12	9/22/2006 10:05
25.3	12	9/22/2006 10:05
26.9	12	9/22/2006 10:05
31.4	12	9/22/2006 10:05
38.4	12	9/22/2006 10:05
45.6	12	9/22/2006 10:05
55.8	12	9/22/2006 10:05
55.1	12	9/22/2006 10:05
33.4	12	9/22/2006 10:05
28.2	12	9/22/2006 10:05
25	12	9/22/2006 10:05
24.5	12	9/22/2006 10:05
24.8	12	9/22/2006 10:05
25.5	12	9/22/2006 10:06
26.2	12	9/22/2006 10:06
31.3	12	9/22/2006 10:06
48	12	9/22/2006 10:06
47	12	9/22/2006 10:06
49.2	12	9/22/2006 10:06
56.8	12	9/22/2006 10:06
48.8	12	9/22/2006 10:06
46.3	12	9/22/2006 10:06
30.6	12	9/22/2006 10:06
24.2	12	9/22/2006 10:06
23.8	12	9/22/2006 10:06
23.6	12	9/22/2006 10:06
23.6	12	9/22/2006 10:06
23.5	12	9/22/2006 10:06
23.6	12	9/22/2006 10:06
24	12	9/22/2006 10:06
23.6	12	9/22/2006 10:06
23.9	12	9/22/2006 10:06
23.8	12	9/22/2006 10:06
23.7	12	9/22/2006 10:06
24	12	9/22/2006 10:06
23.5	12	9/22/2006 10:06
23.7	12	9/22/2006 10:06
23.5	12	9/22/2006 10:06
23.7	12	9/22/2006 10:06
23.2	12	9/22/2006 10:06
23.7	12	9/22/2006 10:06



Path Measurement Data Site 6 Path 5		
ppm*m	pathlength	Timestamp (mountain time)
23.7	12	9/22/2006 10:06
23.5	12	9/22/2006 10:06
23.4	12	9/22/2006 10:06
23.4	12	9/22/2006 10:06
23.4	12	9/22/2006 10:06
23.6	12	9/22/2006 10:06
23.6	12	9/22/2006 10:07
23.5	12	9/22/2006 10:07
23.6	12	9/22/2006 10:07
24.6	12	9/22/2006 10:07
25.1	12	9/22/2006 10:07
23.5	12	9/22/2006 10:07
23.6	12	9/22/2006 10:07
23.3	12	9/22/2006 10:07
23.5	12	9/22/2006 10:07
23.4	12	9/22/2006 10:07
23.5	12	9/22/2006 10:07
23.4	12	9/22/2006 10:07
23.5	12	9/22/2006 10:07
23.6	12	9/22/2006 10:07
23.4	12	9/22/2006 10:07
23.4	12	9/22/2006 10:07
23.5	12	9/22/2006 10:07
23.4	12	9/22/2006 10:07
25.4	12	9/22/2006 10:07
38	12	9/22/2006 10:07
75.8	12	9/22/2006 10:07
137	12	9/22/2006 10:07
255	12	9/22/2006 10:07
169	12	9/22/2006 10:07
124	12	9/22/2006 10:07
134	12	9/22/2006 10:07
106	12	9/22/2006 10:07
50.6	12	9/22/2006 10:07
27.5	12	9/22/2006 10:07
25.1	12	9/22/2006 10:07
23.7	12	9/22/2006 10:07
23.6	12	9/22/2006 10:07
24	12	9/22/2006 10:07
23.5	12	9/22/2006 10:07
23.5	12	9/22/2006 10:07
24	12	9/22/2006 10:08
23.8	12	9/22/2006 10:08
23.5	12	9/22/2006 10:08
23.7	12	9/22/2006 10:08
24	12	9/22/2006 10:08
23.5	12	9/22/2006 10:08
24	12	9/22/2006 10:08
23.7	12	9/22/2006 10:08
23.7	12	9/22/2006 10:08
24	12	9/22/2006 10:08
24.4	12	9/22/2006 10:08
24.1	12	9/22/2006 10:08
23.8	12	9/22/2006 10:08
23.9	12	9/22/2006 10:08
23.9	12	9/22/2006 10:08

Path Measurement Data Site 6 Path 5		
ppm*m	pathlength	Timestamp (mountain time)
23.8	12	9/22/2006 10:08
24.1	12	9/22/2006 10:08
24.2	12	9/22/2006 10:08
23.9	12	9/22/2006 10:08
24	12	9/22/2006 10:08
24.5	12	9/22/2006 10:08
24.1	12	9/22/2006 10:08
24.3	12	9/22/2006 10:08
24.2	12	9/22/2006 10:08
24.3	12	9/22/2006 10:08
24.4	12	9/22/2006 10:08
24.6	12	9/22/2006 10:08
25.1	12	9/22/2006 10:08
25.5	12	9/22/2006 10:08
26.2	12	9/22/2006 10:08
29.5	12	9/22/2006 10:08
28.5	12	9/22/2006 10:08
29.2	12	9/22/2006 10:09
27.9	12	9/22/2006 10:09
25.9	12	9/22/2006 10:09
25	12	9/22/2006 10:09
24.6	12	9/22/2006 10:09
24.3	12	9/22/2006 10:09
24.3	12	9/22/2006 10:09
24	12	9/22/2006 10:09
23.9	12	9/22/2006 10:09
23.9	12	9/22/2006 10:09
23.9	12	9/22/2006 10:09
24	12	9/22/2006 10:09
23.9	12	9/22/2006 10:09
24.1	12	9/22/2006 10:09
24	12	9/22/2006 10:09
24.2	12	9/22/2006 10:09
24.2	12	9/22/2006 10:09
24.1	12	9/22/2006 10:09
24.1	12	9/22/2006 10:09
24.3	12	9/22/2006 10:09
24.2	12	9/22/2006 10:09
24.2	12	9/22/2006 10:09
24.1	12	9/22/2006 10:09
24.1	12	9/22/2006 10:09
24.2	12	9/22/2006 10:09
24.2	12	9/22/2006 10:09
24.1	12	9/22/2006 10:09
25.7	12	9/22/2006 10:09
26.5	12	9/22/2006 10:09
30.7	12	9/22/2006 10:09
26	12	9/22/2006 10:09
24.6	12	9/22/2006 10:09
24.4	12	9/22/2006 10:09
24.5	12	9/22/2006 10:09
24.3	12	9/22/2006 10:10
24.3	12	9/22/2006 10:10
24.9	12	9/22/2006 10:10
24.3	12	9/22/2006 10:10
24.2	12	9/22/2006 10:10

Path Measurement Data Site 6 Path 5		
ppm*m	pathlength	Timestamp (mountain time)
24	12	9/22/2006 10:10
24.1	12	9/22/2006 10:10
24	12	9/22/2006 10:10
24	12	9/22/2006 10:10
23.9	12	9/22/2006 10:10
24.1	12	9/22/2006 10:10
23.9	12	9/22/2006 10:10
24	12	9/22/2006 10:10
24.1	12	9/22/2006 10:10
23.9	12	9/22/2006 10:10
24	12	9/22/2006 10:10
24.1	12	9/22/2006 10:10
24.1	12	9/22/2006 10:10
24.1	12	9/22/2006 10:10
24	12	9/22/2006 10:10
24.3	12	9/22/2006 10:10
24.3	12	9/22/2006 10:10
23.8	12	9/22/2006 10:10
23.9	12	9/22/2006 10:10
23.8	12	9/22/2006 10:10
24	12	9/22/2006 10:10
24	12	9/22/2006 10:10
24	12	9/22/2006 10:10
24	12	9/22/2006 10:10
24.1	12	9/22/2006 10:10
24	12	9/22/2006 10:10
24	12	9/22/2006 10:10
24.2	12	9/22/2006 10:10
24	12	9/22/2006 10:10
24	12	9/22/2006 10:10
24.3	12	9/22/2006 10:11
31.1	12	9/22/2006 10:11
25.1	12	9/22/2006 10:11
24	12	9/22/2006 10:11
24.2	12	9/22/2006 10:11
24.3	12	9/22/2006 10:11
24.3	12	9/22/2006 10:11
24.9	12	9/22/2006 10:11
24.4	12	9/22/2006 10:11
24.1	12	9/22/2006 10:11
24	12	9/22/2006 10:11
24	12	9/22/2006 10:11
24.1	12	9/22/2006 10:11
24	12	9/22/2006 10:11
24.1	12	9/22/2006 10:11
24.1	12	9/22/2006 10:11
24.2	12	9/22/2006 10:11
24	12	9/22/2006 10:11
24.1	12	9/22/2006 10:11
24.2	12	9/22/2006 10:11
24.1	12	9/22/2006 10:11
24	12	9/22/2006 10:11
24.1	12	9/22/2006 10:11
24.1	12	9/22/2006 10:11
23.9	12	9/22/2006 10:11
24	12	9/22/2006 10:11
24.1	12	9/22/2006 10:11

Path Measurement Data Site 6 Path 5		
ppm*m	pathlength	Timestamp (mountain time)
24	12	9/22/2006 10:11
24	12	9/22/2006 10:11
23.9	12	9/22/2006 10:11
24	12	9/22/2006 10:11
23.9	12	9/22/2006 10:11
24	12	9/22/2006 10:11
24	12	9/22/2006 10:11
24	12	9/22/2006 10:11
24	12	9/22/2006 10:12
24.3	12	9/22/2006 10:12
24.1	12	9/22/2006 10:12
24.1	12	9/22/2006 10:12
24.1	12	9/22/2006 10:12
24.2	12	9/22/2006 10:12
24.1	12	9/22/2006 10:12
24.1	12	9/22/2006 10:12
24.1	12	9/22/2006 10:12
24.1	12	9/22/2006 10:12
24.1	12	9/22/2006 10:12
24.2	12	9/22/2006 10:12
24.1	12	9/22/2006 10:12
24.1	12	9/22/2006 10:12
24.2	12	9/22/2006 10:12
24.2	12	9/22/2006 10:12
24.2	12	9/22/2006 10:12
24.3	12	9/22/2006 10:12
24.2	12	9/22/2006 10:12
24.1	12	9/22/2006 10:12
24.2	12	9/22/2006 10:12
24.1	12	9/22/2006 10:12
24.1	12	9/22/2006 10:12
24.4	12	9/22/2006 10:12
24.3	12	9/22/2006 10:12
24.4	12	9/22/2006 10:12
28	12	9/22/2006 10:12
47.9	12	9/22/2006 10:12
40.7	12	9/22/2006 10:12
31.4	12	9/22/2006 10:12
24.6	12	9/22/2006 10:12
24.3	12	9/22/2006 10:12
24	12	9/22/2006 10:12
24.1	12	9/22/2006 10:12
24.2	12	9/22/2006 10:13
24.3	12	9/22/2006 10:13
24.4	12	9/22/2006 10:13
24.6	12	9/22/2006 10:13
24.4	12	9/22/2006 10:13
24.4	12	9/22/2006 10:13
24.4	12	9/22/2006 10:13
24.4	12	9/22/2006 10:13
24.4	12	9/22/2006 10:13
24.5	12	9/22/2006 10:13
24.4	12	9/22/2006 10:13
24.5	12	9/22/2006 10:13
24.4	12	9/22/2006 10:13
24.3	12	9/22/2006 10:13
64.1	12	9/22/2006 10:13
74.1	12	9/22/2006 10:13

Path Measurement Data Site 6 Path 5		
ppm*m	pathlength	Timestamp (mountain time)
164	12	9/22/2006 10:13
203	12	9/22/2006 10:13
180	12	9/22/2006 10:13
183	12	9/22/2006 10:13
306	12	9/22/2006 10:13
140	12	9/22/2006 10:13
55.6	12	9/22/2006 10:13
128	12	9/22/2006 10:13
153	12	9/22/2006 10:13
201	12	9/22/2006 10:13
130	12	9/22/2006 10:13
108	12	9/22/2006 10:13
52	12	9/22/2006 10:13
31.8	12	9/22/2006 10:13
25.7	12	9/22/2006 10:13
26.2	12	9/22/2006 10:13
27.3	12	9/22/2006 10:13
29.1	12	9/22/2006 10:13
30.5	12	9/22/2006 10:13
29.2	12	9/22/2006 10:13
25.7	12	9/22/2006 10:14
25	12	9/22/2006 10:14
24.7	12	9/22/2006 10:14
24.7	12	9/22/2006 10:14
24.8	12	9/22/2006 10:14
24.9	12	9/22/2006 10:14
25.3	12	9/22/2006 10:14
26.7	12	9/22/2006 10:14
25.9	12	9/22/2006 10:14
27	12	9/22/2006 10:14
25.1	12	9/22/2006 10:14
24.8	12	9/22/2006 10:14
24.4	12	9/22/2006 10:14
25.1	12	9/22/2006 10:14
25.3	12	9/22/2006 10:14
24.9	12	9/22/2006 10:14
24.9	12	9/22/2006 10:14
24.7	12	9/22/2006 10:14
24.7	12	9/22/2006 10:14
24.8	12	9/22/2006 10:14
24.8	12	9/22/2006 10:14
24.5	12	9/22/2006 10:14
24.3	12	9/22/2006 10:14
24.4	12	9/22/2006 10:14
24.4	12	9/22/2006 10:14
24.3	12	9/22/2006 10:14
24.4	12	9/22/2006 10:14
24.3	12	9/22/2006 10:14
24.5	12	9/22/2006 10:14
24.4	12	9/22/2006 10:14
24.3	12	9/22/2006 10:14
24.3	12	9/22/2006 10:14
24.5	12	9/22/2006 10:14
24.4	12	9/22/2006 10:14
24.5	12	9/22/2006 10:15
24.3	12	9/22/2006 10:15

Path Measurement Data Site 6 Path 5		
ppm*m	pathlength	Timestamp (mountain time)
24.4	12	9/22/2006 10:15
24.8	12	9/22/2006 10:15
24.5	12	9/22/2006 10:15
25	12	9/22/2006 10:15
36.5	12	9/22/2006 10:15
395	12	9/22/2006 10:15
589	12	9/22/2006 10:15
178	12	9/22/2006 10:15
44.4	12	9/22/2006 10:15
36.6	12	9/22/2006 10:15
35.5	12	9/22/2006 10:15
40.3	12	9/22/2006 10:15
26.2	12	9/22/2006 10:15
27.2	12	9/22/2006 10:15
24.4	12	9/22/2006 10:15
24.2	12	9/22/2006 10:15
24.4	12	9/22/2006 10:15
24.3	12	9/22/2006 10:15
24.2	12	9/22/2006 10:15
24.4	12	9/22/2006 10:15
24.3	12	9/22/2006 10:15
24.5	12	9/22/2006 10:15
24.4	12	9/22/2006 10:15
24.4	12	9/22/2006 10:15
24.5	12	9/22/2006 10:15
24.5	12	9/22/2006 10:15
24.5	12	9/22/2006 10:15
24.4	12	9/22/2006 10:15
24.3	12	9/22/2006 10:15
24.4	12	9/22/2006 10:15
24.3	12	9/22/2006 10:15
24.3	12	9/22/2006 10:16
24.5	12	9/22/2006 10:16
24.3	12	9/22/2006 10:16
24.7	12	9/22/2006 10:16

## **Appendix D**

### **Meteorological Data**

# Site 1 Met Data

Year	Date	Time (hhmm)	Average Wind Speed (mph)	Average Wind Direction (Deg.)	Average Standard Deviation	Resultant Wind Speed	Resultant Wind Direction	Resultant Standard Deviation	Wind Gust (mph)	Tempera- ture (F)
2006	9/19/06	950	0.9	182	0.1	0.9	182.2	0.10	4.2	4.0
2006	9/19/06	955	1.4	183	5.0	1.4	183.9	5.60	2.5	59.0
2006	9/19/06	1000	1.9	208	53.4	1.3	207.8	46.43	3.0	58.7
2006	9/19/06	1005	2.5	231	54.0	1.7	234.1	45.37	5.3	58.3
2006	9/19/06	1020	2.8	245	59.8	1.8	241.6	47.67	7.4	58.2
2006	9/19/06	1025	2.7	142	57.6	1.8	144.1	48.16	12.9	59.1
2006	9/19/06	1030	2.6	101	40.5	2.1	102.4	35.81	13.2	59.9
2006	9/19/06	1035	2.9	85	31.0	2.5	83.2	29.65	4.3	60.9
2006	9/19/06	1040	2.8	134	20.7	2.7	136.9	17.13	4.9	60.5
2006	9/19/06	1045	2.8	116	56.7	1.7	120.2	50.25	5.2	60.8
2006	9/19/06	1050	2.4	130	23.0	2.2	130.5	21.88	3.6	61.2
2006	9/19/06	1055	2.4	109	39.7	1.9	110.3	36.05	3.6	62.2
2006	9/19/06	1100	2.3	110	42.3	1.7	111.8	40.80	13.1	63.2
2006	9/19/06	1105	2.3	65	38.8	1.8	59.2	38.57	3.7	62.6
2006	9/19/06	1110	2.6	69	31.4	2.2	63.6	31.51	5.8	62.8
2006	9/19/06	1115	2.5	118	45.1	1.7	128.4	44.75	5.3	63.3
2006	9/19/06	1120	2.5	112	37.9	2.0	114.7	35.69	4.7	64.4
2006	9/19/06	1125	2.7	150	39.1	2.1	153.3	37.05	4.7	64.6
2006	9/19/06	1130	2.7	52	46.1	2.1	47.7	39.49	11.2	64.7
2006	9/19/06	1135	2.9	121	45.5	2.1	122.7	42.37	5.0	64.4
2006	9/19/06	1140	2.6	142	84.9	0.8	144.1	67.24	4.5	64.7
2006	9/19/06	1145	2.8	122	15.8	2.7	122.2	14.35	4.2	64.0
2006	9/19/06	1150	2.2	126	44.2	1.6	130.1	41.85	4.5	64.1
2006	9/19/06	1155	2.0	121	50.8	1.4	121.2	43.45	3.0	65.5
2006	9/19/06	1200	2.3	111	29.5	2.0	110.1	28.56	3.2	66.1
2006	9/19/06	1205	2.8	123	61.7	1.5	121.8	55.03	5.1	66.1
2006	9/19/06	1210	2.4	15	72.6	1.2	2.8	57.25	6.1	66.6
2006	9/19/06	1215	2.9	132	79.0	0.9	129.0	67.66	6.0	67.2
2006	9/19/06	1220	3.2	153	93.2	0.3	132.1	76.50	5.6	66.4
2006	9/19/06	1225	2.8	116	71.1	1.4	122.3	58.60	4.2	65.8
2006	9/19/06	1230	2.2	92	45.2	1.6	89.7	40.50	3.1	66.0
2006	9/19/06	1235	2.5	27	68.9	0.8	19.3	66.39	7.7	67.2
2006	9/19/06	1240	2.4	109	54.9	1.4	109.9	52.05	4.9	67.1
2006	9/19/06	1245	2.8	137	64.9	1.2	151.4	60.51	7.1	67.2
2006	9/19/06	1250	3.0	104	59.6	1.7	105.8	54.59	5.0	67.1



## Site 2 Met Data

Year	Date	Time (hhmm)	Average Wind Speed (mph)	Average Wind Direction (Deg.)	Average Standard Deviation	Resultant Wind Speed	Resultant Wind Direction	Resultant Standard Deviation	Wind Gust (mph)	Tempera- ture (F)
2006	9/19/06	1510	3.1	134	62.5	1.7	138.2	55.02	9.4	67.2
2006	9/19/06	1515	1.5	82	41.1	1.1	78.1	39.52	6.1	64.7
2006	9/19/06	1520	2.0	126	53.5	1.2	127.0	50.06	3.8	66.3
2006	9/19/06	1525	3.0	88	66.9	1.6	69.0	55.27	9.1	67.7
2006	9/19/06	1530	2.3	104	65.0	1.1	100.0	59.34	4.9	68.7
2006	9/19/06	1531	1.4	148	0.0	1.4	148.0	0.00	1.4	69.3
2006	9/19/06	1532	2.9	63	59.0	1.8	52.6	49.77	10.8	69.2
2006	9/19/06	1533	2.9	80	24.7	2.6	77.9	23.68	3.9	69.2
2006	9/19/06	1534	2.7	80	40.7	2.0	79.0	39.55	4.0	69.3
2006	9/19/06	1535	3.3	73	74.7	1.3	68.9	63.15	4.2	68.8
2006	9/19/06	1536	3.1	69	87.6	0.6	62.7	72.10	3.8	68.7
2006	9/19/06	1537	2.8	326	47.5	2.0	324.4	44.13	3.7	68.4
2006	9/19/06	1538	2.8	73	50.7	2.0	67.4	41.97	4.4	68.7
2006	9/19/06	1539	2.3	102	44.9	1.6	93.9	43.58	4.0	68.9
2006	9/19/06	1540	3.6	52	58.3	2.3	45.4	49.55	7.0	68.6
2006	9/19/06	1541	2.5	105	47.0	1.7	105.4	45.08	3.1	69.0
2006	9/19/06	1542	2.6	132	59.3	1.5	136.9	53.88	4.0	69.1
2006	9/19/06	1543	2.4	105	56.8	1.6	94.9	47.59	13.3	69.1
2006	9/19/06	1544	2.3	79	44.9	1.8	78.1	36.96	3.1	69.2
2006	9/19/06	1545	2.4	82	60.2	1.5	74.0	48.49	5.4	69.3
2006	9/19/06	1546	2.5	51	43.4	1.8	54.5	43.13	5.2	69.3
2006	9/19/06	1547	2.5	95	29.3	2.3	92.8	26.53	3.2	69.3
2006	9/19/06	1548	2.0	61	39.1	1.5	64.2	41.90	3.2	69.5
2006	9/19/06	1549	3.0	125	57.8	1.8	135.0	50.88	4.1	68.7
2006	9/19/06	1550	2.9	38	44.1	2.1	39.5	40.91	3.6	68.1
2006	9/19/06	1551	2.7	76	28.5	2.4	81.2	27.32	3.8	67.5
2006	9/19/06	1552	2.2	39	53.1	1.4	39.8	49.42	2.9	67.0
2006	9/19/06	1553	2.5	66	18.7	2.4	69.7	18.68	3.6	66.6
2006	9/19/06	1554	1.7	80	13.2	1.6	78.7	13.85	2.4	66.3
2006	9/19/06	1555	1.8	55	18.0	1.7	54.0	17.34	2.4	65.9
2006	9/19/06	1556	2.1	84	31.1	1.8	82.9	29.75	2.6	65.7
2006	9/19/06	1557	2.2	98	90.0	0.1	40.0	79.30	3.6	65.5
2006	9/19/06	1558	1.8	127	18.2	1.7	125.3	18.42	2.1	65.3
2006	9/19/06	1559	0.9	134	14.4	0.9	133.2	14.02	1.4	65.3
2006	9/19/06	1600	1.8	80	58.2	0.9	75.7	53.58	2.7	65.3
2006	9/19/06	1601	1.9	141	63.7	1.1	142.7	53.19	2.7	65.2
2006	9/19/06	1602	1.8	90	41.9	1.3	80.8	43.14	2.7	65.7
2006	9/19/06	1603	2.1	104	39.4	1.7	104.5	38.05	2.7	66.1
2006	9/19/06	1604	2.0	182	67.6	0.9	186.2	59.34	2.5	66.1
2006	9/19/06	1605	3.1	268	85.7	0.8	268.6	69.71	4.4	65.9
2006	9/19/06	1606	2.4	105	63.1	1.4	116.0	53.83	3.6	65.7
2006	9/19/06	1607	2.8	307	54.9	1.9	304.9	47.87	4.0	65.7
2006	9/19/06	1608	2.4	149	67.1	0.8	171.7	65.46	3.9	65.5
2006	9/19/06	1609	1.2	118	7.9	1.2	117.1	7.88	1.8	65.7
2006	9/19/06	1610	1.7	85	38.1	1.4	74.1	34.59	3.0	65.8
2006	9/19/06	1611	1.7	133	24.0	1.5	134.0	24.21	2.2	66.0
2006	9/19/06	1612	1.7	111	67.9	0.9	127.9	55.66	2.9	66.1

2006	9/19/06	1613	1.5	98	20.8	1.4	99.0	20.50	2.1	66.1
2006	9/19/06	1614	1.6	128	31.8	1.4	127.0	30.03	1.9	66.2
2006	9/19/06	1615	3.0	183	78.3	1.2	229.2	62.02	7.0	65.8
2006	9/19/06	1616	1.9	134	51.9	1.2	133.5	48.27	2.4	65.5
2006	9/19/06	1617	2.2	88	36.2	1.8	81.8	31.80	3.1	65.2
2006	9/19/06	1618	1.9	104	45.0	1.4	101.5	39.92	2.7	65.0
2006	9/19/06	1619	1.6	129	18.9	1.5	129.7	18.85	1.9	64.7
2006	9/19/06	1620	1.5	148	15.6	1.4	148.7	15.38	1.8	64.5
2006	9/19/06	1621	1.7	111	13.1	1.7	110.5	12.84	2.2	64.2
2006	9/19/06	1622	1.5	101	16.1	1.5	99.4	15.17	2.3	64.0
2006	9/19/06	1623	2.2	82	11.8	2.1	81.5	11.91	2.5	63.8
2006	9/19/06	1624	1.9	78	25.2	1.7	78.4	24.20	2.2	64.0
2006	9/19/06	1625	2.4	92	9.8	2.3	91.0	9.74	3.4	64.2
2006	9/19/06	1626	1.9	105	18.7	1.8	102.6	19.41	2.6	64.3
2006	9/19/06	1627	1.1	101	33.4	0.9	101.2	32.42	1.2	64.4
2006	9/19/06	1628	1.3	114	21.4	1.2	112.4	21.27	1.9	64.3
2006	9/19/06	1629	2.3	57	30.8	2.1	58.2	26.20	3.4	64.3
2006	9/19/06	1630	2.5	91	23.1	2.3	89.2	19.86	3.2	64.4
2006	9/19/06	1631	2.4	66	12.8	2.3	66.3	13.25	3.1	64.5
2006	9/19/06	1632	2.0	68	18.3	1.9	69.4	17.56	3.0	64.8
2006	9/19/06	1633	2.2	76	13.5	2.1	75.5	13.36	2.7	65.0
2006	9/19/06	1634	2.0	41	22.9	1.9	41.3	21.63	2.8	65.1
2006	9/19/06	1635	2.6	19	59.5	1.5	15.3	52.13	3.6	65.3
2006	9/19/06	1636	1.9	114	81.0	0.5	105.7	69.29	2.7	65.6
2006	9/19/06	1637	2.0	91	48.9	1.4	92.7	45.72	2.7	65.8
2006	9/19/06	1638	1.9	71	36.1	1.5	68.0	35.07	2.4	65.7
2006	9/19/06	1639	1.8	78	39.2	1.4	74.6	36.67	2.2	65.6
2006	9/19/06	1640	1.8	168	19.4	1.7	167.2	18.98	2.1	65.5
2006	9/19/06	1641	1.2	119	14.8	1.1	118.6	14.02	1.8	65.4
2006	9/19/06	1642	1.9	140	41.7	1.5	142.8	39.27	2.5	65.1
2006	9/19/06	1643	1.6	100	34.4	1.3	102.4	34.70	2.1	65.0
2006	9/19/06	1644	1.2	107	19.3	1.1	107.8	20.08	1.7	65.0
2006	9/19/06	1645	1.6	124	24.2	1.4	120.2	24.57	2.6	64.8
2006	9/19/06	1646	1.9	88	37.9	1.6	90.3	34.32	2.7	64.4
2006	9/19/06	1647	1.7	111	19.0	1.6	109.5	19.70	2.7	64.2
2006	9/19/06	1648	1.9	108	24.8	1.7	109.1	24.43	3.3	64.0
2006	9/19/06	1649	1.8	28	78.7	0.7	46.7	61.26	2.5	63.8
2006	9/19/06	1650	1.8	103	18.3	1.7	99.6	18.90	2.4	63.8
2006	9/19/06	1651	0.5	114	4.2	0.5	114.3	4.15	1.0	64.1
2006	9/19/06	1652	1.0	91	20.3	1.0	89.9	19.52	1.3	64.2
2006	9/19/06	1653	1.3	93	26.7	1.2	96.8	26.68	2.1	64.4
2006	9/19/06	1654	0.7	99	31.9	0.6	102.2	29.89	1.6	64.6
2006	9/19/06	1655	1.2	184	48.6	0.8	191.7	45.02	2.1	64.8
2006	9/19/06	1656	2.2	45	14.5	2.2	44.8	14.12	3.0	64.9
2006	9/19/06	1657	1.7	113	21.8	1.6	108.4	21.76	2.3	64.9
2006	9/19/06	1658	1.0	113	3.8	1.0	113.1	3.94	1.2	64.9
2006	9/19/06	1659	1.2	103	10.5	1.2	100.1	11.95	2.4	64.8
2006	9/19/06	1700	2.1	100	17.8	2.0	95.3	16.74	2.7	64.7
2006	9/19/06	1701	1.5	144	59.5	0.7	160.6	59.97	2.5	64.4
2006	9/19/06	1702	1.7	138	60.9	0.9	139.7	55.43	2.1	64.3
2006	9/19/06	1703	1.1	131	25.3	1.0	130.4	25.19	1.3	64.2
2006	9/19/06	1704	1.6	145	14.5	1.5	145.2	13.54	2.1	64.0

2006	9/19/06	1705	1.5	123	13.2	1.5	123.7	12.66	2.0	63.8
2006	9/19/06	1706	1.4	130	9.5	1.4	129.7	9.41	1.9	63.7
2006	9/19/06	1707	1.5	131	9.9	1.5	130.5	9.76	1.9	63.5
2006	9/19/06	1708	2.3	81	17.0	2.2	80.3	17.29	3.5	63.1
2006	9/19/06	1709	2.4	92	23.3	2.3	88.9	19.60	3.6	62.9

### Site 3 Met Data

Year	Date	Time (hhmm)	Average Wind Speed (mph)	Average Wind Direction (Deg.)	Average Standard Deviation	Resultant Wind Speed	Resultant Wind Direction	Resultant Standard Deviation	Wind Gust (mph)	Tempera- ture (F)
2006	9/20/06	956	1.6	74	15.4	1.5	74.4	14.61	8.4	61.9
2006	9/20/06	957	2.4	78	0.2	2.4	77.5	0.24	2.5	51.5
2006	9/20/06	958	1.9	102	21.6	1.8	102.5	20.72	9.7	51.6
2006	9/20/06	959	1.8	83	27.6	1.6	80.1	25.15	2.7	51.9
2006	9/20/06	1000	1.8	46	33.2	1.5	50.1	33.12	2.8	51.8
2006	9/20/06	1001	2.0	57	23.2	1.8	57.9	22.22	2.5	51.8
2006	9/20/06	1002	2.0	107	17.6	1.9	105.6	17.07	2.6	51.8
2006	9/20/06	1003	1.8	126	11.7	1.8	125.8	11.14	2.5	51.7
2006	9/20/06	1004	1.9	71	35.9	1.5	75.8	35.08	2.3	51.6
2006	9/20/06	1005	1.9	113	53.0	1.2	112.3	49.11	2.2	51.4
2006	9/20/06	1006	2.1	87	49.6	1.5	79.4	42.20	3.0	51.4
2006	9/20/06	1007	1.8	82	21.0	1.6	84.7	20.75	2.2	51.2
2006	9/20/06	1008	2.6	122	9.3	2.6	121.6	9.14	3.1	51.0
2006	9/20/06	1009	1.8	93	16.1	1.7	93.0	15.96	2.3	50.9
2006	9/20/06	1010	1.7	113	30.2	1.5	113.0	27.67	2.9	50.9
2006	9/20/06	1011	3.1	113	45.5	2.4	112.2	38.84	4.2	50.7
2006	9/20/06	1012	2.5	59	41.6	1.9	58.1	39.68	2.9	50.6
2006	9/20/06	1013	2.5	112	16.9	2.4	113.3	15.65	3.6	50.6
2006	9/20/06	1014	1.9	97	12.0	1.8	97.1	11.77	2.2	50.6
2006	9/20/06	1015	1.3	84	17.9	1.2	85.2	17.24	1.8	50.6
2006	9/20/06	1016	1.8	62	12.7	1.8	62.7	11.85	2.4	50.5
2006	9/20/06	1017	1.4	98	15.1	1.4	97.3	15.71	2.3	50.5
2006	9/20/06	1018	2.2	116	28.1	1.9	114.9	26.92	2.4	50.6
2006	9/20/06	1019	1.8	92	25.0	1.7	92.8	23.48	2.6	50.6
2006	9/20/06	1020	1.6	83	20.1	1.5	81.9	19.63	1.9	50.6
2006	9/20/06	1021	1.7	101	27.2	1.5	99.4	26.22	2.2	50.6
2006	9/20/06	1022	1.4	99	18.2	1.3	98.1	18.38	1.7	50.6
2006	9/20/06	1023	1.4	113	7.6	1.4	111.1	7.81	2.1	50.6
2006	9/20/06	1024	1.3	108	17.3	1.3	107.3	17.05	1.6	50.8
2006	9/20/06	1025	1.4	96	9.7	1.4	93.9	10.04	2.5	50.8
2006	9/20/06	1026	1.7	84	24.5	1.5	81.8	23.93	2.4	50.9
2006	9/20/06	1027	1.6	112	15.8	1.6	109.7	14.45	2.1	51.0
2006	9/20/06	1028	2.4	106	45.2	1.9	104.9	37.59	3.7	50.8
2006	9/20/06	1029	2.0	92	5.1	2.0	91.9	5.30	2.4	51.0
2006	9/20/06	1030	1.4	94	23.6	1.3	99.9	23.43	2.0	51.0
2006	9/20/06	1031	1.7	106	13.8	1.7	105.6	13.54	2.0	51.1
2006	9/20/06	1032	2.1	133	17.1	2.0	133.1	16.82	2.4	51.0
2006	9/20/06	1033	2.4	123	19.2	2.2	122.1	18.89	2.7	50.9
2006	9/20/06	1034	2.3	117	18.6	2.2	117.2	18.13	2.8	50.9
2006	9/20/06	1035	1.6	103	6.4	1.5	103.0	6.78	1.9	51.0
2006	9/20/06	1036	2.2	68	27.2	2.0	70.4	24.73	2.7	50.9
2006	9/20/06	1037	2.2	95	38.9	1.8	91.5	35.50	2.8	50.8
2006	9/20/06	1038	1.9	122	37.6	1.5	120.3	35.76	2.5	50.8
2006	9/20/06	1039	1.9	54	32.8	1.6	54.1	31.33	2.2	50.6
2006	9/20/06	1040	2.3	150	29.2	2.0	150.9	28.91	3.8	50.4
2006	9/20/06	1041	2.4	111	47.1	1.8	111.7	41.28	3.2	50.3

2006	9/20/06	1042	2.2	91	24.7	2.0	90.6	24.49	2.7	50.2
2006	9/20/06	1043	2.0	138	19.3	1.9	139.4	19.48	2.7	50.2
2006	9/20/06	1044	2.0	216	54.0	1.3	213.1	48.02	2.7	50.0
2006	9/20/06	1045	1.6	71	46.0	1.1	70.7	42.86	1.8	50.0
2006	9/20/06	1046	1.5	102	12.1	1.5	103.1	12.07	1.9	50.0
2006	9/20/06	1047	2.1	109	18.4	2.0	109.2	18.52	2.7	50.0
2006	9/20/06	1048	1.6	94	49.5	1.0	94.0	49.49	2.3	50.0
2006	9/20/06	1049	2.1	153	37.0	1.7	152.9	36.14	2.5	50.0
2006	9/20/06	1050	2.0	172	31.0	1.7	174.0	30.89	2.4	49.9
2006	9/20/06	1051	2.0	135	18.6	1.9	134.4	16.83	2.5	49.7
2006	9/20/06	1052	2.5	136	15.5	2.4	136.2	15.22	2.9	49.7
2006	9/20/06	1053	1.8	110	21.3	1.6	112.8	22.25	2.7	49.8
2006	9/20/06	1054	1.6	86	17.5	1.5	85.5	17.23	1.9	49.9
2006	9/20/06	1055	1.8	94	34.8	1.5	93.9	34.18	2.2	49.9
2006	9/20/06	1056	2.0	143	46.1	1.4	148.7	44.53	2.5	50.1
2006	9/20/06	1057	1.5	79	11.2	1.5	79.2	10.54	2.0	50.1
2006	9/20/06	1058	1.1	143	36.3	0.9	146.3	35.74	1.4	50.2
2006	9/20/06	1059	1.3	187	9.4	1.3	187.0	9.42	1.5	50.3
2006	9/20/06	1100	1.5	143	25.2	1.4	142.6	25.26	1.9	50.3
2006	9/20/06	1101	2.5	45	27.4	2.3	44.0	25.58	3.2	50.4
2006	9/20/06	1102	1.8	67	5.3	1.8	66.9	5.13	2.2	50.3
2006	9/20/06	1103	1.5	72	4.9	1.5	71.4	4.89	1.8	50.4
2006	9/20/06	1104	1.7	73	15.6	1.6	74.4	16.47	2.7	50.5
2006	9/20/06	1105	3.4	141	38.7	2.8	142.1	34.75	5.2	50.5
2006	9/20/06	1106	2.9	130	22.9	2.7	132.6	22.63	4.4	51.0
2006	9/20/06	1107	2.5	154	51.8	1.8	157.7	42.21	3.5	50.9
2006	9/20/06	1108	2.2	96	17.9	2.1	96.2	17.24	2.6	51.0
2006	9/20/06	1109	2.8	118	87.4	0.4	128.4	74.30	4.0	51.1
2006	9/20/06	1110	2.5	144	8.8	2.5	143.4	9.63	4.3	51.4
2006	9/20/06	1111	2.0	126	13.7	1.9	123.9	12.79	2.4	51.3
2006	9/20/06	1112	2.6	117	30.6	2.3	114.9	27.93	3.3	51.3
2006	9/20/06	1113	2.6	156	83.4	0.9	143.1	66.06	3.6	51.3
2006	9/20/06	1114	1.8	63	39.2	1.5	58.6	36.29	2.6	51.4
2006	9/20/06	1115	1.8	153	75.9	0.6	160.4	64.60	2.2	51.3

## Site 4 Met Data

Year	Date	Time (hhmm)	Average Wind Speed (mph)	Average Wind Direction (Deg.)	Average Standard Deviation	Resultant Wind Speed	Resultant Wind Direction	Resultant Standard Deviation	Wind Gust (mph)	Tempera- ture (F)
2006	09/21/06	1110	2.7	155	46.5	1.7	147.9	49.05	5.7	51.9
2006	09/21/06	1111	1.3	67	17.2	1.2	68.3	17.34	1.4	54.1
2006	09/21/06	1112	1.3	120	42.2	1.0	119.7	40.42	1.5	54.0
2006	09/21/06	1113	1.5	131	24.1	1.4	134.4	25.31	2.1	54.0
2006	09/21/06	1114	2.3	183	25.6	2.1	183.4	25.43	2.9	53.9
2006	09/21/06	1115	3.4	166	8.5	3.3	165.0	7.93	14.9	53.5
2006	09/21/06	1116	1.3	141	6.8	1.3	143.3	11.49	5.7	53.6
2006	09/21/06	1117	1.9	319	53.4	1.5	317.9	36.81	2.9	53.5
2006	09/21/06	1118	2.1	316	19.5	2.0	318.6	18.36	2.9	53.5
2006	09/21/06	1119	0.5	276	0.0	0.5	276.4	0.00	1.3	53.6
2006	09/21/06	1120	0.2	191	1.5	0.2	190.8	1.49	0.8	53.7
2006	09/21/06	1121	0.9	328	53.6	0.6	334.1	40.22	1.7	53.7
2006	09/21/06	1122	2.8	339	7.1	2.7	338.6	7.11	3.3	53.7
2006	09/21/06	1123	3.2	345	14.6	3.1	344.3	13.67	4.5	53.6
2006	09/21/06	1124	1.7	344	23.6	1.5	347.3	23.15	2.1	53.5
2006	09/21/06	1125	2.2	227	41.8	1.8	216.8	34.45	3.3	53.5
2006	09/21/06	1126	3.1	290	50.9	2.4	300.0	37.06	4.4	53.4
2006	09/21/06	1127	2.6	303	18.3	2.5	301.2	19.06	3.9	53.3
2006	09/21/06	1128	1.4	303	6.5	1.3	303.4	6.79	1.7	53.4
2006	09/21/06	1129	1.8	274	61.9	1.2	274.2	43.60	3.2	53.4
2006	09/21/06	1130	1.8	333	23.0	1.6	335.2	22.54	2.7	53.4
2006	09/21/06	1131	2.3	329	10.0	2.3	329.0	10.07	2.8	53.4
2006	09/21/06	1132	2.1	338	15.6	2.0	338.4	15.13	2.4	53.5
2006	09/21/06	1133	2.1	245	46.0	1.6	239.4	41.92	3.6	53.7
2006	09/21/06	1134	1.8	231	23.1	1.7	229.0	23.37	2.5	54.0
2006	09/21/06	1135	2.6	187	21.4	2.4	187.5	20.95	3.2	54.3
2006	09/21/06	1136	2.8	181	25.1	2.5	177.3	22.22	3.6	54.7
2006	09/21/06	1137	1.1	316	41.5	0.8	304.8	43.90	2.3	55.0
2006	09/21/06	1138	1.6	248	18.2	1.5	247.6	17.74	2.2	55.4
2006	09/21/06	1139	1.9	286	13.7	1.9	285.3	13.57	2.1	55.5
2006	09/21/06	1140	1.7	266	8.9	1.7	266.4	8.71	1.9	55.7
2006	09/21/06	1141	1.3	246	31.1	1.1	244.4	32.40	2.0	56.3
2006	09/21/06	1142	1.7	127	47.4	1.2	129.2	40.94	2.1	56.7
2006	09/21/06	1143	0.9	140	48.2	0.6	143.4	43.53	1.6	57.2
2006	09/21/06	1144	1.3	64	59.0	0.7	69.3	53.34	1.8	57.6
2006	09/21/06	1145	0.9	50	17.6	0.8	48.1	19.20	1.4	57.8
2006	09/21/06	1146	2.7	147	17.8	2.6	150.1	15.03	3.6	57.6
2006	09/21/06	1147	2.4	146	9.4	2.4	147.1	9.34	2.9	57.3
2006	09/21/06	1148	2.0	158	18.8	1.9	158.9	18.53	2.6	57.1
2006	09/21/06	1149	1.6	62	54.6	1.0	60.1	47.58	1.9	56.9
2006	09/21/06	1150	1.9	36	7.1	1.9	36.1	7.17	2.2	56.6
2006	09/21/06	1151	1.5	41	15.2	1.5	41.0	15.48	1.9	56.5
2006	09/21/06	1152	1.4	69	18.7	1.4	72.0	18.46	2.0	56.6
2006	09/21/06	1153	1.1	61	15.0	1.1	61.5	14.88	1.2	56.6
2006	09/21/06	1154	1.9	8	9.8	1.9	7.3	9.90	3.0	56.7
2006	09/21/06	1155	3.3	338	11.4	3.3	339.6	11.26	4.4	56.1
2006	09/21/06	1156	2.0	314	20.3	1.8	312.0	19.78	2.2	56.0

2006	09/21/06	1157	1.5	297	49.1	1.0	293.1	48.00	2.0	55.9
2006	09/21/06	1158	1.1	179	82.1	0.4	186.5	63.19	2.0	55.9
2006	09/21/06	1159	1.1	238	39.1	0.9	236.5	35.35	1.4	55.9
2006	09/21/06	1200	1.2	89	67.5	0.6	100.4	57.87	1.6	56.0
2006	09/21/06	1201	1.8	159	15.1	1.7	160.3	14.85	2.1	56.0
2006	09/21/06	1202	1.9	133	12.1	1.9	133.9	12.00	2.3	55.9
2006	09/21/06	1203	2.7	154	12.0	2.7	155.3	11.84	3.2	55.9
2006	09/21/06	1204	2.0	192	47.4	1.5	185.8	40.37	3.2	55.9
2006	09/21/06	1205	1.0	131	33.1	0.9	133.6	32.36	1.6	56.0
2006	09/21/06	1206	2.0	156	30.5	1.8	161.7	25.79	2.4	56.1
2006	09/21/06	1207	2.3	157	13.4	2.2	157.0	13.33	2.9	55.9
2006	09/21/06	1208	2.7	180	10.4	2.6	179.6	10.61	3.2	55.6
2006	09/21/06	1209	1.8	174	52.7	1.3	172.7	44.15	2.7	55.6
2006	09/21/06	1210	1.9	185	16.7	1.8	186.0	16.71	2.6	55.6
2006	09/21/06	1211	2.5	198	20.5	2.4	196.4	20.23	3.1	55.4
2006	09/21/06	1212	2.1	305	45.9	1.5	300.1	42.24	2.7	55.3
2006	09/21/06	1213	1.4	223	36.6	1.1	224.6	36.13	1.7	55.3
2006	09/21/06	1214	1.3	215	20.9	1.2	214.1	20.62	1.4	55.4
2006	09/21/06	1215	1.0	256	37.5	0.8	257.0	36.94	1.2	55.5
2006	09/21/06	1216	1.2	1	30.6	1.1	358.3	25.90	1.7	55.5
2006	09/21/06	1217	0.4	73	28.2	0.3	75.1	25.62	1.0	55.8
2006	09/21/06	1218	1.3	100	32.1	1.1	111.6	31.05	2.1	55.9
2006	09/21/06	1219	1.8	122	20.3	1.7	124.8	19.55	2.2	56.0
2006	09/21/06	1220	2.6	169	14.0	2.5	169.1	13.78	2.8	56.1
2006	09/21/06	1221	2.7	187	20.9	2.5	188.2	21.16	3.3	56.0
2006	09/21/06	1222	2.2	172	27.3	2.0	171.3	26.77	2.6	56.1
2006	09/21/06	1223	1.5	143	30.6	1.3	147.5	28.14	2.2	56.4
2006	09/21/06	1224	1.1	14	62.1	0.5	3.0	54.19	1.9	56.5
2006	09/21/06	1225	1.4	302	29.2	1.3	296.0	26.61	2.0	56.4
2006	09/21/06	1226	1.6	263	4.2	1.6	262.6	4.23	2.0	56.4
2006	09/21/06	1227	0.5	259	0.9	0.5	259.5	0.97	1.3	56.5
2006	09/21/06	1228	1.3	52	24.9	1.1	58.1	22.76	1.8	56.4
2006	09/21/06	1229	1.3	105	12.4	1.3	104.1	12.02	1.8	56.3
2006	09/21/06	1230	1.6	152	7.1	1.6	152.5	7.09	1.9	56.2
2006	09/21/06	1231	1.0	153	2.1	1.0	153.1	2.35	1.5	56.2
2006	09/21/06	1232	0.7	138	56.3	0.3	135.2	50.45	1.2	56.2
2006	09/21/06	1233	0.6	353	6.8	0.6	352.2	6.31	1.1	56.2
2006	09/21/06	1234	0.7	146	11.4	0.7	148.3	10.74	1.4	56.2
2006	09/21/06	1235	1.5	163	8.1	1.5	163.7	8.24	1.8	56.0
2006	09/21/06	1236	1.3	174	0.0	1.3	174.3	0.00	1.6	55.9
2006	09/21/06	1237	1.1	133	41.6	0.9	140.5	36.74	1.6	55.8
2006	09/21/06	1238	1.7	168	6.0	1.7	168.0	5.90	1.9	55.8
2006	09/21/06	1239	1.6	183	15.5	1.5	181.0	14.62	1.9	55.6
2006	09/21/06	1240	1.0	225	17.0	1.0	223.1	16.83	1.3	55.6
2006	09/21/06	1241	0.9	205	0.5	0.9	205.1	0.46	1.0	55.7
2006	09/21/06	1242	0.9	243	29.0	0.8	244.7	27.28	1.0	55.6
2006	09/21/06	1243	0.8	283	0.0	0.8	283.3	0.00	1.0	55.6
2006	09/21/06	1244	0.9	179	38.3	0.8	178.4	35.23	1.2	55.6
2006	09/21/06	1245	0.9	178	30.2	0.8	180.5	31.11	1.2	55.6
2006	09/21/06	1246	1.1	222	49.1	0.8	225.3	42.79	1.3	55.6
2006	09/21/06	1247	0.6	117	0.0	0.6	116.8	0.00	1.1	55.8
2006	09/21/06	1248	0.3	151	16.6	0.3	154.9	15.72	1.0	55.8

2006	09/21/06	1249	0.9	202	4.4	0.9	202.2	4.21	1.2	55.9
2006	09/21/06	1250	1.9	153	13.5	1.9	154.0	13.17	2.5	55.9
2006	09/21/06	1251	1.5	172	1.2	1.5	172.2	1.40	2.3	55.7
2006	09/21/06	1252	0.5	172	0.0	0.5	171.9	0.00	1.0	55.8
2006	09/21/06	1253	1.3	160	8.5	1.3	156.5	8.65	2.7	55.8
2006	09/21/06	1254	2.0	149	4.7	2.0	148.9	4.76	2.3	55.7
2006	09/21/06	1255	1.3	144	14.4	1.2	146.4	14.72	1.9	55.8
2006	09/21/06	1256	1.4	175	9.3	1.3	174.7	9.55	1.9	55.9
2006	09/21/06	1257	1.8	153	9.9	1.8	152.8	9.71	2.0	55.8
2006	09/21/06	1258	2.3	148	4.7	2.3	147.7	4.65	2.6	55.7
2006	09/21/06	1259	1.8	151	6.6	1.8	151.3	6.21	2.2	55.7
2006	09/21/06	1300	1.3	154	3.5	1.3	154.5	3.44	1.6	55.7
2006	09/21/06	1301	1.6	157	9.1	1.6	157.3	9.00	1.9	55.8
2006	09/21/06	1302	1.5	162	9.1	1.5	161.6	9.14	1.7	55.8
2006	09/21/06	1303	1.5	160	12.1	1.5	160.2	12.18	1.7	55.8
2006	09/21/06	1304	1.3	165	0.5	1.3	165.0	0.52	1.4	55.6
2006	09/21/06	1305	1.1	172	1.5	1.1	171.8	1.57	1.2	55.7
2006	09/21/06	1306	0.1	173	0.0	0.1	172.5	0.00	0.8	55.6
2006	09/21/06	1307	1.0	176	2.9	1.0	176.4	2.81	1.5	55.6
2006	09/21/06	1308	1.1	196	31.5	0.9	198.9	32.23	1.4	55.6
2006	09/21/06	1309	1.3	234	52.4	0.8	238.1	46.56	1.5	55.5
2006	09/21/06	1310	1.3	195	34.1	1.1	197.0	33.64	1.7	55.6
2006	09/21/06	1311	1.1	178	18.5	1.0	176.5	17.44	1.5	55.6
2006	09/21/06	1312	0.7	165	8.0	0.7	165.4	7.26	1.3	55.6
2006	09/21/06	1313	1.4	180	15.4	1.3	180.5	14.09	1.9	55.6
2006	09/21/06	1314	1.4	150	23.5	1.3	146.5	20.95	1.9	55.8
2006	09/21/06	1315	1.4	149	20.2	1.3	151.1	20.44	1.9	55.8
2006	09/21/06	1316	1.7	137	9.7	1.7	137.1	9.53	2.4	55.8
2006	09/21/06	1317	2.3	233	48.6	1.6	234.3	45.31	2.7	55.9
2006	09/21/06	1318	2.2	223	43.6	1.6	228.1	40.84	2.9	56.2
2006	09/21/06	1319	2.0	227	37.0	1.6	229.5	35.15	2.5	56.5
2006	09/21/06	1320	1.8	166	18.9	1.7	167.3	18.90	2.1	56.7
2006	09/21/06	1321	1.5	79	48.4	1.0	95.6	44.23	2.3	56.9
2006	09/21/06	1322	2.5	142	4.0	2.5	142.8	3.99	3.5	57.1
2006	09/21/06	1323	3.2	163	10.9	3.2	163.1	10.57	4.0	57.1
2006	09/21/06	1324	3.8	199	48.1	2.7	198.6	43.81	6.2	57.1
2006	09/21/06	1325	3.2	199	62.4	2.0	194.8	48.85	4.4	57.0
2006	09/21/06	1326	1.6	49	15.0	1.5	48.7	16.12	2.1	56.9
2006	09/21/06	1327	1.5	92	18.8	1.4	93.9	19.50	1.9	56.8
2006	09/21/06	1328	1.4	158	52.8	0.9	168.1	49.59	2.3	57.0
2006	09/21/06	1329	1.4	340	83.4	0.3	332.6	70.40	1.8	57.3
2006	09/21/06	1330	1.5	57	28.5	1.3	59.9	29.79	2.0	57.7
2006	09/21/06	1331	2.0	359	22.9	1.9	359.2	22.67	2.4	58.1
2006	09/21/06	1332	1.9	65	22.2	1.7	63.5	21.44	2.0	58.3
2006	09/21/06	1333	1.7	87	12.1	1.7	88.0	12.48	2.3	58.6
2006	09/21/06	1334	2.0	94	13.1	2.0	94.5	13.14	2.5	58.6
2006	09/21/06	1335	2.5	126	24.7	2.3	132.1	24.23	4.5	58.7
2006	09/21/06	1336	3.0	153	12.6	2.9	153.5	11.48	4.1	58.9
2006	09/21/06	1337	2.1	120	19.1	2.0	121.5	17.49	2.7	59.1
2006	09/21/06	1338	2.4	151	9.5	2.3	152.0	9.14	3.3	59.1
2006	09/21/06	1339	2.4	156	22.9	2.2	155.8	20.36	3.0	59.1
2006	09/21/06	1340	2.7	147	15.4	2.6	147.4	15.15	3.6	58.8



2006	09/21/06	1341	2.6	191	39.2	2.1	183.8	33.17	3.4	58.6
2006	09/21/06	1342	2.7	161	11.4	2.7	161.3	10.55	3.3	58.4
2006	09/21/06	1343	1.9	168	12.3	1.8	166.9	12.05	2.4	58.3
2006	09/21/06	1344	1.6	152	8.3	1.6	151.2	8.02	1.9	58.2
2006	09/21/06	1345	1.9	171	13.1	1.9	171.1	12.42	2.4	57.9
2006	09/21/06	1346	1.4	182	13.1	1.4	180.9	12.61	1.8	57.8
2006	09/21/06	1347	1.4	168	7.3	1.4	167.9	7.24	1.7	57.7
2006	09/21/06	1348	2.0	174	4.9	2.0	174.4	4.83	2.5	57.5
2006	09/21/06	1349	1.7	176	7.7	1.6	176.2	7.54	2.1	57.4
2006	09/21/06	1350	1.6	169	7.4	1.5	168.7	7.59	1.9	57.3
2006	09/21/06	1351	2.4	177	17.4	2.3	177.8	16.54	2.9	57.2
2006	09/21/06	1352	1.8	208	33.3	1.5	208.3	32.56	2.1	57.2
2006	09/21/06	1353	1.8	183	18.4	1.7	183.8	19.93	2.9	57.1
2006	09/21/06	1354	1.5	238	37.8	1.2	236.9	35.76	1.9	57.1
2006	09/21/06	1355	1.3	219	56.5	0.8	222.9	50.85	1.6	57.1
2006	09/21/06	1356	1.4	219	85.5	0.5	178.3	64.67	2.2	57.1
2006	09/21/06	1357	1.8	170	14.4	1.7	169.5	14.51	2.0	57.1
2006	09/21/06	1358	1.9	173	11.3	1.9	175.2	11.31	2.8	57.0
2006	09/21/06	1359	1.7	181	2.0	1.7	180.7	2.00	2.0	56.9
2006	09/21/06	1400	1.7	195	9.2	1.6	193.6	9.35	2.3	56.8
2006	09/21/06	1401	1.5	195	16.1	1.5	195.3	15.85	1.9	56.8
2006	09/21/06	1402	1.8	185	7.4	1.8	185.2	7.42	2.1	56.8
2006	09/21/06	1403	1.6	176	10.4	1.6	177.2	9.87	1.9	56.7
2006	09/21/06	1404	1.3	173	17.1	1.3	179.0	17.62	2.2	56.8
2006	09/21/06	1405	1.6	209	24.7	1.4	209.6	24.15	1.9	56.8

## Site 5 Met Data

Year	Date	Time (hhmm)	Average Wind Speed (mph)	Average Wind Direction (Deg.)	Average Standard Deviation	Resultant Wind Speed	Resultant Wind Direction	Resultant Standard Deviation	Wind Gust (mph)	Tempera- ture (F)
2006	09/22/06	955	0.1	182	0.0	0.1	181.5	0.02	6.1	-95.4
2006	09/22/06	956	2.1	182	0.1	2.1	181.5	0.12	2.1	54.7
2006	09/22/06	957	2.7	182	0.1	2.7	181.5	0.12	12.7	54.7
2006	09/22/06	958	2.3	182	0.1	2.3	181.5	0.13	2.7	54.6
2006	09/22/06	959	4.7	181	29.2	0.6	78.8	75.40	39.7	54.8
2006	09/22/06	1000	2.9	320	18.2	2.7	322.6	22.20	6.5	54.5
2006	09/22/06	1001	3.0	308	67.7	1.0	285.9	66.06	20.5	54.6
2006	09/22/06	1002	2.7	313	52.3	1.7	310.6	49.45	4.5	54.5
2006	09/22/06	1003	2.7	353	71.6	0.9	11.2	66.63	4.4	54.4
2006	09/22/06	1004	2.5	297	32.1	2.1	299.5	31.21	3.6	54.5
2006	09/22/06	1005	1.5	299	20.0	1.4	300.3	21.02	2.0	54.5
2006	09/22/06	1006	2.4	302	39.3	1.9	306.4	36.78	3.3	54.5
2006	09/22/06	1007	2.7	304	65.3	1.2	305.1	59.96	4.0	54.6
2006	09/22/06	1008	3.0	359	59.8	1.8	5.3	51.44	4.0	54.8
2006	09/22/06	1009	1.9	314	61.5	1.1	321.7	52.72	3.2	55.0
2006	09/22/06	1010	2.2	279	43.5	1.7	282.9	39.83	3.1	55.1
2006	09/22/06	1011	3.4	16	71.2	1.6	27.1	59.35	5.1	55.1
2006	09/22/06	1012	2.3	318	38.3	1.9	321.2	35.50	3.6	55.2
2006	09/22/06	1013	2.6	63	37.7	2.1	66.2	34.21	2.9	55.4
2006	09/22/06	1014	2.2	60	90.8	0.9	90.5	61.59	3.7	55.7
2006	09/22/06	1015	1.9	184	75.4	0.6	173.7	66.94	2.7	55.7
2006	09/22/06	1016	1.4	22	48.2	0.9	24.3	48.42	2.3	55.7
2006	09/22/06	1017	2.8	96	62.6	1.5	83.6	56.35	4.7	55.7
2006	09/22/06	1018	2.3	255	31.1	1.9	253.1	32.65	3.5	55.6
2006	09/22/06	1019	1.1	339	62.3	0.6	315.2	54.16	1.8	55.6
2006	09/22/06	1020	1.2	71	35.2	1.1	77.9	30.37	2.1	55.7
2006	09/22/06	1021	1.9	112	59.5	0.9	134.6	57.36	3.4	55.7
2006	09/22/06	1022	2.4	105	83.8	0.6	79.3	69.22	3.4	55.8
2006	09/22/06	1023	2.6	32	26.4	2.4	33.4	23.86	3.7	55.8
2006	09/22/06	1024	1.3	310	33.3	1.0	310.3	33.97	1.7	55.8
2006	09/22/06	1025	2.2	347	77.6	0.9	326.7	62.03	3.6	55.7
2006	09/22/06	1026	2.3	188	58.2	1.5	182.1	47.60	3.5	55.8
2006	09/22/06	1027	2.4	46	50.3	1.6	45.4	46.23	3.1	55.9
2006	09/22/06	1028	3.1	62	48.9	2.3	71.8	42.49	4.6	56.0
2006	09/22/06	1029	2.8	70	37.4	2.2	64.1	36.03	4.1	56.2
2006	09/22/06	1030	1.6	68	49.1	1.1	76.9	45.40	2.2	56.3
2006	09/22/06	1031	1.7	220	68.6	0.7	213.8	61.86	2.5	56.3
2006	09/22/06	1032	2.2	98	30.7	1.9	96.2	28.84	2.7	56.4
2006	09/22/06	1033	4.1	81	58.2	2.6	58.5	49.63	11.0	56.7
2006	09/22/06	1034	6.8	51	40.7	5.7	42.7	32.95	11.5	56.7
2006	09/22/06	1035	3.9	66	65.4	2.2	69.4	53.32	5.3	56.7
2006	09/22/06	1036	3.8	36	47.7	2.9	34.4	39.38	8.3	56.8
2006	09/22/06	1037	3.3	25	57.4	2.3	27.3	45.97	6.7	56.9
2006	09/22/06	1038	2.1	334	40.8	1.6	338.4	38.17	2.8	56.9
2006	09/22/06	1039	1.4	289	25.4	1.3	289.8	25.05	1.7	56.9
2006	09/22/06	1040	2.1	341	58.1	1.2	359.0	51.75	3.5	56.9
2006	09/22/06	1041	4.1	337	39.9	3.2	356.9	37.55	8.6	57.2

2006	09/22/06	1042	2.8	270	67.5	1.1	272.3	62.40	4.1	57.3
2006	09/22/06	1043	4.2	32	54.2	2.8	32.8	46.40	10.2	57.5
2006	09/22/06	1044	3.8	64	59.4	2.4	67.6	49.27	5.4	57.6
2006	09/22/06	1045	3.3	294	60.7	1.8	309.2	53.60	7.0	57.6
2006	09/22/06	1046	6.4	2	45.0	5.3	14.0	34.22	14.6	57.4
2006	09/22/06	1047	7.1	22	19.4	6.8	25.2	17.87	12.8	57.2
2006	09/22/06	1048	3.3	320	56.9	2.0	319.7	50.73	4.2	57.0
2006	09/22/06	1049	3.8	11	59.3	2.5	17.8	47.47	7.0	56.9
2006	09/22/06	1050	2.5	280	77.8	1.0	288.1	63.54	3.1	56.9
2006	09/22/06	1051	2.3	338	45.3	1.7	346.8	43.63	8.3	56.8
2006	09/22/06	1052	5.2	50	53.2	3.8	44.6	43.05	8.3	57.0
2006	09/22/06	1053	3.9	40	43.7	2.9	38.1	40.42	6.7	57.1
2006	09/22/06	1054	4.6	52	47.9	3.3	42.9	42.79	12.2	57.3
2006	09/22/06	1055	2.7	36	35.5	2.2	36.0	34.36	3.0	57.6
2006	09/22/06	1056	2.2	309	22.2	2.0	311.6	21.88	2.7	57.5
2006	09/22/06	1057	2.2	284	30.2	1.9	282.3	28.74	3.2	57.5
2006	09/22/06	1058	2.7	342	38.9	2.1	341.7	38.23	3.6	57.6
2006	09/22/06	1059	3.2	348	48.8	2.3	353.0	43.29	4.6	57.7
2006	09/22/06	1100	3.0	348	47.8	2.2	355.9	42.67	4.3	57.8
2006	09/22/06	1101	4.1	333	49.7	3.0	345.8	41.45	7.7	57.8
2006	09/22/06	1102	2.7	11	70.6	1.4	34.8	56.87	4.9	58.0
2006	09/22/06	1103	1.4	299	21.3	1.3	302.0	22.24	1.9	58.0
2006	09/22/06	1104	1.4	300	43.7	1.1	295.6	39.66	1.9	58.0
2006	09/22/06	1105	1.4	9	42.8	1.1	15.4	39.81	1.9	58.1
2006	09/22/06	1106	2.1	90	26.2	1.9	91.8	27.26	4.2	58.3
2006	09/22/06	1107	4.5	107	44.8	3.3	90.1	42.24	8.8	58.5
2006	09/22/06	1108	1.6	302	18.2	1.5	303.0	20.01	2.3	58.5
2006	09/22/06	1109	2.0	47	48.8	1.4	56.0	42.76	2.9	58.6
2006	09/22/06	1110	1.6	152	72.8	0.9	148.1	55.91	2.2	58.7
2006	09/22/06	1111	2.0	339	28.8	1.6	1.5	33.29	6.7	58.7
2006	09/22/06	1112	5.1	19	51.4	3.9	24.0	39.32	8.0	58.8
2006	09/22/06	1113	2.6	324	89.7	0.1	217.6	79.00	5.2	58.8
2006	09/22/06	1114	2.3	348	78.3	0.9	352.3	63.75	2.9	58.7
2006	09/22/06	1115	2.0	13	36.2	1.7	9.5	32.90	3.2	58.9
2006	09/22/06	1116	2.2	9	28.7	1.9	4.6	28.29	3.2	59.0
2006	09/22/06	1117	2.3	341	48.3	1.6	341.5	42.37	3.6	59.0
2006	09/22/06	1118	2.5	277	32.9	2.2	276.5	31.16	3.8	59.0
2006	09/22/06	1119	2.7	344	45.2	2.0	349.6	41.41	4.7	59.1
2006	09/22/06	1120	2.9	281	34.1	2.4	281.2	32.95	3.6	59.1
2006	09/22/06	1121	2.8	309	28.4	2.5	308.0	27.84	3.6	59.1
2006	09/22/06	1122	2.9	281	58.0	1.8	285.2	51.47	3.9	59.0
2006	09/22/06	1123	3.2	354	95.3	0.9	126.4	69.18	6.9	59.0
2006	09/22/06	1124	2.7	265	44.2	1.6	258.4	50.79	5.3	58.9
2006	09/22/06	1125	2.0	315	19.5	1.9	314.2	19.46	2.6	59.0
2006	09/22/06	1126	1.9	292	20.7	1.8	291.2	20.71	2.5	59.0
2006	09/22/06	1127	1.7	326	46.6	1.2	327.8	43.75	2.2	59.0
2006	09/22/06	1128	1.6	324	39.4	1.3	327.8	36.96	2.7	59.1
2006	09/22/06	1129	2.6	60	53.1	1.6	53.2	49.54	3.6	59.2
2006	09/22/06	1130	2.1	84	55.9	1.3	81.5	51.37	2.5	59.4
2006	09/22/06	1131	2.0	87	63.9	1.0	86.1	58.11	2.5	59.7
2006	09/22/06	1132	2.5	176	52.3	1.9	167.1	40.32	4.5	59.8
2006	09/22/06	1133	2.2	348	68.9	1.4	7.7	49.72	5.3	59.8

2006	09/22/06	1134	3.7	28	26.1	3.4	30.6	25.27	7.2	59.8
2006	09/22/06	1135	3.1	88	31.8	2.6	90.7	30.86	5.2	60.3
2006	09/22/06	1136	2.9	87	30.9	2.5	86.9	29.62	3.9	60.4
2006	09/22/06	1137	2.9	356	48.9	2.0	4.2	45.32	5.9	60.3
2006	09/22/06	1138	3.8	49	39.1	3.2	43.7	32.13	7.7	60.1
2006	09/22/06	1139	6.5	74	59.3	3.6	63.3	53.80	12.2	60.2
2006	09/22/06	1140	4.3	49	53.9	2.7	45.4	48.56	6.0	60.0
2006	09/22/06	1141	3.2	10	58.3	1.6	18.9	57.61	6.0	60.0
2006	09/22/06	1142	3.5	113	51.2	2.4	108.2	45.87	5.3	60.0
2006	09/22/06	1143	3.4	61	50.4	2.3	52.7	46.37	5.3	60.0
2006	09/22/06	1144	3.1	49	27.6	2.7	45.1	27.53	4.4	59.8
2006	09/22/06	1145	4.4	52	34.5	3.6	48.1	34.05	7.2	59.9
2006	09/22/06	1146	4.9	61	60.6	2.9	52.9	51.86	7.5	59.8
2006	09/22/06	1147	4.1	54	50.8	2.7	49.8	47.39	7.0	59.9
2006	09/22/06	1148	3.0	78	64.0	1.5	83.4	56.88	4.5	59.9
2006	09/22/06	1149	4.4	7	50.2	3.0	10.1	46.16	7.3	59.7
2006	09/22/06	1150	4.5	346	69.9	1.9	12.2	62.00	8.8	59.7
2006	09/22/06	1151	4.7	28	40.8	3.6	29.9	38.39	7.7	59.6
2006	09/22/06	1152	5.8	357	58.6	4.3	13.0	41.82	15.1	59.5
2006	09/22/06	1153	2.8	6	49.6	1.9	358.2	46.81	4.4	59.3
2006	09/22/06	1154	3.5	351	77.8	1.6	348.4	59.61	8.6	59.3
2006	09/22/06	1155	4.2	9	57.1	2.7	16.2	48.47	8.4	59.3
2006	09/22/06	1156	2.7	62	98.7	0.3	141.3	76.10	5.2	59.4
2006	09/22/06	1157	5.1	21	63.8	2.7	21.7	56.24	8.6	59.4
2006	09/22/06	1158	4.2	111	71.0	1.5	101.2	65.28	6.9	59.5
2006	09/22/06	1159	2.3	107	52.9	1.6	98.6	44.75	3.9	59.6
2006	09/22/06	1200	4.8	67	65.2	2.9	38.1	51.72	11.5	59.9
2006	09/22/06	1201	3.8	67	38.5	3.0	66.6	36.17	9.3	59.8
2006	09/22/06	1202	3.2	71	60.3	1.7	68.2	55.29	4.6	59.9
2006	09/22/06	1203	2.7	83	49.2	1.8	85.1	46.31	4.5	60.1
2006	09/22/06	1204	4.0	43	55.0	2.8	34.7	43.06	7.4	60.2
2006	09/22/06	1205	3.0	33	39.6	2.3	33.5	37.28	3.8	60.4
2006	09/22/06	1206	3.9	348	43.4	3.2	2.0	35.98	7.9	60.4
2006	09/22/06	1207	6.0	26	58.0	3.8	30.6	49.24	8.9	60.2
2006	09/22/06	1208	6.6	32	28.1	5.9	35.1	27.15	12.8	59.9
2006	09/22/06	1209	3.2	29	48.9	2.2	19.1	44.81	6.1	59.9

### Site 6 Met Data

No met data were taken at this spot check measurement site.

## **Appendix E**

### **CHARM® Software Information**

# **CHARM User's Manual**

**URS Corporation**  
**Austin, Texas**

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## Chapter 1: Introducing CHARM Version 9

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Radian's Complex Hazardous Air Release Model (CHARM®) is a modeling software program that calculates and predicts:

- the movement and concentration of airborne plumes from released chemicals;
- mechanical overpressures from pressurized vessels and explosion overpressures from ignition of vapor clouds;
- thermal radiation footprints associated with jet fires, pool fires, and boiling liquid expanding vapor explosions (BLEVE); and
- population impacts associated with any one of the footprints described above.

The CHARM program is useful for preparing for or responding to the occurrence of an accidental release, designing response plans, and implementing training programs. Whether you are developing an emergency response plan or responding to an actual event, the CHARM program provides a quick and accurate method for assessing the potential impacts of airborne chemical releases, overpressures, and thermal radiation.

### Planning Mode

---

Planning for emergency response involves describing the potential release. You can define maps with the CHARM Editor for use in CHARM displays. In the planning mode, CHARM guides you through a list of input fields that describe a particular release and the present meteorological conditions. When you request a Plume display, CHARM requests a release time to use in the calculations which enable simulation of the release. The various graphic displays can be altered with a variety of options, and the release information can be stored in a scenario file for use with CHARM's emergency response mode.

### Emergency Response Mode

---

In the emergency response mode, CHARM quickly accesses pre-stored input in one or more scenario files. To save time in an emergency situation, CHARM enables you to define and store a base map that will

be displayed automatically whenever the CHARM program is started. Ideally, the map display will have icons that can be selected to show release scenarios and other maps.

CHARM generates plume displays, radiation and overpressure footprint displays, plots, tables, and site information. Emergency response procedures for a particular chemical release, local sources of help, and important phone numbers stored in the CHARM Editor (CHARMED) can be retrieved quickly in the emergency response mode.

## CHARM Input

---

The Main CHARM Input Window guides you through a list of characteristics that describe the release and the meteorological conditions. The selected species and release type determine which data fields are displayed for input. Although default data values are provided for the input fields, any data in the input window can be changed, including all of the default values (see “CHARM.INI File Description” in Chapter 3).

To assess the effects of an actual or potential accident, CHARM needs information about the toxicity of the released substance and how it disperses under different conditions. CHARM provides data on the physical, chemical, and toxic properties of over 180 chemical compounds. The chemical database can be expanded or modified through the CHARM editor (CHARMED). If you are unable to locate those chemical properties associated with a desired chemical which is not in CHARM's chemical database, Radian does provide services to gather necessary data to be used with CHARM.

A release can be described as a liquid or gas escaping from a container, or a liquid pool/lagoon. In either case, the conditions are defined right at or just prior to the release. CHARM also has the capability of defining release conditions right at or after the release has occurred, called “User-Specified After-Release Condition”. You can describe a release that is heavier or lighter than air, a ground-level or elevated release, and the type of surface on which a spill occurred. CHARM also allows you to describe liquid pool fires, Boiling Liquid Expanding Vapor Explosions (BLEVE), and jet fires. For a flammable vapor cloud, overpressures from the detonation or deflagration of the cloud can be estimated. In addition to explosion overpressures, CHARM can calculate mechanical overpressures from failures of pressurized vessels. Once an impacted area from any one of the available footprints has been identified, CHARM can estimate population impacts based on U.S. Census Bureau

Tiger/Line™ 1992 Data.

Meteorological data for input to CHARM can be obtained from instruments brought to the site, from a nearby meteorological station(s), or from estimates prepared by a remote weather center. CHARM can also be set up permanently as part of a facilities operation to automatically receive continuous data from a meteorological station, or from multiple data collection sites. For automatic meteorological data retrieval, CHARM requires an additional program called METINTER which is custom designed to integrate with the protocol sent by your met station hardware.

## Map Displays

---

Maps cannot be created in CHARM or CHARMED. Drawings must be created with some type of third-party software and then defined in the Map Definition Editor in CHARMED before the map can be utilized in CHARM. The Map Definition Utility in CHARMED can import properly scaled, site-specific or area maps created with the Microsoft® Windows Paint Program or other more sophisticated Windows-compatible drawing programs. Detailed maps of areas may be found on and downloaded from the internet. Maps can be read from the clipboard or from files. Maps must be read and edited with the CHARM Editor before they can be used in CHARM. During a CHARM run, you can overlay displays of concentration, thermal radiation, and overpressure levels on a selected map to identify local impact areas. Icons representing release locations and other maps can also be defined on a map display.

## Population Impacts

---

CHARM has the ability to calculate the number of people affected by footprints of desired concentrations, radiation fluxes, or overpressures. The number of people is determined from the population information available on U.S. Census Bureau Tiger/Line™ 1992 Data. To use population data with CHARM, the U.S. Census Bureau data files must be preprocessed with the CHARM TigerMap Utility. After preprocessing, the data files must be defined in the CHARM Editor. Once a footprint is displayed, CHARM uses one of three different methods to calculate population impacts. For more information defining and displaying population data, see "Population Data" in Chapter 4. To order Census Bureau data, contact:

U.S. Department of Commerce  
BUREAU OF THE CENSUS  
Data User Service Division

Washington, DC 20233-8300  
301-673-4100

## CHARM Calculations

---

When the required input has been entered, CHARM calculates the radiation footprint, overpressure footprint, or concentration of a chemical plume, and predicts the dispersion of the release. CHARM is a Gaussian puff model that considers any release to be a series of **puffs**. CHARM determines the number of puffs in a release and the initial characteristics of each puff.

CHARM creates a source term based on the user input then proceeds to generate the transport/dispersion, radiation, or overpressure calculations to describe an impact. The resulting displays simulate the release according to the specified input and the calculations. For information on CHARM algorithms, refer to the “CHARM Technical Reference Documentation.”

## Graphic Displays

---

CHARM provides plume displays to show the locations, shapes, and up to three concentration isopleths of the chemical plume resulting from a release. Footprint displays show up to three values each for thermal radiation and overpressures. Any footprint display may overlay a map. Vertical cross-sections, tables, and two-dimensional plots are also provided.

The CHARM displays include:

- An instantaneous plume view showing the concentrations at the specified time since release;
- An integrated plume view showing a minute-by-minute (or second-by-second) time history of the impact area;
- A time-averaged plume based on a user-defined averaging interval and a user-defined grid size;
- A dose display showing the time history of concentration at any point;
- A vertical cross-section of the plume or footprint;
- Thermal radiation footprints from liquid pool and jet fires;

- Overpressure footprints resulting from mechanical failure of a pressurized vessel;
- Overpressure footprints resulting from ignition of a vapor cloud at a specified time;
- A table showing the location of maximum concentrations as a function of time;
- A plot and table showing the maximum downwind distance from the source of a specific concentration level as a function of time;
- A plot and table showing the concentrations through the centerline of the plume;
- A plot and table showing the maximum crosswind width of a user-specified concentration as a function of time;
- A plot and table showing the crosswind half-width down the centerline of the plume as a function of concentration;
- A 3-Dimensional view of a single user-specified concentration;
- Population impacts of a plume or footprint (requires 1992 Tiger/Line Census Bureau Data);
- Circular Population impacts associated with a radial distance from the source (requires 1992 Tiger/Line Census Bureau Data);
- A plot and table illustrating emission rates from both the container and the pool;
- A detailed report (Source/Puff Calculation) showing the output of the source term calculation performed by CHARM. The data consists mainly of the numbers used to describe the source term, emission out of the container, emission of each puff into the atmosphere during the release, etc.;
- Displays showing chemical data and emergency response action to be taken in association with the species being modeled; and
- User-definable site specific information.

## The CHARM Environment

---

CHARM operates in the Microsoft Windows environment. The Windows program comes with thorough documentation for using the menus and dialog boxes with and without a mouse. CHARM menus and dialog boxes follow the same style. CHARM comes with a complete on-line help system. A help command is available for every CHARM window and dialog box. The on-line help screens provide additional information to describe the window or explain the type of data requested.

Within the Windows environment, a single CHARM run can display several scenarios of the same or a different chemical under different meteorological and/or time-release conditions simultaneously. In addition, both text and graphic displays can be sent to the clipboard for use with Windows-compatible word processors.

## Hardware Requirements

---

The hardware requirement for the CHARM program depends on the type of processor (CPU) in the computer.

The minimum hardware requirements are a computer with a 80486 CPU and 8 megabytes (M) RAM.

In addition, the hardware requirements include:

- A 20M hard disk;
- A 1.44M, 3.5 inch diskette drive;
- Graphics card/monitor with a Microsoft Windows software driver; (Many drivers come with Windows. Some manufacturers supply drivers with their products. You may have to check with the manufacturer.)
- A math co-processor;
- A mouse is highly recommended, although not required. The mouse requires a Windows driver;



## Software Requirements

---

CHARM 9 requires Microsoft Windows95 or WindowsNT as the operating system. CHARM does not include a run-time version of the Windows program; it must be purchased separately.

## About This Manual

---

The CHARM User's Manual is divided into the following sections:

- |                  |  |
|------------------|--|
| <b>Chapter 1</b> | "Introducing CHARM" is an overview of the features of the CHARM program. It also includes the hardware and software requirements, and a description of the contents of this book.  |
| <b>Chapter 2</b> | "Installing CHARM" provides the steps for installing CHARM and information for updating a previous CHARM version. This chapter also explains how CHARM is protected from unauthorized use and how to solve insufficient memory problems.   |
| <b>Chapter 3</b> | "Getting Started" describes how to start and stop the CHARM program and provides general conventions for running the program.  |
| <b>Chapter 4</b> | "Using the CHARM Editor" explains how to use the editors to modify CHARM file location information; modify and update the chemical database; enter site-specific information; specify 1992 Tiger/Line Census Bureau data for determining population impacts; and set the parameters for communication with a meteorological tower(s). This chapter also describes how to edit the maps you want to use with CHARM. |
| <b>Chapter 5</b> | "The Main CHARM Input Window" explains how to use CHARM in the planning mode and describes the input for creating a release scenario.  |
| <b>Chapter 6</b> | "Understanding CHARM Displays" describes the displays that CHARM generates for a release scenario.   |
| <b>Chapter 7</b> | "Using CHARM for Emergency Response" describes how to use CHARM in the emergency response mode.  |
| <b>Chapter 8</b> | "Using the TigerMap Utility" explains how to preprocess U.S. Census Bureau Tiger/Line™ 1992 Data for   |

preparation for use with the CHARM Editor and CHARM in determining population impacts.

**Chapter 9** "Menus and Commands Reference" is an alphabetical listing of the CHARM menus and their commands. This chapter functions as a reference for quickly accessing detailed information in the CHARM User's Manual.

This manual also provides a list of figures for each screen in the manual and an index for locating specific information quickly.

## Manual Conventions

This manual uses the conventions for terminology and typography discussed in the following paragraphs.

### Key Names

The names of keys on the computer keyboard appear capitalized and enclosed in angle brackets. For example, the Enter key is represented as <Enter> in this manual. The actual key names seen on your particular keyboard may be a little different.

### Key Combinations

In some cases, two keys must be pressed at the same time to achieve the intended result. In these cases, the two key names are hyphenated. For example, <Ctrl-Del> means hold <Ctrl> while pressing <Del>.

### Arrow Keys

The four arrow keys on the computer keypad refer to the directions in which you can move the selection, the pointer, or the insertion point on your screen. The arrow keys are also used to position icons on a map display. These keys are particularly useful if you are using the keyboard instead of the mouse.

### Menu and Command Names

The names of menu commands and their commands are capitalized in this manual. They appear in text just as they appear on the screen.

### What You Type

Whenever this manual presents something you should type verbatim, the characters are shown in **bold** typeface. If the letter case is significant, uppercase or lowercase information is specified in the directions.

## Terms

Many of the computer terms used in this manual are equivalent to the terms used by Windows documentation. When a term is defined, it appears in **bold** typeface. *Italics* indicate emphasis.

## Notes and Cautions

A note provides information that is specific to certain circumstances or is of special interest. A caution contains information about actions that can cause you to lose or damage your data. Notes and cautions are shown in *italics*.

## Figures

CHARM windows are shown as numbered figures throughout this manual. A complete list of figures is provided immediately following the Table of Contents. The appropriate dialog box is shown for each CHARM data entry field. These graphics are not numbered, but the field names are listed in the Table of Contents. Window examples are generated from Windows95, and may differ if you are running another Windows Operating System

## Chapter 2: Installing CHARM

---

The initial steps to use for installation depend on whether you are installing CHARM for the first time or updating a previous version of CHARM. After installation, you must install the parallel port key to indicate to CHARM that this license of CHARM is authorized for use. This chapter also contains suggestions for handling insufficient memory problems.

### Updating a Previous CHARM Version

---

CHARM is backward compatible as far as reading scenario and meteorological files from a previous version of CHARM. However, you may have added chemical data to the chemical database, in which case you do not want to overwrite CHMDAT8 files. Be sure to backup CHMDAT8 files before installing CHARM version 9, or simply install CHARM version 9 in another directory. (see "Updating Chemical Database from a Previous Version" in Chapter 3).

### Installing CHARM for the First Time

---

Use the following steps to install CHARM for the first time:

1. Turn on or boot your computer.
2. If a Microsoft Windows operating system is not already installed on your PC, install Microsoft Windows version Windows95 or WindowsNT.
3. If Microsoft Windows is not already running, start MS Windows by typing the following command at the DOS prompt:

**WIN**

4. Select the 'Run' option from the appropriate Windows OS. The following window is displayed:



5. Place the CHARM diskette labeled "Disk 1" in the diskette drive, and enter the following command at the Command Line prompt of the 'Run' window:

**A: \SETUP**

If you are using a diskette drive other than A, use its name in place of the **A** shown in the command above. Alternatively, you may initiate the CHARM installation procedure by executing My Computer or Windows Explorer from the desktop, and executing SETUP.EXE from your floppy drive.

6. Once the Setup program is running, follow the instructions on the screen to continue or exit the installation.

## Handling Insufficient Memory Problems

---

Several conditions may cause a "Not enough memory" message to be displayed. Some conditions to check for and their possible remedies are described here.

1. The Windows program must be started before the CHARM program is started. CHARM requires Microsoft Windows to run. This means that CHARM cannot be started from the DOS command prompt like other DOS programs. If you enter **CHARM** at the command prompt, an insufficient memory message is generated because the size of the CHARM program is greater than 640K.
2. Start Windows as described in the Windows documentation for your computer system. CHARM can then be started by selecting the CHARM icon from the CHARM group in the Program Manager.

3. Other programs may be running and taking up memory needed by CHARM. These programs are called Terminate but Stay Resident (TSR) programs, and they reduce the amount of memory available to CHARM. For example, the programs necessary for computer networking require memory. Another example is a utility program, such as Sidekick, that requires memory. A mouse driver need not be loaded, because Windows provides its own. TSRs and some drivers are normally loaded with the AUTOEXEC.BAT file. Most drivers are loaded with the CONFIG.SYS file.
4. The AUTOEXEC.BAT and the CONFIG.SYS files must always allow Windows and CHARM to operate. Some sample AUTOEXEC.BAT and CONFIG.SYS files that represent the simplest cases are provided below. It is possible that other directives have been added to these files to the extent that memory is no longer available for completing a CHARM run.

Example 1 shows the contents of one of the simplest AUTOEXEC.BAT files that can be used. The example creates a prompt of the default directory and identifies the PATH directive. The PATH directive tells the computer where to look for programs named in a command that are not in the default directory (the directory from which the command is issued).

Example 1:

```
ECHO OFF
PROMPT $P$G
PATH C:\WIN;C:\DOS;C:\BIN;C:\UTIL;C:\CHARM
```

Example 2 shows the minimum requirements for a CONFIG.SYS file to operate correctly with Windows.

Example 2:

```
FILES=30
BUFFERS=10
```

## Protecting CHARM from Unauthorized Use

---

The CHARM software is protected from unauthorized use by a hardware device called a **key**, which is supplied as a part of the purchase of CHARM. This key must be installed before CHARM is run or the program will not perform any calculations. If no key is present, a warning is displayed, and calculation is halted, and CHARM terminates.

The type of key CHARM uses is a parallel port (LPT) key. The standard key being sent with CHARM Version 9 software is the printer port key. This key connects in line with the parallel port and the printer cable.

Use the following steps to install the printer port key:

1. Disconnect any cable connected to the designated LPT output (printer) port of your computer.
2. Connect the parallel port key to the designated LPT output port.
3. Connect the printer cable to the other side of the key. The male end of the key attaches to the female end of the LPT port.

You are now ready to execute CHARM.

## Chapter 3: Getting Started

---

This chapter provides information for starting and stopping the CHARM program and CHARM utilities, and understanding the general conventions used throughout the CHARM program.

### Starting and Stopping the CHARM Program

---

After the CHARM program is installed as described in Chapter 2, use the following steps to start CHARM.

5. Turn on the computer, if necessary.
6. Start Microsoft Windows, if necessary.
7. Double click the CHARM icon in the CHARM Group of select CHARM from the Start menu.

To stop CHARM or a CHARM utility program, select the Exit command from the File menu. CHARM can also be stopped by double-clicking the icon at the upper left corner of the CHARM window, or by single-clicking the X icon at the upper right corner of the window.

### General CHARM Conventions

---

The general conventions used by the CHARM program involve file names, on-line help, dialog boxes, and the search function. Familiarity with the Windows program is helpful in understanding these features.

CHARM uses a Windows application style that is common for large-scale software programs. This application style is called a Multiple Document Interface, or MDI. This particular style allows the application to display multiple windows in a single CHARM window. The user can view and move among multiple windows, but every window is bounded by the extents of the single larger CHARM window frame. A standard MDI window frame usually contains a menu bar, an optional toolbar, and microhelp in the lower left portion of the window. Using the MDI application style also dictates that only the single larger CHARM window frame contain the menu bar, the toolbar, and the microhelp; that is, the multitude of windows that may be generated in the MDI frame do NOT contain menus, as the menu bar and the toolbar on the MDI frame dynamically change when a child window is selected.



## CHARM Menus and Commands

All CHARM commands are organized in menus on the menu bar on the CHARM MDI frame. A menu lists all the available commands for a selected window, but only those that are not grayed are executable at a particular time. Since CHARM operates in the Microsoft Windows environment, many of the conventions are similar. For example, CHARM provides drop-down menus, icons, and the choice of using the mouse, the keyboard, or both.

The File, Edit, and Window menus represented in the CHARM program are similar to the Windows menus of the same names. Refer to the Microsoft Windows User's Guide for a more detailed description of the standard Windows menus and commands. The CHARM program provides additional menus and commands.

CHARM provides menus for displaying and altering text and graphics. These menus include the File, MetFile, Options, and Displays menus. The commands on these menus change depending on the currently displayed window and user input. Refer to Chapter 8, "Menu and Command Reference" for a complete listing of all CHARM menus and commands.

The CHARM editor (CHARMED) has special menus and commands that are described in Chapter 4, "Using the CHARM Editor."

## CHARM File Names

When you save a file in CHARM or CHARMED, you can assign the base file name and let CHARM assign the default extension, or you can assign the base name and the extension. CHARM uses the file name extension for identifying the names to display for selection lists.

CHARM uses several default file name extensions that are assigned according to the file type. Some file type extensions are user-definable (see "CHARM.INI File Description" in this chapter). The default extensions used by CHARM and a brief description of each file type follows:

<b>.IND</b>	A file containing subdirectory information that CHARM uses to locate .EMG files. Files with .IND extensions are created by the user with a text editor and are only used in accordance with the Scenario command under the File menu.
-------------	---

<b>.EMG</b>	A file containing release scenario data. When you save a release scenario without specifying a file name extension, CHARM assigns the .EMG default extension.
<b>.MET</b>	A file containing meteorological data. When you save met data without specifying a file name extension, CHARM assigns the .MET default extension.
<b>.MAP</b>	A file containing a map. When you save a map without specifying a file name extension, CHARM assigns the .MAP default extension.
<b>.MFD</b>	A file containing a map definition. CHARM automatically creates this file when you save a map. A file with the .MFD extension should not be deleted unless its corresponding .MAP file is also deleted. Likewise, if the .MAP file is moved to a different location (subdirectory) on the PC disk, the .MFD file should also be moved to the same location.
<b>.TPY</b>	A file containing population information to be used in determining population impacts for a plume or footprint. This file is initially generated from the TIGERMAP Utility program. The user then specifies in CHARMED under 'Edit/Select Population Files' which population files are to be used to calculate population impacts in CHARM.
<b>.TGR</b>	A map file initially generated from the TIGERMAP Utility program. The file is merely graphic information processed from 1992 Tiger Line Census Bureau data. The format is not readable from within CHARM or CHARMED, and is only displayed in the TIGER MAP Utility.
<b>.PLM</b>	An ascii text file that contains the Cartesian x, y, and z coordinates and other pertinent information that define the extents of a plume or footprint.

**.SHP** A file which describes a footprint of impact (concentration, thermal radiation, or overpressure) which can be transferred to ArcView for display. An ArcView shape file is actually three files: the main file, an index file, and a dBase file with attributes. These three files all have the same names and locations except for their extensions. The main file extension is .SHP. The index file extension is .SHX and the dBase file extension is .DBF.

Files with .EMG, .MET, .MAP, TPY, TGR, and PLM extensions are used in selection lists when no other extension is specified. Files with .IND and .MFD extensions have exclusive purposes in CHARM. Files with the .IND extension are user-created ascii files that identify the locations of certain .EMG files. Files with .MFD extensions are created by CHARM to accompany a .MAP file and provide the necessary map definition information specified with the map editor. These file name extensions should not be used for other purposes.

### **Creating .IND Files**

Files with the .IND extension are index files that point to subdirectories containing .EMG files. You can create .IND files with a text editor. When the Scenarios command is selected from the File menu in the Main CHARM Input Window, CHARM initially searches the initial lookup directory for files that have the .EMG extension. This initial lookup directory is defined in CHARMED under the File Locations command of the Edit menu labeled 'Scenario Files'. If no .EMG files are found, CHARM searches for an .IND file for directions. Files with .EMG and .IND extensions should not exist in the same directory, because only the .EMG files will be accessed. Additionally, only the first .IND file CHARM encounters in a directory is used and any others are ignored. Therefore, only one .IND file should exist per directory.

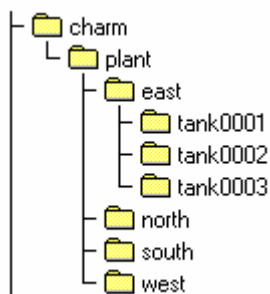
An .IND file can have multiple pairs of subdirectory listings. Each subdirectory can have subdirectories. A subdirectory that has .EMG files can have multiple .EMG files associated with that subdirectory.

To create an .IND file, use a text editor to open a new file. Enter a pair of lines for each subdirectory. The first line of the pair can have up to 60 characters naming the subdirectory. Full path names are not required, because the named subdirectory is added to the full path name of the

previous directory searched. The second line of the pair provides CHARM with a detailed description of the subdirectory when the directory is listed to the user for selection.

#### Steps for creating IND Files:

- 1) The user must define the location of the initial .IND file under the File Locations command in the CHARM editor (CHARMED) in the field labeled 'Scenario Files'.
- 2) From Windows Explorer, create subdirectories which layout, for example, geographical aspects of possible release sites. Other alternatives for organizing your data may be by process or chemical inventory.



- 3) From Notepad (or some other text editor), create a file with the .IND extension and format the file as follows:

#### **Format**

```

<Subdirectory Name>
<Description associated with subdirectory name>
<Subdirectory Name>
<Description associated with subdirectory name>
<Subdirectory Name>
<Description associated with subdirectory name>
  
```

#### **Example**

The EXAMPLE.IND would read as follows and reside in the C:\CHARM\PLANT subdirectory:

```

EAST
Relase occurred in east side of plant
NORTH
Relase occurred in north side of plant
SOUTH
  
```

Relase occurred in south side of plant  
 WEST  
 Relase occurred in west side of plant

*NOTE: The above file should reside in the initial Emergency Response file location defined by the CHARM editor (CHARMED). No prestored data files (.EMG) should reside in the same directory as .IND files. CHARM attempts to locate EMG files first. If EMG files are located and read, no attempt is made to locate IND files.*

4) Repeat Step 3 for all directories.

### **Creating .EMG Files**

CHARM creates files with the .EMG extension when you save the release input data. Initially, this file type extension is .EMG. However, refer to “CHARM.INI File Description” later in this chapter for information about redefining this default extension. You must specify a base name for the file. Unless you specify a different file name extension, CHARM automatically adds the default extension. Files with the default extension can be created with the Save and Save As commands on the File menu.

## **On-line Help**

CHARM provides on-line help that explains each window and field in the program. On-line help is available in both CHARM and CHARMED. Press <F1> for a description of the contents of the current window or dialog box. When you select a field for data input, the dialog box contains a Help command button that displays field information and the data entry requirements. To select help on a menu or topic, select <Shift-F1>. The cursor will change to a pointer with a question mark. Simply point to the menu item or the editable text and click the left mouse button. CHARM will attempt to locate on-line help for the selected menu or topic. If CHARM cannot locate the menu or topic, it will display an index into on-line help.

## **Dialog Boxes**

CHARM displays a dialog box whenever it needs additional information to carry out a command. Dialog boxes typically contain text, lists of available choices, command buttons, and option buttons. You may be required to make a selection or enter text or values. Normally, default values are provided. Any units of measure that are acceptable for the entry are available in drop-down lists. The OK, Cancel, and Help command buttons are also available in dialog boxes.

Many of the values solicited in a CHARM dialog box require you to make an entry. If you try to select the OK command button when the entry field is blank, CHARM displays a message saying an entry is required. However, in some cases, it may be OK to leave the field blank, whereby CHARM will accept the blank entry.

CHARM often accepts only those values that are within certain limits. For example, relative humidity must be less than or equal to 99. If you try to enter an unacceptable value, CHARM displays a message showing the acceptable range of values.

## Default Input Values

On some occasions, you may need to estimate a release incident about which you have little data. In an emergency situation, you may not only have little data, but you need to enter the data quickly. To address this, CHARM provides default values for data fields that are essential to the calculations. Default values appear on the screen as already entered data. In some cases, these default values may be user-definable (see “CHARM.INI File Description” in this chapter). These values may represent the worst-case conditions or some typical situation. You can accept the default values or replace them with more accurate data.

## CHARM.INI File Description

The file CHARM.INI is used to store information which CHARM reads and uses as defaults upon starting the program. The file is divided into two sections: [Directories] and [Default settings]. The [Directories] section associates types of files with physical subdirectory locations on your hard disk. Currently, CHARM differentiates between fifteen types of files. Initially, upon installation, all subdirectories default to the setup directory. Thirteen of these fifteen subdirectories may and should be modified from CHARM or CHARMED. The two file types (HelpDir and WinchDir) can only be changed by modifying the CHARM.INI file itself. In order to do this, use the following instructions:

- 1) Exit CHARM.
- 2) Open your CHARM.INI file using a text editor such as Notepad.
- 3) Find the [Directories] section of the file. It should be the first section.
4. Change the subdirectory associated with any one of the following:

(NOTE: Make sure the subdirectory truly exists.)

**HelpDir** - this subdirectory will contain CHARM help files (.HLP files).

For example, HelpDir=c:\charm\help\;

**WinchDir** - this subdirectory will contain your encrypted hidden password file for access to the CHARM Editor.

For example, WinchDir=c:\charm\winch\;

*NOTE: Any other modifications to the following should be made from within CHARM or CHARMED.*

**DataDir** - this subdirectory will contain CHMDAT\*. \* files (chemical database files).

For example, DataDir=c:\charm\data\;

**SiteDir** - This subdirectory will contain site specific information in the a file labeled USRMSG.

For example, SiteDir=c:\charm\site\;

**CommDir** - this subdirectory contains files (METINTER.EXE, METINTER.INI, and METDAT\*. \*) necessary to establish and maintain communication with a data logger (if available).

For example, CommDir=c:\charm\comm\;

**ScenDir** - this subdirectory contains a \*.IND file or \*.EMG files.

For example, ScenDir=c:\charm\scenario\;

**MapDir** - this subdirectory is the default for saving or displaying map files with the extensions associated with the keyword **MapExt** under the section labeled [Default settings] in CHARM.INI.

For example, MapDir=c:\charm\maps\;

**EmgDir** - this subdirectory is the default for saving or displaying pre-stored scenario data files with the extensions associated with the keyword **EmgExt** under the section labeled [Default Settings] in CHARM.INI.

For Example, EmgDir=c:\charm\emgs\;

**MetDir** - this subdirectory is the default for saving or displaying pre-stored met data files with the extensions associated with the keyword **MetExt** under the section labeled [Default settings] in CHARM.INI.

For Example, MetDir=c:\charm\mets\;

**AsciiDir** - this subdirectory is the default for storing data files containing real-world coordinates of plume, thermal radiation, or overpressure footprints generated by CHARM. The default extension for listing these data files is associated with the keyword **AsciiExt** under the section labeled [Default settings].

For Example, AsciiDir=c:\charm\ascii\;

**ShapeFileDir** - this subdirectory is the default for storing ArcView shape files containing plume, thermal radiation, or overpressure footprints generated by CHARM. The default extension for listing these data files is associated with the keyword **ShapeFileExt** under the section labeled [Default Settings]. A set of files for an ArcView shape file also consist of files containing the SHX and DBF extensions.

For Example, ShapeFileDir=c:\charm\shapes\;

**DIPPRDir** - this subdirectory is the default where CHARMED looks to find the DIPPR database for importing chemical data into CHARM's chemical database.

For Example, DIPPRDir=c:\charm\dippr\;

**PopFiles** - this keyword contains a list of comma delimited files (including paths) of those population files that were processed from CHARM's TIGERMAP Utility for use with population impacts.

For Example,  
PopFiles=c:\charm\popfiles\county1.tpy, county2, tpy;

**RelDir** - this subdirectory is the default from which CHARMED displays scenario data files when using the BROWSE button upon selecting files associated with a release icon. The default extension for listing these scenario files is associated with the keyword **RelExt** under the selection labeled [Default settings].

For Example, RelDir=c:\charm\emgs\;

**PopDir** - this subdirectory is the default where CHARMED displays population files when using the BROWSE button upon selecting files used for population impacts. The default extension for listing these



population files is associated with the keyword **PopExt** under the selection labeled [Default settings].

For Example, PopDir=c:\charm\popdata\;

5) Save your CHARM.INI file.

6) Restart CHARM.

The [Default settings] section contains default values for variables within CHARM itself. **DO NOT CHANGE ANY OF THESE VALUES AS THEY ALL MAY BE CHANGED FROM WITHIN CHARM. CHANGING A VALUE MAY CAUSE CHARM TO RUN IN AN INCORRECT MANNER OR POSSIBLY CRASH THE SYSTEM.** You may change some variables without having severe effects on CHARM: MapExt, EMGExt, MetExt, AsciiExt, ShapeFileExt, PopExt, and RelExt. MapExt contains the default extension for map files; EMGExt contains the default extension for prestored scenario files; MetExt contains the default extension for met data files; AsciiExt contains the default extension for text files that contain x,y, and z real world coordinates of a plume or footprint; ShapeFileExt contains the default extension for plume or footprint datafiles formatted to import into ArcView; PopExt contains the default extension to browse for when selecting population files in CHARMED; RelExt contains the default extension to browse for when associating emergency response files with release icons in Map Definition in CHARMED.

## Search Function

When the chemical selection list is being displayed, you can perform a forward or backward search through the chemical database. First, select Set String and enter the character string for which you want to search. Then, select Up to search backward or Down to search forward through the database.

When you specify the character string, you can use the wild card characters, \* (asterisk) and ? (question mark). The \* represents zero or more characters. The ? represents a character location within the string rather than a special character.

## Using the Mouse

The mouse can be used to move icons, expand and shrink windows, and select menus and commands. The mouse techniques used in CHARM include pointing, dragging, clicking, and double-clicking.

The CHARM program responds to left mouse button clicks and combining keys (e.g. Shift, Ctrl, and Alt) with left mouse button clicks. Menus and commands are selected in the same manner in CHARM as in the Windows program. Clicking the left mouse button highlights a field or selects a location pointed to by the cursor. Double-clicking the left mouse button on a field displays a dialog box for data input.

The CHARM dialog boxes display command buttons that can be selected with the mouse. You can select the OK command button to complete an action, or select the Cancel command button to ignore the attempted action. These are standard techniques for Windows applications.

## Using the Keyboard

The keyboard can be used to achieve the same results as the mouse. The following keys are standard for the CHARM application:

<b>&lt;Alt&gt;</b>	Moves the inverse video bar to the menu bar. Use the arrow keys to position the inverse video bar.
<b>&lt;Esc&gt;</b>	Clears a menu from the screen.
<b>Arrow keys</b>	Move the inverse video bar (highlighted selection) up, down, right, or left. In CHARM and CHARMED, the arrow keys can also be used to move the crosshair cursor on graphic displays, define a zoom area, define a map scale, and reposition plumes, footprints, and icons.
<b>&lt;Enter&gt;</b>	Selects the highlighted item or map location represented by the cursor. On a map display, <Enter> can be used to select an icon or generate a dose display at a specific location. In a dialog box, <Enter> directs CHARM to accept the displayed values or cancel the operation, depending on which command button is highlighted.

<b>Page Up</b>	Scrolls a window display up. In CHARMED, after an option from the Define menu of the Map Definition window is selected, <Page Up> moves the cursor instead of the map display.
<b>Page Down</b>	Scrolls a window display down. In CHARMED, after an option from the Define menu of the Map Definition windows is selected, <Page Down> moves the cursor instead of the map display.
<b>&lt;Ctrl-Arrow key&gt;</b>	Changes the position of the plume, overpressure, or radiation footprint within the viewport by virtually moving the solid circle on the CHARM display.
<b>&lt;Shift-Enter&gt;</b>	In CHARM, when the cursor is on a map location icon on a snapshot footprint view, <Shift-Enter> displays the enlarged map represented by the icon. When the cursor is on a release icon, <Shift-Enter> displays a selection list of release scenarios for the location. In CHARMED, <Shift-Enter> selects an icon to be repositioned.
<b>&lt;Shift-Arrow key&gt;</b>	In CHARMED, <Shift-Arrow key> moves an icon that has been selected with <Shift-Enter>.

## Chapter 4: Using the CHARM Editor

---

Use the CHARM editor (CHARMED) to identify the locations of the files that CHARM uses; add, modify, or delete data from the chemical database; update chemical data from a previous version of a CHARM database; enter site-specific information; set up communication with a meteorological tower(s); select population data files to determine population impacts; and define maps for display with the CHARM program.

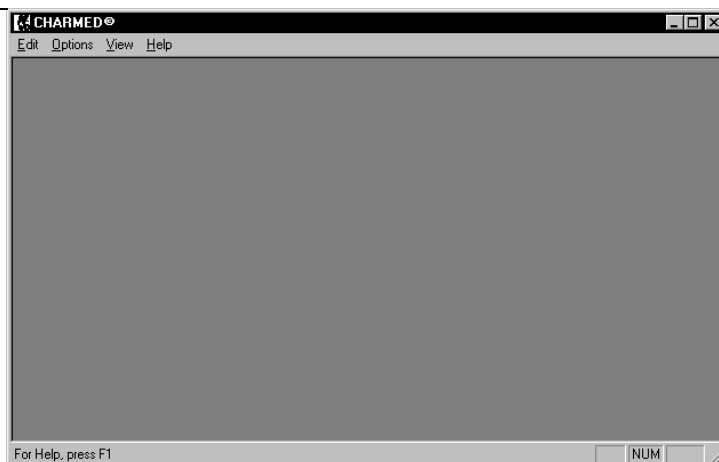
Use the following steps to run the CHARM editor:

1. Double click the CHARMED icon in the CHARM Group in Program Manager, or

Select CHARMED.EXE from the CHARM installation directory using the Windows Explorer or My Computer from the desktop. The CHARMED window is displayed.

The CHARMED window shown in Figure 4.1 is displayed.

**Figure 4.1**  
Main CHARM  
Editor  
Window



### The CHARMED Window

---

The main CHARM editor window has several menus, the most significant one where the user will spend most of the time is the Edit menu. The Edit menu provides a command for each of the following CHARM editors:

**Chemical Database** Add, modify, or delete data in the chemical database.

<b>Import Previous Database</b>	Displays a dialog box requesting the path to the previous version of the CHARM database. Once the path is entered, CHARM will attempt to update the current database from those records in the previous database. The user will be prompted to add or modify any data that exists in the previous database and not in the most recent database.
<b>Update Plot Concentrations</b>	Displays a dialog box requesting the path to the previous version of the CHARM database. Once the path is entered, CHARM will attempt to update the default plot concentrations in the current database from those records in the previous database. The user will be prompted for verification.
<b>Pack Chemical Database</b>	Physically removes logically deleted records from the chemical database. Records are logically deleted from within the Chemical Database editor using the Delete button.
<b>Local Met Comm Parameters</b>	Sets the parameters for communications with a meteorological tower. Another Radian software program (METINTER.EXE) is required for the implementation of communication with a tower.

<b>Network Met Server Location</b>	Sets the logical name of the server to where a network version of the Meteorological Interface (METINTER.EXE) will reside for LAN/WAN access.
<b>File Location</b>	Specifies where CHARM can find necessary files.
<b>Site Information</b>	Specifies site-specific information for a release in a file labeled USRMSG.
<b>Map Definition</b>	Reads maps and provides commands to edit them for use with CHARM.
<b>Select Population Files</b>	Select population files to be used in determining population impacts for a plume or footprint. These files are initially generated from the TIGERMAP Utility program.
<b>Change Password</b>	Defines CHARM/System password to regulate CHARMED entry. This menu item may be grayed and optional to the user. Contact Radian to allow password access.
<b>Exit</b>	Exits CHARMED.

Only one editor can be used at a time. When you exit from an editor, you are returned to the CHARMED window.

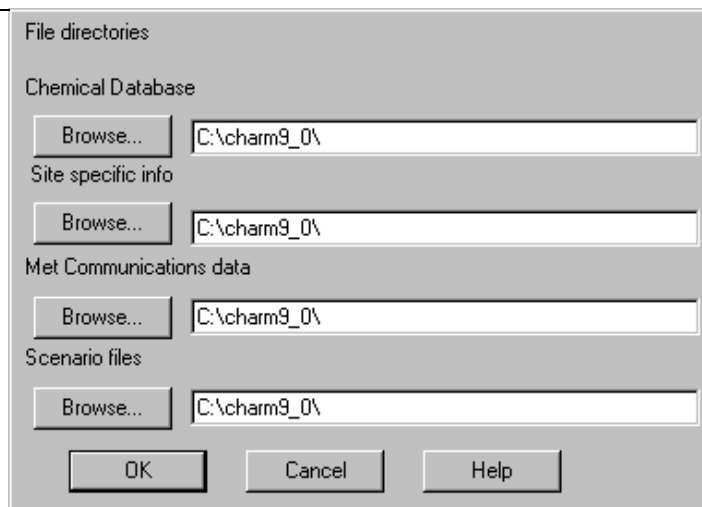
## **Editing File Locations for CHARM**

---

Use the File Location command on the Edit menu of the CHARMED window to identify the directory locations for the chemical database, site specific information, meteorological communication parameters, as well as the location of the emergency response files. Emergency response files have default .EMG extensions, unless you specify a

different extension (see Chapter 3: CHARM.INI File Description). CHARM uses this directory information to locate necessary files. Figure 4.2 shows the CHARMED File Location Editor.

**Figure 4.2**  
File Location  
Editor



To identify directory locations:

1. Run the CHARM editor by selecting the CHARMED.EXE file. The CHARMED window is displayed.
2. Select the File Locations command on the Edit menu of the CHARMED window.
3. Enter the full path names for the directories containing the Chemical Database, Site Specific Information, Meteorological Communication Parameters, and Scenario files. Alternatively, use the Browse button associated with each file directory to input full path names.
4. Select OK or press <Enter>.

## Maintaining the Chemical Database

---

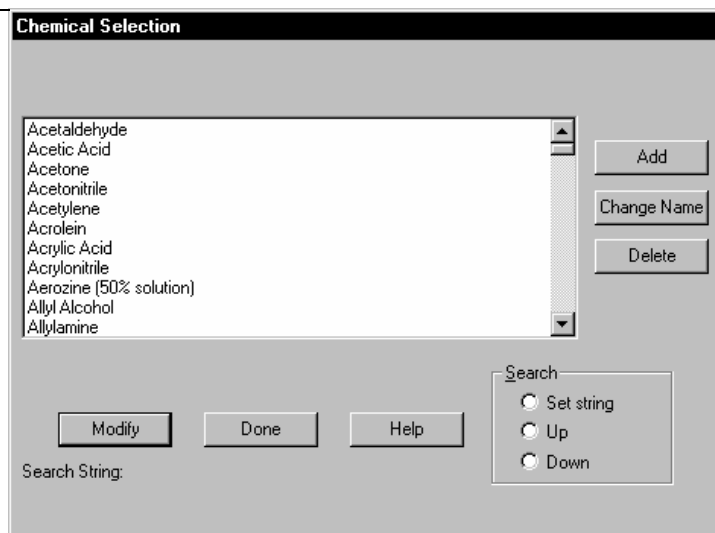
The chemical database provides over 180 chemical species and their characteristics for use with the CHARM program. Information from the chemical database is displayed in the Chemical Selection and Chemical Editor windows of the CHARM editor.

## The Chemical Selection Window

After you select the Chemical Database command from the Edit menu, the Chemical Selection window shown in Figure 4.3 is displayed. This window contains a list of all the chemicals in the database. The

Change Name, Delete, and Modify commands require you to select the chemical name first. To select a chemical, simply highlight the desired compound by left mouse clicking on the chemical name. You can use the search or scroll functions to look for a particular chemical species.

**Figure 4.3**  
Chemical  
Selection  
Window



## Using the Search Function

Use the Search function to look for a particular chemical in the chemical database. This function can be used to find entire chemical names quickly or to find a chemical whose name is only partially known. The Search function is also available in CHARM when the chemical species is selected for input. The following dialog box is displayed when you select the Set Search String command button from the Chemical Selection window.



To perform a search on the list of chemical names:

1. Run the CHARM editor by selecting the CHARMED icon from the CHARM group or by executing the CHARMED.EXE file from the Windows Explorer or My Computer on the desktop. The CHARMED window is displayed.
2. Select the Chemical Database command on the Edit menu. The



Chemical Selection window is displayed.

3. Select the Set string radio button from within the Search group box.
4. Type a character string for the search and include one of the wild card characters, \* (asterisk) or ? (question mark).

The \* represents zero or more characters. The ? represents the position of a character in the string, rather than a particular character.

A search allows for multiple order-dependent strings to be used. For example, a search for the character string "di\*meth\*e?e" retrieves all strings with the substrings "di," followed by "meth," and then followed by "e?e." The ? represents any character with an "e" on either side.

5. Select OK or press <Enter>.
6. Specify whether to search backward or forward from the currently highlighted species by selecting the Up or Down button. Either the highlight bar moves to the first name that matches the search string, or a message displays saying no matches were found.

## Chemical Species

The chemicals available with CHARM are listed below. *(NOTE: Your copy of CHARM may actually contain more than the names listed below, since new chemicals are periodically added to this list).*

Acetaldehyde  
 Acetic Acid  
 Acetone  
 Acetonitrile  
 Acetylene  
 Acrolein  
 Acrylic Acid  
 Acrylonitrile  
 Aerozine (50% solution)  
 Allyl Alcohol  
 Allylamine  
 Allyl Chloride (3-Chloropropene)  
 Ammonia  
 Ammonia 25%  
 Ammonia (15% solution)  
 Ammonia (20% solution)  
 Ammonia (29% solution)  
 Ammonia (3.6% solution)  
 Ammonia (49.9% solution)  
 Ammonia (5% solution)  
 Aniline

Arsine  
Benzene  
Benzyl Chloride (Tolyl Chloride)  
Benzyl Cyanide  
Boron Trichloride  
Boron Trifluoride  
Bromine  
2-Bromopropionic Acid  
1,3-Butadiene  
Butane  
1-Butene(a-Butylene)  
2-Butene-cis  
2-Butene-trans  
Carbon Dioxide  
Carbon Disulfide  
Carbon Monoxide  
Carbon Tetrachloride  
Chlorine  
2-Chloroethanol  
Chloroform  
Chloromethly Ether  
Chloromethly Methyl Ether  
2-Chloropropylene  
Crotonaldehyde, (E)  
Cyanogen Bromide  
Cyanogen Chloride  
Cyclohexylamine  
Cyclopropane  
Diallylamine  
Diborane  
Dibutyl Phthalate  
2,3 Dichloropropene  
Dichlorosilane  
Diethylene Triamine  
Difluoroethane  
Diisopropylaminoethanol  
Diisopropylcarbonate  
Dimethylamine  
Dimethyldichlorosilane  
Dimethyl Disulfide  
2,2-Dimethylpropane  
Dimethyl Sulfate  
Di-tert-butylethyldiamine  
Epichlorohydrin  
Ethane  
Ethanol  
Ethyl Acetylene  
Ethyl Acrylate  
Ethylamine  
Ethyl Chloride  
Ethylene  
Ethylenediamine  
Ethylene Dibromide(1,2-Dibromoethane)  
Ethylene Dichloride(1,2-Dichloroethane)

Ethylene Glycol  
Ethyleneimine  
Ethylene Oxide  
Ethyl Ether  
2-Ethyl-1-Hexanol  
Ethyl Mercaptan  
Fluorine  
Formaldehyde  
Formaldehyde (37% solution)  
Formaldehyde (56% solution)  
Formic Acid  
Freon 12 (Dichlorodifluoromethane)  
Freon 14 (Carbon Tetrafluoride)  
Freon 16 (Hexafluoroethane)  
Furan  
Furfural  
Hexamethylenediamine  
37% Hydrochloric Acid  
Hydrazine  
Hydrazine Monohydrate (35% Solution)  
Hydrazine (54% Solution)  
Hydrochloric Acid (30% Solution)  
Hydrogen  
Hydrogen Bromide  
Hydrogen Chloride  
Hydrogen Cyanide  
Hydrogen Fluoride  
Hydrogen Fluoride (30% Solution)  
Hydrogen Selenide  
Hydrogen Sulfide  
IRFNA (Inhibited Red Fuming Nitric Acid)  
Isoamylene (2-Methyl-2-Butene)  
Isobutane  
Isobutyronitrile  
Isopentane  
Isoprene  
Isopropanol  
Isopropylamine  
Isopropyl Benzene (Cumene)  
Isopropyl Chloride  
Isopropyl Ether  
Mesityl Oxide  
Methacrylonitrile  
Methane  
Methanol  
2-Methyl-1-Butene  
3-Methyl-1-Butene  
Methyl Chloride  
Methyl Diisocyanate  
Methylene Chloride (Dichloromethane)  
Methyl Ether  
Methyl Ethyl Ketone  
Methyl Formate  
Methyl Hydrazine

Methyl Isobutyl Ketone  
Methyl Isocyanate  
Methyl Mercaptan  
Methyl Methacrylate  
Methyl Phosphonic Dichloride  
Methyl Phosphonic Difluoride  
2-Methylpropene  
Methyltrichlorosilane  
Morpholine  
Mustard Gas  
m-Xylene  
n-Butane  
n-Butyl Acetate  
n-Butyl Acrylate  
n-Butyl Alcohol (1-Butanol)  
n-Decane  
n-Hexane  
Nitric Acid (70% Solution)  
Nitric Acid (98Solution)  
Nitric Oxide  
Nitrogen Dioxide  
Nitrogen Dioxide/ Dinitrogen Tetroxide  
Nitrogen Tetroxide  
Nitrogen Trifluoride  
N,N-DimethylFormamide  
o-Cresol  
o-Dichlorobenzene  
Oleum (35%)  
Oxygen  
Parathion  
Pentane  
1-Pentene  
2-Pentene,(E)  
2-Pentene,(Z)  
Phenol  
Phosgene  
Phosphine  
Phosphorous Oxychloride  
Phosphorous Trichloride  
Pinacolyl Alcohol  
Piperidine  
Propadiene  
Propane  
Propionic Acid (Methylacetic Acid)  
Propionitrile  
Propylene  
Propyleneimine  
Propylene Oxide  
Sarin  
Silane  
Soman  
Styrene  
Sulfur Dioxide  
Sulfuric Acid (98% solution)

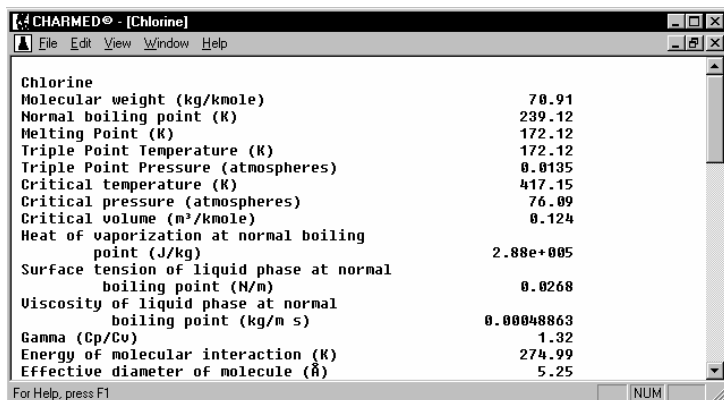
Sulfur Trioxide  
 tert-Butyl Alcohol (2-Methyl-2-Propanol)  
 tert-Butylamine  
 Tetrachloroethylene (Perchloroethylene)  
 Tetraethyl Lead  
 Tetrafluoroethylene  
 Tetrahydrofuran  
 Tetramethylsilane  
 Tetranitromethane  
 Thionyl Chloride  
 Thiophenol (Benzenethiol)  
 Toluene  
 Toluene Diisocyanate  
 Toluene 2,4-Diisocyanate  
 1,1,1-Trichloroethane (Methyl Chloroform)  
 Trichloroethylene  
 Trichlorosilane  
 Trifluorochloroethylene  
 Trimethylamine  
 TriMethylChloroSilane  
 Unsymmetrical Dimethyl Hydrazine  
 Vinyl Acetate  
 Vinyl Chloride  
 Vinyl Ethyl Ether  
 Vinyl Fluoride  
 Vinylidene Chloride  
 Vinylidene Fluoride  
 Vinyl Methyl Ether  
 VX

## The Chemical Editor Window

The Chemical Editor Window contains the thermodynamic data that define the chemical in the database. The window shown in Figures 4.4, 4.5, and 4.6 is displayed when you select the Add or Modify command buttons in the Chemical Selection window.

---

**Figure 4.4**  
 Chemical  
 Editor  
 Window (top)

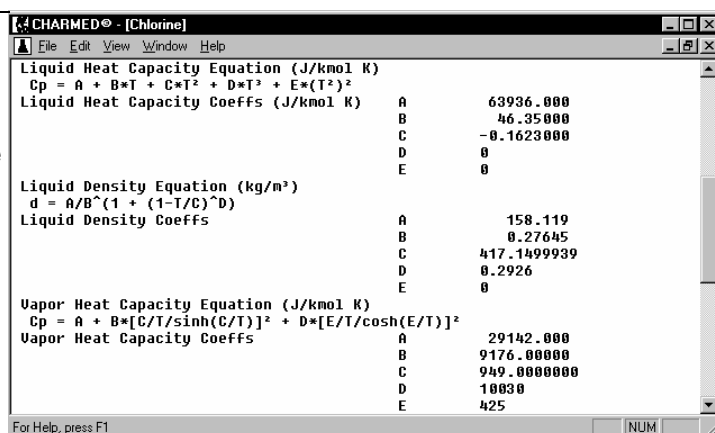


CHARMED - [Chlorine]

Chlorine	
Molecular weight (kg/kmole)	70.91
Normal boiling point (K)	239.12
Melting Point (K)	172.12
Triple Point Temperature (K)	172.12
Triple Point Pressure (atmospheres)	0.0135
Critical temperature (K)	417.15
Critical pressure (atmospheres)	76.09
Critical volume (m³/kmole)	0.124
Heat of vaporization at normal boiling point (J/kg)	2.88e+005
Surface tension of liquid phase at normal boiling point (N/m)	0.0268
Viscosity of liquid phase at normal boiling point (kg/m s)	0.00048863
Gamma (Cp/Cv)	1.32
Energy of molecular interaction (K)	274.99
Effective diameter of molecule (Å)	5.25

For Help, press F1

**Figure 4.5**  
Chemical  
Editor  
Window  
(Temperature  
Dependent  
Equations)

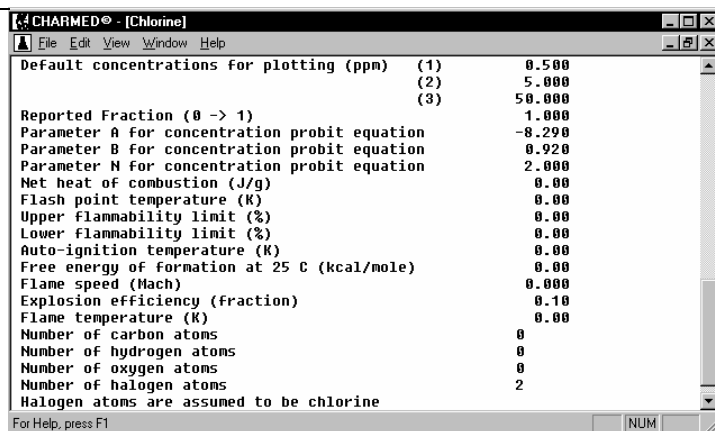


CHARMED - [Chlorine]

Liquid Heat Capacity Equation (J/kmol K)	
$C_p = A + B \cdot T + C \cdot T^2 + D \cdot T^3 + E \cdot (T^2)^2$	
Liquid Heat Capacity Coeffs (J/kmol K)	
A	63936.000
B	46.35000
C	-0.1623000
D	0
E	0
Liquid Density Equation (kg/m³)	
$d = A/B \cdot (1 + (1-T/C)^D)$	
Liquid Density Coeffs	
A	158.119
B	0.27645
C	417.1499939
D	0.2926
E	0
Vapor Heat Capacity Equation (J/kmol K)	
$C_p = A + B \cdot [C/T/\sinh(C/T)]^2 + D \cdot [E/T/\cosh(E/T)]^2$	
Vapor Heat Capacity Coeffs	
A	29142.000
B	9176.00000
C	949.0000000
D	10030
E	425

For Help, press F1

**Figure 4.6**  
Chemical  
Editor  
Window  
(Bottom)



CHARMED - [Chlorine]

Default concentrations for plotting (ppm)	(1)	0.500
	(2)	5.000
	(3)	50.000
Reported Fraction (0 -> 1)		1.000
Parameter A for concentration probit equation		-8.290
Parameter B for concentration probit equation		0.920
Parameter N for concentration probit equation		2.000
Net heat of combustion (J/g)		0.00
Flash point temperature (K)		0.00
Upper flammability limit (%)		0.00
Lower flammability limit (%)		0.00
Auto-ignition temperature (K)		0.00
Free energy of formation at 25 C (kcal/mole)		0.00
Flame speed (Mach)		0.000
Explosion efficiency (fraction)		0.10
Flame temperature (K)		0.00
Number of carbon atoms		0
Number of hydrogen atoms		0
Number of oxygen atoms		0
Number of halogen atoms		2
Halogen atoms are assumed to be chlorine		

For Help, press F1

To edit chemical data, move the highlight bar over the field and double-click the left mouse button or press <Enter>. A dialog box is displayed in which you can change the value. When you edit chemical data, the database is updated only if you select Close or Save from the File menu. If you select Close after making changes to the data, CHARMED will prompt the user to save changes to the chemical database.

When you are running the CHARM program, you can display chemical data for the selected species by selecting the Chemical Data command on the Displays menu of the Main CHARM Input Window and the Displays menu of plan view windows. You can also display the Emergency response text from the database by selecting the Emergency Response command on the Displays menu.

### **File Menu**

The File menu in the Chemical Editor closes the chemical data window, saves any changes to the database, edits emergency response text, prints the text in a window, previews the data before printing, configures the printer, or exits the CHARM Editor.

### **Edit Menu**

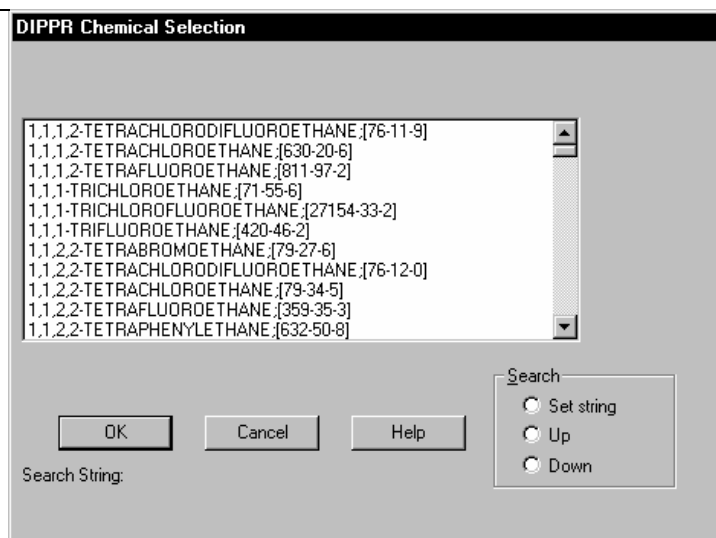
The Edit menu in the Chemical Editor window allows the user to export the chemical data currently displayed in the window. To accomplish this, select the Copy Data command from the Edit Menu. The chemical data are copied to Window's Clipboard in an ordered, comma delimited format. Likewise, chemical data may be imported in the same manner. Once comma delimited data exists in the Clipboard, select the Paste Data command from the Edit menu, and the data is copied from the Clipboard into the Chemical Database window into the appropriate data fields.

Another method of importing data involves CHARM's interface to the DIPPR database. For this option, select Import From DIPPR under the Edit menu. CHARMED displays a selection list of all the species in the DIPPR chemical database (see Figure 4.7). The display window is much like the CHARM Chemical Species selection window. The user may build a search string containing wild card characters \* (asterisk) or ? (question mark). The \* wild card character represents zero or more character, and the ? wild card character represents the position of a single character (see Using the Search Function in this chapter).

The user may search by name or by CAS number. After selecting a chemical, the DIPPR database is read and the data in the original data display window is replaced. To exit the Chemical Selection window without choosing a chemical, select the Cancel command button. CHARMED will inform the user if any values required by CHARM were not located in the DIPPR database. The missing data values will be reported as zeros (0.00) in the CHARMED Chemical Data sheet.

The Copy menu item simply copies the contents of the Chemical Database window, including field description text, into the clipboard.

**Figure 4.7**  
DIPPR  
Selection  
Window



## Chemical Data

The chemical database includes the following thermodynamic data for each chemical:

### Molecular Weight

The molecular weight (grams per mole) of the species.

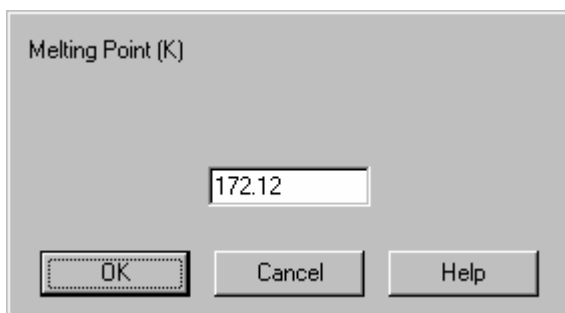
### Normal Boiling Point (NBP)

The temperature (Kelvin) at which the vapor pressure of the liquid is equal to one atmosphere.

### Melting Point



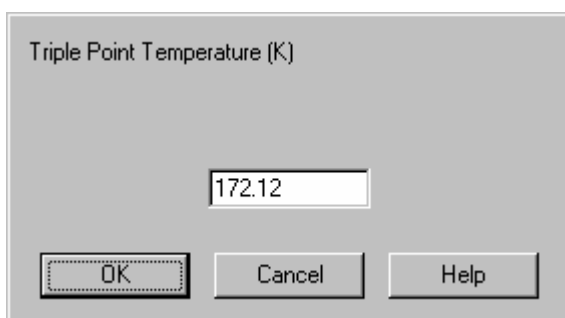
This is the temperature (Kelvin) at 1 atmosphere of pressure at which the solid phase of the species changes to liquid.



A dialog box titled "Melting Point (K)". It contains a text input field with the value "172.12". Below the input field are three buttons: "OK", "Cancel", and "Help". The "OK" button is highlighted with a dashed border.

### Triple Point Temperature

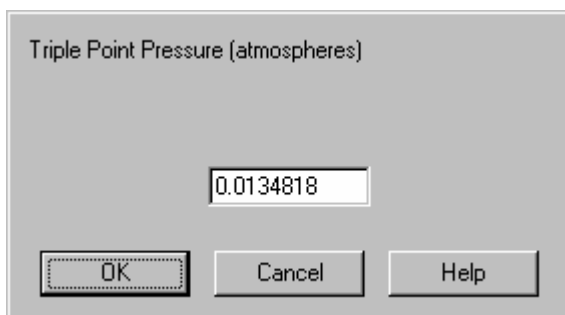
This is the temperature (Kelvin) at the triple point pressure which all three phases (solid, liquid, and vapor) of the species exist.



A dialog box titled "Triple Point Temperature (K)". It contains a text input field with the value "172.12". Below the input field are three buttons: "OK", "Cancel", and "Help". The "OK" button is highlighted with a dashed border.

### Triple Point Pressure

This is the pressure (atmospheres) at the triple point temperature which all three phases (solid, liquid, and vapor) of the species exist.



A dialog box titled "Triple Point Pressure (atmospheres)". It contains a text input field with the value "0.0134818". Below the input field are three buttons: "OK", "Cancel", and "Help". The "OK" button is highlighted with a dashed border.

### Critical Temperature

The temperature (Kelvin) above which a gas cannot be liquefied, regardless of pressure.

Critical temperature (K)

417.15

OK Cancel Help

### Critical Pressure

The lowest pressure (atmospheres) required to liquefy the gas at the critical temperature.

Critical pressure (atmospheres)

76.0918

OK Cancel Help

### Critical Volume

The molar volume (cubic centimeters) at the critical point. The critical point is the temperature and pressure at which the liquid and vapor states of a material have the same density.

Critical volume (m<sup>3</sup>/kmole)

0.124

OK Cancel Help

### Heat of Vaporization at Normal Boiling Point

The heat of vaporization (Joules per kilogram) at normal boiling point (NBP). This value is used to determine the heat required (ambient air to be entrained) to evaporate any droplets of the released species.

Heat of vaporization at NBP (J/kg)

287844

OK Cancel Help

### Surface Tension of Liquid Phase at NBP

A measure (Newtons per meter) of the lateral elasticity of a liquid surface. This is a measure of the resistance of a fluid to flow.

Surface tension at NBP (N/m)

0.0268199

OK Cancel Help

### Viscosity of Liquid Phase at NBP

A measure (kilograms per meter seconds) of the resistance of a fluid to flow.

Viscosity at NBP (kg/m s)

0.000488629

OK Cancel Help

### Gamma (Cp/Cv)

The ratio of the vapor state heat capacity at constant pressure to the vapor state heat capacity at constant volume. This is a dimensionless value.

### Energy of Molecular Interaction

Energy divided by the Boltzman constant (hence Kelvin units). The value can be estimated with the following equation:

$$E/k = 1.15 T_B$$

where  $T_B$  is the normal boiling point. The energy of molecular interaction is used in calculating the rate at which molecules of an evaporating liquid leave the surface.

### Effective Diameter of Molecule

The diameter (Angstroms) of an average molecule. This diameter is determined from the volume of an average molecule, which is the molar volume divided by Avogadro's number, and then solved for the diameter. Normally, the liquid molar volume used is at normal boiling point. The diameter can be computed from the liquid molar volume ( $V$ ) at the normal boiling point using the following equation:

$$D = 1.18 (V / N)^{1/3}$$

where  $N$  is Avogadro's number.

Effective diameter of molecule (Å)

5.24509

OK Cancel Help

### Liquid Heat Capacity Equation

This is the form of the equation used to calculate the liquid phase heat capacity (J/kmole K). Two forms are allowed. After selecting the form, the parameters in the equation must be entered. The two forms of the equation are:

$$C_p = A + B \cdot T + C \cdot T^2 + D \cdot T^3 + E \cdot (T^2)^2$$

$$C_p = A^2/T + B - 2 \cdot A \cdot C \cdot T - A \cdot D \cdot T^2 - C^2 \cdot T^3/3 - C \cdot D \cdot (T^2)^2/2 - D^2 \cdot T^2 \cdot T^3/5$$

where

T = temperature (K)

A, B, C, D, and possibly E = parameters to be input.

Liquid Heat Capacity Equation (J/kmol K)

$C_p = A^2/t + B - 2 \cdot A \cdot C \cdot t - A \cdot D \cdot t^2 - C^2 \cdot t^3/3 - C \cdot D \cdot (t^2)^2/2 - D^2 \cdot t^2 \cdot t^3/5$

OK Cancel Help

### Liquid Heat Capacity Coefficient A

This is the A term of the equation used to calculate the liquid phase heat capacity (J/kmole K). The equation takes one of the two forms described in the section above labeled 'Liquid Heat Capacity Equation'. Depending on the form of the Liquid Heat Capacity Equation, the coefficients A, B, C, D, and possibly E are required to be input.

### Liquid Heat Capacity Coefficient B

This is the B term of the equation used to calculate the liquid phase heat capacity (J/kmole K). The equation takes one of the two forms described in the section above labeled 'Liquid Heat Capacity Equation'. Depending on the form of the Liquid Heat Capacity Equation, the coefficients A, B, C, D, and possibly E are required to be input.

### Liquid Heat Capacity Coefficient C

This is the C term of the equation used to calculate the liquid phase heat capacity (J/kmole K). The equation takes one of the two forms described in the section above labeled 'Liquid Heat Capacity Equation'. Depending on the form of the Liquid Heat Capacity Equation, the coefficients A, B, C, D, and possibly E are required to be input.

### Liquid Heat Capacity Coefficient D

This is the D term of the equation used to calculate the liquid phase heat capacity (J/kmole K). The equation takes one of the two forms described in the section above labeled 'Liquid Heat Capacity Equation'.

Depending on the form of the Liquid Heat Capacity Equation, the coefficients A, B, C, D, and possibly E are required to be input.

### Liquid Heat Capacity Coefficient E

This is the E term of the equation used to calculate the liquid phase heat capacity (J/kmole K). This coefficient is only required if the form of the Liquid Heat Capacity Equation described in the section above labeled 'Liquid Heat Capacity Equation' is of the form

$$C_p = A + B \cdot T + C \cdot T^2 + D \cdot T^3 + E \cdot (T^2)^2$$

The coefficients A, B, C, and D are required to be input.

### Liquid Density Equation

This is the form of the equation used for calculation of liquid density (d). Three forms are allowed. After selecting the form, the parameters in the equation must be entered. The three forms of the equation are:

$$\begin{aligned} d &= (MW/V_c) \cdot (1 + A \cdot (1 - T_r)^{1/3} + B \cdot (1 - T_r)) \\ d &= A / B^{(1 + (1 - T/C)^D)} \\ d &= A + B \cdot T + C \cdot T^2 + D \cdot T^3 + E \cdot (T^2)^2 \end{aligned}$$

where

MW = molecular weight (kg/kmole)  
 V<sub>c</sub> = critical volume (m<sup>3</sup>/kmole)  
 T = temperature (K)  
 T<sub>r</sub> = T / T<sub>c</sub>  
 T<sub>c</sub> = critical temperature (K)

A, B, and possibly C, D, and E = parameters to be input, depending on the form of the equation chosen.

### Liquid Density Equation Coefficient A

This is the A term (units depend on the equation form) of the equation used to calculate the liquid density (d). The equation takes one of the three forms described in the section above labeled 'Liquid Density Equation'. In any form of the Liquid Density Equation, the coefficient A is required.

### Liquid Density Equation Coefficient B

This is the B term (units depend on the equation form) of the equation used to calculate the liquid density (d). The equation takes one of the three forms described in the section above labeled 'Liquid Density Equation'. In any form of the Liquid Density Equation, the coefficient B is required.

### Liquid Density Equation Coefficient C

This is the C term (units depend on the equation form) of the equation



used to calculate the liquid density (d). The equation takes one of the three forms described in the section above labeled 'Liquid Density Equation'. If the Liquid Density Equation is of the form

$$d = A/B^{(1 + (1-T/C)^D)}, \text{ or}$$

$$d = A + B*T + C*T^2 + D*T^3 + E*(T^2)^2,$$

the coefficient C is required. Otherwise, set C=0.

### Liquid Density Equation Coefficient D

This is the D term of the equation used to calculate the liquid density (d). The equation may only take one of three forms described in the section above labeled 'Liquid Density Equation'. If the Liquid Density Equation is of the form

$$d = A + B*T + C*T^2 + D*T^3 + E*(T^2)^2,$$

the coefficient D is required. Otherwise, set D=0.

### Liquid Density Equation Coefficient E

This is the E term of the equation used to calculate the liquid density (d). The equation may only take one of three forms described in the section above labeled 'Liquid Density Equation'. If the Liquid Density Equation is of the form

$$d = A + B*T + C*T^2 + D*T^3 + E*(T^2)^2,$$

the coefficient E is required. Otherwise, set E=0.

Liquid Density (kg/m³) Coeff. C

417.15

OK Cancel Help

### Vapor Phase Heat Capacity Equation

This is the form of the equation used for calculation of vapor phase heat capacity ( $C_p$ ). Three forms are allowed. After selecting the form, the parameters in the equation must be entered. The three forms of the equation are:

$$C_p = A + B \cdot \exp[-C/T^E]$$

$$C_p = A + B \cdot [C/T \cdot \sinh(C/T)]^2 + D \cdot [E/T \cdot \cosh(E/T)]^2$$

$$C_p = A + B \cdot T + C \cdot T^2 + D \cdot T^3 + E \cdot (T^2)^2$$

where

$T$  = temperature (K)

$A$ ,  $B$ ,  $C$ ,  $D$ , and possibly  $E$  = parameters to be input, depending on the form of the equation chosen.

Vapor Heat Capacity Equation (J/kmol K)

$C_p = A + B \cdot [C/T / \sinh(C/T)]^2 + D \cdot [E/T / \cosh(E/T)]^2$

OK Cancel Help

### Vapor Phase Heat Capacity Equation Coefficient A

This is the  $A$  term of the equation used to calculate the vapor phase heat capacity (J/kmole K). The equation takes one of the three forms described in the section above labeled 'Vapor Phase Heat Capacity Equation'. In any form of the Liquid Density Equation, the coefficient  $A$  is required.

Vapor Heat Capacity (J/kmol K) Coeff. A

29142

OK Cancel Help

### Vapor Phase Heat Capacity Equation Coefficient B

This is the B term of the equation used to calculate the vapor phase heat capacity (J/kmole K). The equation takes one of the three forms described in the section above labeled 'Vapor Phase Heat Capacity Equation'. In any form of the Liquid Density Equation, the coefficient B is required.

Vapor Heat Capacity (J/kmol K) Coeff. B

9176

OK Cancel Help

### Vapor Phase Heat Capacity Equation Coefficient C

This is the C term of the equation used to calculate the vapor phase heat capacity (J/kmole K). The equation takes one of the three forms described in the section above labeled 'Vapor Phase Heat Capacity Equation'. In any form of the Liquid Density Equation, the coefficient C is required.

Vapor Heat Capacity (J/kmol K) Coeff. C

949

OK Cancel Help

### Vapor Phase Heat Capacity Equation Coefficient D

This is the D term of the equation used to calculate the vapor phase heat capacity (J/kmole K). The equation takes one of the three forms described in the section above labeled 'Vapor Phase Heat Capacity

Equation'. If the Vapor Phase Heat Capacity Equation is of the form

$$C_p = A + B*[C/T*\sinh(C/T)]^2 + D*[E/T*\cosh(E/T)]^2$$

or

$$C_p = A + B*T + C*T^2 + D*T^3 + E*(T^2)^2,$$

the coefficient D is required. Otherwise, set D=0.

### Vapor Phase Heat Capacity Equation Coefficient E

This is the E term of the equation used to calculate the vapor phase heat capacity (J/kmole K). The equation may takes two of the three forms described in the section above labeled 'Vapor Phase Heat Capacity Equation'. If the Vapor Phase Heat Capacity Equation is of the form

$$C_p = A + B*[C/T*\sinh(C/T)]^2 + D*[E/T*\cosh(E/T)]^2$$

or

$$C_p = A + B*T + C*T^2 + D*T^3 + E*(T^2)^2,$$

the coefficient E is required. Otherwise, set E=0.

### First Default Concentration for plotting

The first of three isopleth concentrations (parts per million) to be used as defaults for plotting the plume. The defaults can be changed while you are running or storing a scenario.

First default concentration for plotting (ppm)

0.5

OK Cancel Help

### Second Default Concentration for plotting

The second of three isopleth concentrations (parts per million) to be used as defaults for plotting the plume. The defaults can be changed while you are running or storing a scenario.

Second default concentration for plotting (ppm)

5

OK Cancel Help

### Third Default Concentration for plotting

The third of three isopleth concentrations (parts per million) to be used as defaults for plotting the plume. The defaults can be changed while you are running or storing a scenario.

Third default concentration for plotting (ppm)

50

OK Cancel Help

### Reported Fraction

If the emission entering the atmosphere as a gas is actually a mixture this parameter allows you to allocate only part of the concentration to a single species. If 20% of the emission were species A and 40% species B, two chemicals could be added to the database. All the parameters would be the same for the two species except the name and this parameter. For species A to be reported correctly, this parameter should be 0.20. For species B it should be 0.40. Most species will have this parameter as

1.0. If it is set to zero, it is assumed to be 1.0.

A dialog box titled "Fraction of total emission of interest (0 -> 1)". It contains a text input field with the value "1". Below the input field are three buttons: "OK", "Cancel", and "Help".

### Parameter A for Concentration Probit Equation

The **A** term in the probit equation, which has the following form:

$$P = A + B \log N(TC^N)$$

where **C** is the concentration (parts per million) and **T** is the exposure time (minutes). The probit is used to determine the probability of fatality.

A dialog box titled "Parameter A for concentration probit equation". It contains a text input field with the value "-8.29". Below the input field are three buttons: "OK", "Cancel", and "Help".

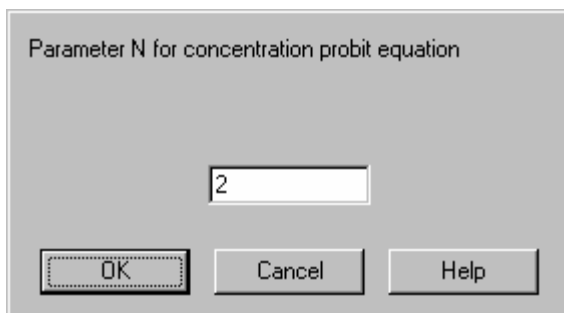
### Parameter B for Concentration Probit Equation

The **B** term in the probit equation shown previously for Parameter A for Concentration Probit Equation.

A dialog box titled "Parameter B for concentration probit equation". It contains a text input field with the value "0.92". Below the input field are three buttons: "OK", "Cancel", and "Help".

### Parameter N for Concentration Probit Equation

The **N** term in the probit equation shown previously for Parameter A for Concentration Probit Equation.



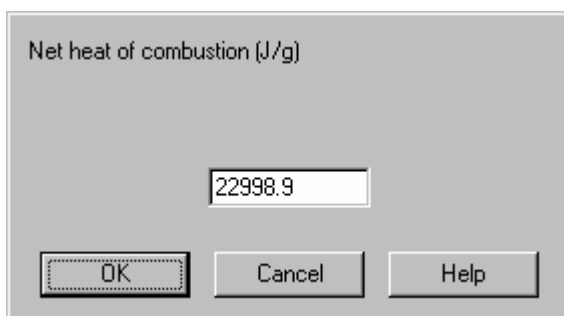
Parameter N for concentration probit equation

2

OK Cancel Help

### Net Heat of Combustion

The amount of energy released (Joules per gram) when the material is burned.



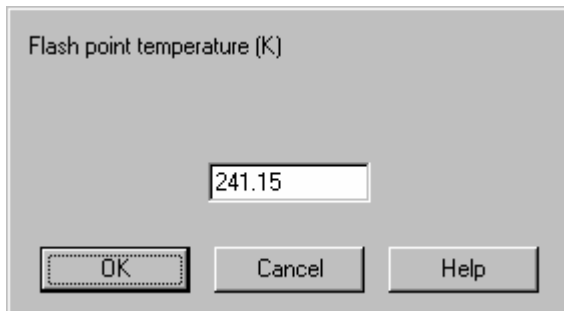
Net heat of combustion (J/g)

22998.9

OK Cancel Help

### Flash Point Temperature

The lowest temperature (degrees Kelvin) at which the vapor in air can be made to ignite momentarily.



Flash point temperature (K)

241.15

OK Cancel Help

### Upper Flammability Limit

The highest concentration (percent) at which the vapor will burn.

Upper flammability limit (%)

11.1

OK Cancel Help

### Lower Flammability Limit

The lowest concentration (percent) at which the vapor will burn.

Lower flammability limit (%)

2.9

OK Cancel Help

### Auto-Ignition Temperature

The lowest temperature (Kelvin) at which the vapor in air can be made to ignite and burn.

Auto-ignition temperature (K)

758.15

OK Cancel Help

### Free Energy of Formation at 25°C

The amount of energy (kilocalories per mole) required to bring together the individual atoms in the molecule.



Free energy of formation at 25°C (kcal/mole)

10.4132

OK Cancel Help

### Flame Speed

The speed (Mach) at which the flame will spread if a vapor cloud of the material is ignited. If the speed is greater than Mach 1, it is assumed to be a detonation. If the speed is less than Mach 1, it is assumed to be a deflagration.

Flame speed (Mach)

0

OK Cancel Help

Below is a table of flame speeds from Quentin A. Baker, Ming Jun Tang, Ephraim Scheier, and Gustavo J. Silva, Vapor Cloud Explosion Analysis, Process Safety Progress, Vol. 15, No. 2, Summer 1996.

Type of Flame <u>Expansion</u>	Mixture <u>Reactivity</u>	<u>Obstacle Density</u>		
1-D	High	High	Medium	Low
	High	5.2	5.2	5.2
	Medium	2.265	1.765	1.029
	Low	2.265	1.029	0.294
2-D	High	1.765	1.029	0.588
	Medium	1.235	0.662	0.118
	Low	0.662	0.471	0.079

3-D	High	0.588	0.153	0.071
	Medium	0.206	0.100	0.037
	Low	0.147	0.100	0.037

#### Table Explanation

Type of Flame Expansion refers to the geometry associated with the propagating (expanding) flame front. Propagation of the flame front in a long pipe corresponds to 1-D.

Propagation of the flame front between two flat plates corresponds to 2-D. Propagation of the flame front in three dimensions corresponds to 3-D. Note: Multi-deck, open framework structures should be treated as 2-D.

Reactivity is classified as low, average (medium), or high according to the recommendations of TNO (Methods for the Calculation of Physical Effects Resulting from Releases of Hazardous Materials (Liquids and Gases), CPR 14E, Second Edition 1992.) Ammonia, carbon monoxide, methane, and natural gas are the only materials regarded as having low reactivity. Hydrogen, acetylene, ethylene, ethylene oxide, and propylene oxide are considered highly reactive. All other fuels (ethane, propane, propylene, butane, isobutane, etc.) are classified as average (medium) reactivity.

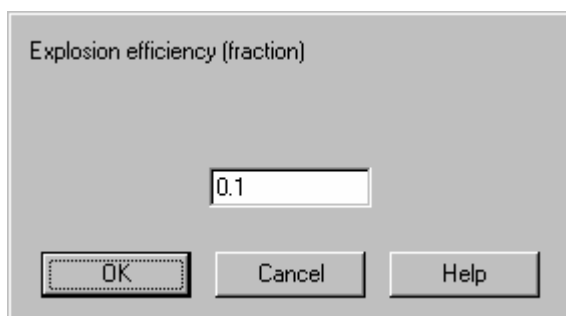
Obstacle Density refers to the presence of obstacles that may enhance flame propagation. Low obstacle density is applicable when there are few obstacles in the flames path, or the obstacles are widely spaced (blockage ratio [see below] < 10 %) and only 1 or 2 layers of obstacles are present. High obstacle density is applicable when there are 3 or more fairly closely-spaced layers of obstacles with a blockage ratio of > 40 % per layer (e.g., closely-spaced structural members, pipes, valves, and pipe racks). Medium obstacle density is that which falls between the low and high categories.

This table assumes that the vapor cloud explosion is initiated from soft ignition sources. Soft ignition sources include open flames, spark, or hot surfaces (i.e., sources that do not significantly affect the flame speed). The above table would not apply to ignition of highly turbulent jets or to high energy ignition sources (i.e., high explosives); the maximum flame speed (Mach number 5.2) should be assumed for these situations.

Blockage ratio is defined as the ratio of the area blocked by obstacles to the total cross-sectional area.

### Explosion Efficiency

The fraction of material actually consumed if a vapor cloud is ignited. The explosion efficiency is normally about 0.10.



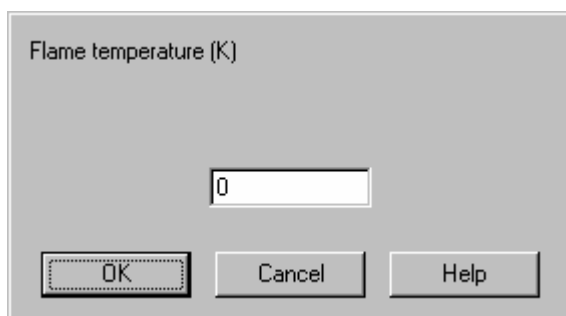
Explosion efficiency (fraction)

0.1

OK Cancel Help

### Flame Temperature

The temperature (Kelvin) at which the flame will burn when a vapor cloud is ignited. Typical values are 2000°K to 2500°K.



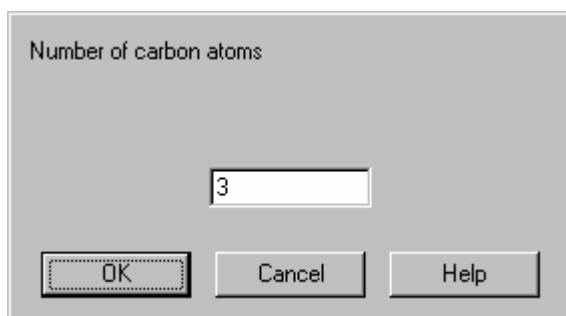
Flame temperature (K)

0

OK Cancel Help

### Number of Carbon Atoms

This is the number of carbon atoms in a single molecule of the species. If -1 is entered, CHARM ignores this material as being flammable for liquid pool fires.



Number of carbon atoms

3

OK Cancel Help

### Number of Hydrogen Atoms

The number of hydrogen atoms in a single molecule of the species.

Number of hydrogen atoms

5

OK Cancel Help

### Number of Oxygen Atoms

The number of oxygen atoms in a single molecule of the species.

Number of oxygen atoms

0

OK Cancel Help

### Number of Halogen Atoms

The number of halogen atoms in a single molecule of the species.

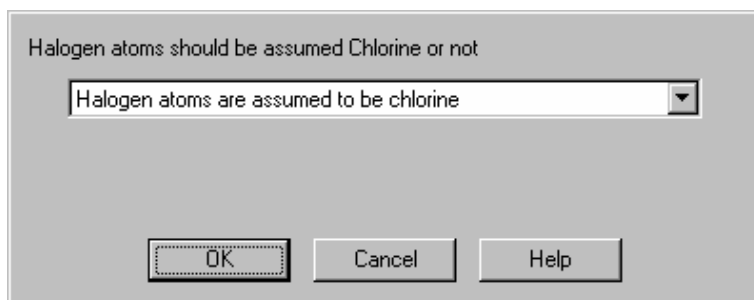
Number of halogen atoms

1

OK Cancel Help

### Halogen Atoms Being Chlorine

This field indicates whether the halogen atoms are chlorine. If the halogen atoms are chlorine, an emission rate of phosgene gas will be calculated for the burn. The phosgene emission rate and concentration are reported in the Source/Puff Calculation display. These values can be used in a separate run.



## Editing the Chemical Database

Use the Chemical Database command on the Edit menu of the CHARMED window to edit the chemical database. You can add a chemical and its data, change a chemical name, modify the chemical data, or logically/physically delete a chemical. You can also edit the Emergency Response Text for the selected chemical. On-line help is available for each CHARMED window and input field to guide you through entering the appropriate information.

### Adding a Chemical to the Database

Use the Add command button in the Chemical Selection window to add new chemicals to the database.

To add a chemical species:

1. Run the CHARM editor by selecting the CHARMED icon from the CHARM group or by executing the CHARMED.EXE file from the Windows Explorer or My Computer on the desktop. The CHARMED window is displayed.
2. Select the Chemical Database command on the Edit menu. The Chemical Selection window is displayed.
3. Select the Add command button. A dialog box requesting the name of the chemical is displayed.



4. Type the name of the chemical to add and select OK or press <Enter>. The Chemical Editor window is displayed.

5. Enter the requested data for the chemical.

To do this, place the highlight bar over the desired field, and double-click the mouse or press <Enter>. Then type the appropriate value in the dialog box, and select OK or press <Enter> to close the dialog box.

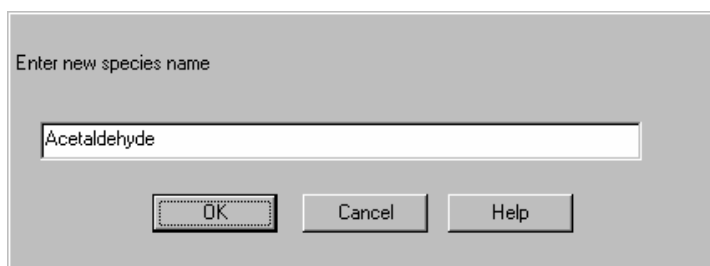
6. Select Save and then Close from the File menu to save the addition. The Chemical Selection window is again displayed.

### Changing a Chemical Name

Use the Change Name command button in the Chemical Selection window to change the name of a chemical species in the database. The dialog box for changing a chemical name is the same as the dialog box for adding a new chemical.

To change the name of a chemical:

1. Run the CHARM editor by selecting the CHARMED icon from the CHARM group or by executing the CHARMED.EXE file from the Windows Explorer or My Computer on the desktop. The CHARMED window is displayed.
2. Select the Chemical Database command on the Edit menu. The Chemical Selection window is displayed.
3. Place the highlight bar over the name of the chemical in the list to change. You can use the scroll or search function to locate the chemical name.
4. Select the Change Name command button. A dialog box requesting the new name is displayed.



5. Type the new chemical name, and select OK or press <Enter>. The Chemical Selection window is again displayed.

### Modifying Chemical Data

Use the Modify command button in the Chemical Selection window to modify chemical data and emergency response text stored in the

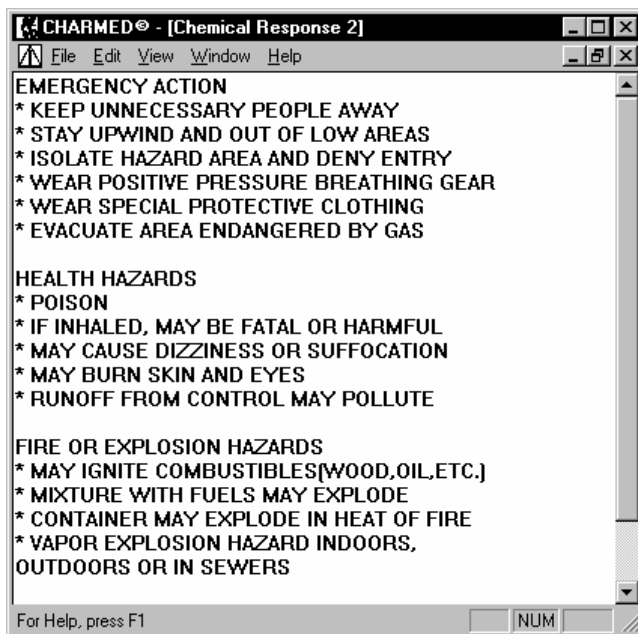
database. The chemical data window is shown in Figures 4.4, 4.5, and 4.6 earlier in this chapter.

To modify the data for a chemical:

1. Run the CHARM editor by selecting the CHARMED icon from the CHARM group or by executing the CHARMED.EXE file from the Windows Explorer or My Computer on the desktop. The CHARMED window is displayed.
2. Select the Chemical Database command on the Edit menu. The Chemical Selection window is displayed.
3. Place the highlight bar over the name of the chemical in the list. You can use the scroll or search function to locate the chemical name.
4. Double-click the left mouse button or select the Modify command button. The Chemical Editor window is displayed with data for the selected chemical.
5. Move the highlight bar over the field you want to modify and select it. A dialog box showing the current value is displayed.
6. Change the value in the dialog box.
7. Select OK or press <Enter> to close the dialog box.
8. If you want to edit the emergency response information for a chemical, select the Emergency Response Text command from the File menu while the chemical data are displayed. The text editor window is displayed and you can change the text. Select Save and Close from the File menu to return to the Chemical Editor window.
9. Select Save and Close from the File menu of the Chemical Editor window to save the changes. The Chemical Selection window is displayed.

### **Modifying Emergency Response Text**

Use the Emergency Response Text command on the File menu of the Chemical Editor window to display the text editor window. Emergency response text is provided for each chemical species in the database. You can add, delete, or modify this information using the text editor.



The text editor is similar to the Windows Notepad. Use the Print command from the File menu to print all the text in a window. To return to the Chemical Editor window, select the Save and Close commands from the File Menu. Use the Edit menu to undo the most recent action, cut and paste text, clear selected text, and select all text in the file. Unlike other windows in the application, the File menu has no New, Open, or Save commands, because the file being edited is known and specific to CHARM.

The Emergency Response Text command and the Site Information command use the same text editor. However, the methods for saving emergency response text and site information text are different. If you use the Save command on the File menu of the Emergency Response Text window, the text changes are flagged. The changes are not saved until you select the Exit command on the File menu of the Chemical Editor window.

To edit the Emergency Response Text:

1. Run the CHARM editor by selecting the CHARMED.EXE file. The CHARMED window is displayed.
2. Select the Chemical Database command on the Edit menu of the CHARMED window.
3. Place the highlight bar over the name of the chemical whose information you want to change. You can use the scroll or search



function to locate the chemical name.

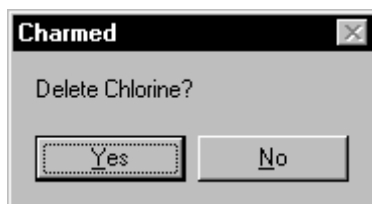
4. Select the Modify command button. The Chemical Editor window is displayed.
5. Select Emergency Response Text from the File menu. The text editor window is displayed.
6. Modify the Emergency Response Text as needed. You can enter a maximum of 32,000 characters of information.
7. Select Save and Close from the File menu of the text editor window.
8. Select Save and Close from the File menu of the Chemical Editor to save the changes. The Chemical Selection window is displayed.

### Deleting a Chemical

Use the Delete command button on the Chemical Selection window to logically delete a chemical. Deleting a chemical does not actually remove the data from the database; it simply flags the data in the database and does not display the chemical name in CHARM selection lists. To physically remove the data from the database, delete the chemical and then run the Pack Database command.

To delete a chemical:

1. Run the CHARM editor by selecting the CHARMED.EXE file. The CHARMED window is displayed.
2. Select the Chemical Database command on the Edit menu of the CHARMED window. The Chemical Selection window is displayed.
3. Place the highlight bar over the chemical name in the list and select the name. You can use the scroll or search function to locate the chemical name.
4. Select the Delete button. CHARM will prompt the user to verify deletion of the desired chemical.



If you inadvertently delete a chemical from the database with the Delete command button, you can retrieve the data by adding the

chemical. Use the Add command button in the Chemical Selection window and enter the chemical name. CHARMED displays the chemical data for that chemical as they appeared before the delete operation. In fact, any chemical that was logically deleted using the Delete button from the Chemical Selection window can be retrieved simply by adding chemicals back into the database. The rule that CHARM follows is simply this: The last chemical that was logically deleted from the Chemical Selection window is the data which is used as the default data when a chemical is added.

## Packing the Chemical Database

Packing the chemical database actually removes from the database all records that have been previously deleted. Figure 4.6 shows the confirmation window for packing the chemical database.

To pack the database:

1. Run the CHARM editor by selecting the CHARMED icon from the CHARM group or by executing the CHARMED.EXE file from the Windows Explorer or My Computer on the desktop. The CHARMED window is displayed.
2. Select the Pack Chemical Database command on the Edit menu of the CHARMED window. CHARMED displays a dialog box that asks you to confirm the deletion.



3. To confirm the deletion, select the Yes command button or press <Enter>. All deleted records are removed from the database and the CHARMED window is displayed.

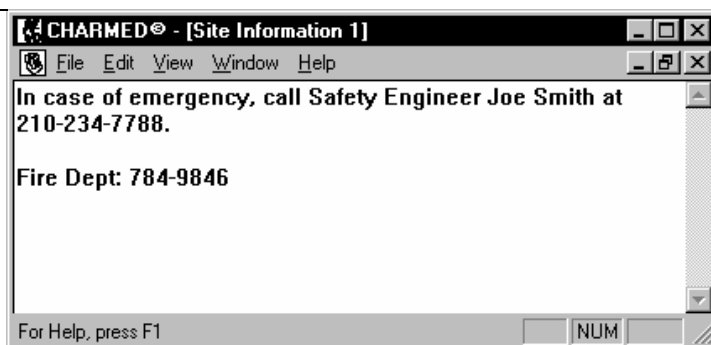
To cancel the deletion, select the No command button. No changes are made to the database and the CHARMED window is displayed.

## Entering Site Information

Use the Site Information command on the Edit menu of the CHARMED window to enter and edit site-specific information such as names and telephone numbers. This information can be displayed while you are running CHARM. Figure 4.8 shows an example of a site information

text editor window.

**Figure 4.8**  
Site  
Information  
Editor



The Site Information command and the Emergency Response Text command use the same text editor. However, the method by which the information is saved is different. Site information is saved when you select Save and Close from the File menu of the text editor window. If you select Exit from the File menu after making changes to the text, CHARMED will prompt you to save the changes, and then proceed to exit the CHARM Editor. Conversely, emergency response text is not saved until you select Save and Close from the Chemical Editor Window (See 'Modifying Emergency Response Text' previously mentioned in this Chapter).

The text editor is similar to the Windows Notepad. Use the File menu to print all the text in a window, save changes to the text, or close the window. Use the Edit menu to Undo the most recent action, or Copy, Cut and Paste text in the file. Unlike Windows, the File menu has no New, Open, or Save commands, because the file being edited is known and specific to CHARM.

When you are running the CHARM program, you can display site information for the current release by selecting the Site Information command on the Displays menu of the Main CHARM Input Window, or any subsequent footprint display.

To enter site information:

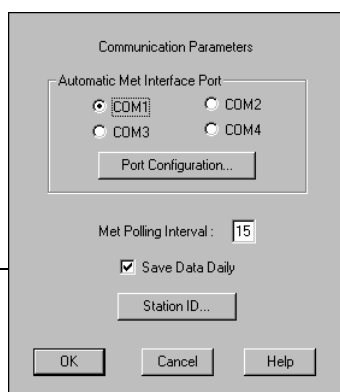
1. Run the CHARM editor by selecting the CHARMED icon from the CHARM group or by executing the CHARMED.EXE file from the Windows Explorer or My Computer on the desktop. The CHARMED window is displayed.
2. Select the Site Information command on the Edit menu of the CHARMED window. The text editor window is displayed.

3. Enter up to 32,000 characters of site-specific information.
4. Select Save and Close from the File menu in the text editor to save the site information. The CHARMED window is displayed.

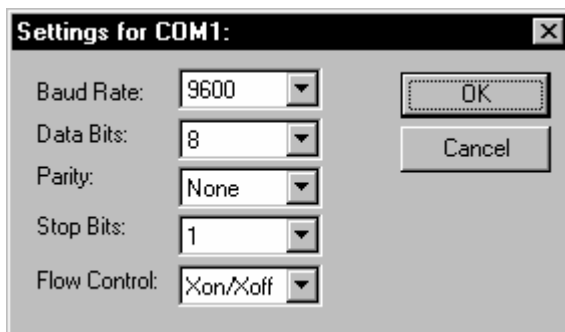
## Setting the Communication Parameters

Use the Communications Parameters command on the Edit menu of the CHARMED window to define the communications port, the polling interval, and other configuration items for communication with a meteorological tower. This editor is only useful if the CHARM meteorological interface program (supplied by Radian) is on the computer. The meteorological interface program (METINTER.EXE) provides the tower-specific interface to CHARM. Figure 4.9 shows the Communications Parameters Editor window.

**Figure 4.9**  
Communica-  
tions  
Parameters  
Editor



The communications parameters consist of defining and configuring the Automatic Met Interface Port, specifying the Met Polling Interval, saving Data Daily, and defining station connectivity. The choices for communication ports are COM1, COM2, COM3, and COM4. One of these specifies connection with the meteorological tower. Accurate port specification is required for proper information exchange. Select the Port Configuration button to specify additional information, including the baud rate, data bits, parity, stop bits, and flow control type for the selected communication port.



The Met Polling Interval defines the frequency with which meteorological tower communications take place. The time interval should be the same as the averaging time interval for the data.

To set the parameters for communication with a meteorological tower:

1. Run the CHARM editor by selecting the CHARMED icon from the CHARM group or by executing the CHARMED.EXE file from the Windows Explorer or My Computer on the desktop. The CHARMED window is displayed.
2. Select the Local Met Comm Parameters command on the Edit menu of the CHARMED window. The text editor window is displayed.
3. Specify the communications port (COM1, COM2, COM3, or COM4) to use.
4. Select the Port Configuration button to specify additional port configuration information. Select OK or press <Enter>.
5. Enter the interval for polling the met tower in minutes.
6. Check the Save Data Daily checkbox if you want CHARM to archive meteorological data from your data logger on a daily basis into a file which timestamped with a Julian date. *[NOTE: This feature is strictly for archival purposes. CHARM cannot read these files back into the model as a source for meteorological data input. This feature is simply an add-on feature as some data loggers are not capable of archiving data.]*
7. Select OK or press <Enter>. The CHARMED window is displayed.

## Defining Station ID's

Select the Station ID button to define multiple station names and means of communication (i.e. direct connection with the PC or remote connection via modem). Input up to 30 characters describing a

meteorological station to be used by CHARM to acquire real-time met data. Also, type in a phone number that will be used to access the met tower remotely if communications between the PC and the datalogger are to be connected via dial-up modems. The phone number is optional. If no phone number is specified, CHARM will assume direct connection between the PC and the data logger.

Station ID	Phone Number
Station Name 002	210-987-6543
Station Name 000	210-345-6789
Station Name 001	210-987-6543
Station Name 002	210-987-6543

Buttons: Add, Delete, Change, Save Change, Delete All, Site ID..., OK, Cancel, Help

### Adding a Station ID

Upon entering the Station ID and Phone Number (optional), press the Add button to enter the Station ID/Phone Number input into the list of possible stations. Currently, the user may define up to 100 stations.

### Deleting a Station ID

Select the Delete button to delete the highlighted Station ID from the list of possible stations. All associated sites and their information will also be deleted. Select the Delete All button to delete all Station IDs and associated Phone Numbers in the list of possible stations. Again, all associated sites and their information will also be deleted.

### Modifying a Station ID

Select the Change button to change the highlighted Station ID character name or associated phone number. The highlighted information will be placed in the Station ID and Phone Number input boxes. Make the appropriate changes and then select the Save Change button. The changes will be reflected in the list of stations.

### Site ID

Select the Site ID button to define multiple site names associated with the highlighted station.

## Defining Site ID's

Input up to 30 characters describing a site associated with the

specified station.



### **Adding a Site ID**

Upon entering the Site ID, select Add to enter the Site ID input into the list of possible sites. Currently, the user may define up to 100 sites.

### **Deleting a Site ID**

Select the Delete button to delete the highlighted Site ID from the list of possible sites. All associated site information will also be deleted. Select the Delete All button to delete all Site IDs and associated site information from the list of possible sites.

### **Modifying a Site ID**

Select the Change button to change the highlighted Site ID character name. The highlighted information will be placed in the Site ID input boxes. Make the appropriate changes and then select Save Change. The changes will be reflected in the list of possible sites.

### **Specifying Site Information**

Select the Site Information button to display the Cartesian coordinates (x,y,z) and some default parameters associated with the highlighted site.

## **Defining Site Information**

Define default parameters specific to a site.

**Site: Site Name 000**

Site Coordinates

X: 30.5 feet

Y: -17.0 meters

Z: 976.5 feet

Relative Humidity (0-100): 85

Ambient Pressure: 1.000000 atms

Surface Roughness: 1 centimeters

OK Cancel Help

### Defining Site Coordinates

Input the site location in Cartesian coordinates (x,y,z) and the associated units. Accurate site location relative to the source will ensure proper met conditions will be utilized correctly in CHARM.

### Defining Relative Humidity

Enter the default ambient relative humidity in percent. Acceptable values are greater than 0 and less than 99. If relative humidity is not available to CHARM real-time, CHARM will use this value as the default.

### Defining Ambient Pressure

Enter the default ambient atmospheric pressure at ground level. The pressure can be entered in atmospheres, pounds/square inch, inches of Mercury, millimeters of Mercury, or millibars. If pressure is not available to CHARM real-time, CHARM will use this value as the default.

Normal atmospheric pressure at sea level has the following equivalents:

- 1 atmosphere (atm)
- 14.7 pounds/square inch (psi)
- 1013.25 millibars (mb)
- 29.92 inches of Mercury (in Hg)
- 760 millimeters of Mercury (mm Hg)

### Defining Surface Roughness

Surface roughness is a measure of the interaction between the wind and surface. It affects wind speed with altitude and thus the amount of mixing that can occur. The units are inches, feet, centimeters, or meters. If the field is left blank, no surface roughness is assumed and



the wind is assumed constant with height. See “Surface Roughness” in Chapter 5 “The Main CHARM Input Window” for some examples of surface roughness.

## Defining Maps for Use With CHARM

Use the Map Definition command on the Edit menu of the CHARMED window to read a map from the clipboard or a file. After the map is displayed, you must define a scale and location with respect to some point of origin. You can also define release locations and map locations. You can define an area to zoom or unzoom, and name a larger-scaled map that will replace the current map in CHARM. You can also associate textual information to, perhaps, indicate when the map was created, evacuation routes, etc.

All maps used in CHARM are assumed to be created outside of CHARMED but accessible by CHARMED. The map definition editor can read maps from the clipboard, from Windows metafiles, Tagged Information File Format (TIFF) files, device independent bitmap (DIB) files, or from previously edited and stored files.

Improved internet browsing and downloading allows you to examine and extract map files directly from the internet. In many cases, you can simply download a file into a form that CHARM can read directly. In other instances, however, you may have to read the file into third-party software, copy the map to the clipboard, and then paste the image into the Map Definition Editor.

### Reading Maps From the Clipboard

The Map Definition command can be used with other Windows programs that create metafiles, picture files, or bitmaps and place them on the clipboard. For example, MicroGrafx Draw Plus, MicroGrafx Designer, and Microsoft Windows Paint programs can generate maps for use with CHARM. AutoCAD's DXF (drawing interchange) file formats can be read into a program such as Designer® or Hijaak®, copied to the clipboard, and then read into the CHARM map editor. Refer to the Microsoft Windows user's guide for details on sending a drawing to the clipboard.

When a map has been created and placed on the clipboard, it can be accessed and displayed by the Map Definition Editor. Simply use the Paste command from the Edit menu and the map will be displayed.

### Reading Maps From Files

The Map Definition command can also read previously stored files. For example, the map editor can read files stored in the Micrografx Draw Plus or PageMaker format directly instead of reading them through the

clipboard. These files must have the Windows metafile, TIFF, or windows bitmap format. Maps that have been edited and saved in CHARMED can also be read again.

To read a file into the Map Definition Editor, use the Open command on the File menu and select the name of the file to display. The Open command works the same in CHARM as in other Windows applications.

*Caution: When you edit a metafile or TIFF file, be sure to rename the edited version when saving the map or the original file will be overwritten. Map information, such as scaling and map location, requires CHARM to use a different file format.*

### The Map Definition Command

Use the Map Definition command to edit maps for use in CHARM. After a map has been displayed in the Map Definition Editor either by opening a file or pasting an image in from the clipboard, you must perform a minimum of two operations before the map can be used from within CHARM proper. Select the Define Point command or the Define Scale command from the Define menu. It is irrelevant which operation is performed first, but a point of reference and scale must be defined to ensure that a footprint is overlaid properly on the map when displayed in CHARM proper. Other options include defining detailed map and release location icons, associating textual information with the map, and associating an expanded map to use with the Auto Map Change and Larger Scale Map options in CHARM. The map must be saved for recall when running CHARM.

While a map is displayed, you can move the cursor with the mouse or the keyboard. To scroll the map, use the mouse and the scroll bars or use <Page Up>, <Page Down>, and the arrow keys. The keys are used to move the map until an option from the Define menu is selected. After a define option is selected, the keys move the cursor.

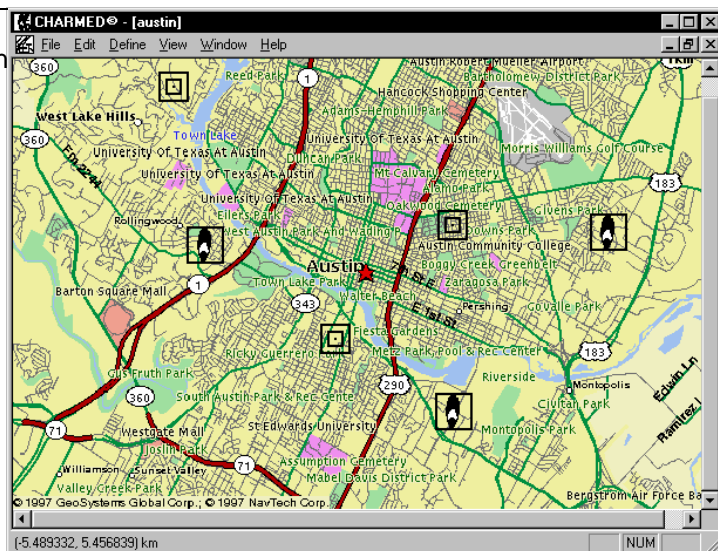
Figure 4.8 shows a sample map display. The sample shows three map location icons,



which can be selected to display a smaller scaled, or more detailed, version of the map area. Likewise, the sample illustrates three possible release sites with release locations icons



**Figure 4.8**  
Map Definition  
Editor



## The Define Menu

Use the Define menu in the Map Definition window to define a point and scale. After the Map Definition Editor displays a map from the clipboard or a file, you must define a point location and a map scale. The point and scale together identify the point of origin. The origin should be the same for all maps that you intend to use with the Zoom or Automap functions. You can also use the Define menu to define zoom area, detailed map location, release location, map description, default size, and/or an expanded map name.

## Using the Zoom Command

Use the Zoom command on the Define menu to define an area (zoom box) on the displayed map for enlargement. Notice that the cursor is transformed to a magnifying glass. The size of the zoom box determines the degree of zoom. The upper left corner of the box is used to determine the region that will be displayed. There may not be a one-to-one correspondence between the box and the displayed zoom area since the x,y aspect is maintained. To return a zoomed map to its original size when the window was opened, use the Unzoom command on the Define menu.

After you decide on the area to zoom in on, follow these steps:

1. Run the CHARM editor by selecting the CHARMED icon from the CHARM group or by executing the CHARMED.EXE file from the Windows Explorer or My Computer on the desktop. The

CHARMED window is displayed.

2. Select the Map Definition command on the Edit menu of the CHARMED window. The map editor window is displayed.

Use the Open command on the File menu or use the Paste command on the Edit menu to select and display a map.

3. While the map is displayed, select the Zoom command on the Define menu.
4. Move the cursor to the location of one corner of the area to be zoomed. This location represents one corner of the zoom box.
5. Define the zoom box by creating a rubberband box around the intended area to zoom. This can be done by using the mouse, or by using keyboard strokes.

If you are using a mouse, hold the left mouse button down, drag the cursor to the opposite corner of the box, and release the button.

If you are not using a mouse, press <Enter> to define the first corner of the zoom box. Next, use the arrow keys to draw the zoom box, and press <Enter> again to complete the drawing.

To return the map to its initial size when the window was opened, select the Unzoom command on the Define menu.

### **Defining a Point**

Use the Define Point command on the Define menu to define a point of reference for a map. Notice that the cursor is transformed to an axial representation of a 3D coordinate system. You must define a point and scale for each map you use. To ensure proper placement of the plume on the map, the origin should be the same for all related maps. You can redefine the point location by repeating the steps for defining a point.

Defining a point involves identifying the location for the point on the displayed map and specifying the X and Y coordinates for the point.

Use the following steps to define a point:

1. Run the CHARM editor by selecting the CHARMED icon from the CHARM group or by executing the CHARMED.EXE file from the Windows Explorer or My Computer on the desktop. The CHARMED window is displayed.
2. Select the Map Definition command on the Edit menu of the

CHARMED window. The Map Definition window is displayed.

Use the Open command on the File menu or use the Paste command on the Edit menu to select and display a map.

3. While a map is displayed, select the Define Point command on the Define menu.
4. Move the cursor to the location for the point on the map.

If you are using a mouse, click the left button to identify the point location.

If you are not using a mouse, press <Enter> to identify the point location. CHARMED prompts the user for the point of reference.

5. Enter the X and Y coordinates for the point in the dialog box. The units are feet, miles, kilometers, or meters. A positive (+) X number is East of the origin and a negative (-) X number is West. A positive Y number is North of the origin and a negative Y number is South.
6. Select the OK command button or press <Enter>.

### Defining a Scale

Use the Define Scale command on the Define menu to define a map scale. Notice that the cursor is transformed into a scale pointer. CHARM uses this scale to automatically expand or contract the map when a plume is displayed. You must define a point and scale for each map you use. You should use the measurement between two known points, which are preferably as far apart as possible.

A scale definition involves drawing a line on the displayed map and specifying the length of the line. After the line is drawn, CHARMED prompts the user to specify the line length.

Use the following steps to define a scale:

1. Run the CHARM editor by selecting the CHARMED icon from the CHARM group or by executing the CHARMED.EXE file from the Windows Explorer or My Computer on the desktop. The CHARMED window is displayed.
2. Select the Map Definition command on the Edit menu of the CHARMED window. The Map Definition window is displayed.

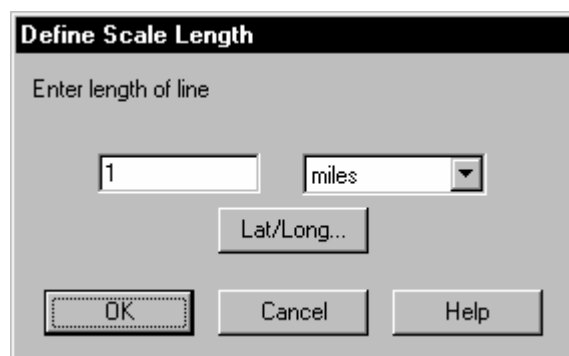
Use the Open command on the File menu or use the Paste command on the Edit menu to select and display a map.

3. While a map is displayed, select the Define Scale command on the Define menu.
4. Draw a line between two points on the map.

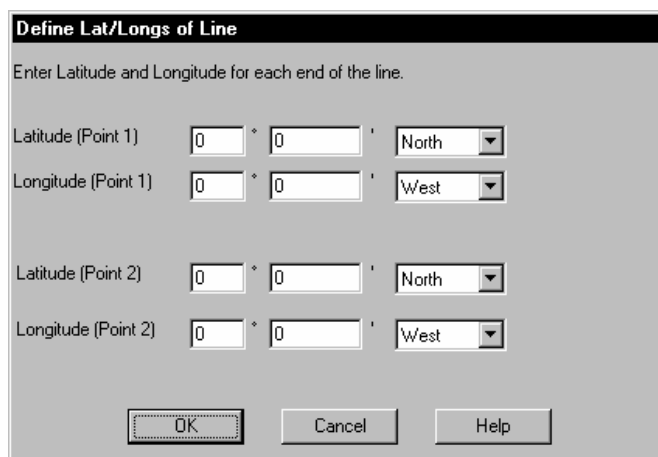
To draw the line with a mouse, move the cursor to the beginning point for the line. Press and hold the left mouse button, drag the cursor to the end point of the line, and then release the button.

To draw the line with the keyboard, move the cursor to the beginning point for the line. Press <Enter> to mark the beginning point of the line, extend the line with the arrow keys, and press <Enter> again to mark the end point of the line. CHARMED prompts the user for the length of the line.

*NOTE: Bitmaps only allow a horizontal line to be drawn. Vector maps allows the user to draw the line at any angle.*



5. Enter the length of the line in the dialog box. The units are feet, miles, kilometers, or meters. Alternatively, if latitude/longitude coordinates are known at the line endpoints, you may enter those coordinates by selecting the Lat/Long button.



**Define Lat/Longs of Line**

Enter Latitude and Longitude for each end of the line.

Latitude (Point 1)    0   \*   0   '   North

Longitude (Point 1)    0   \*   0   '   West

Latitude (Point 2)    0   \*   0   '   North

Longitude (Point 2)    0   \*   0   '   West

OK    Cancel    Help

6. Select the OK command button or press <Enter>. CHARMED returns to the Scale Length dialog box. Select the OK command button or press <Enter>. CHARMED returns to the Map Definition window.

### Defining a Map Location

Use the Define a Map Location command to define and edit the location of an icon that represents another map. The icon looks like boxes within boxes on the map.



Notice that the cursor is transformed to a representation of this icon. The map is a smaller-scaled map to be used with the zoom feature in CHARM. Defining a map location involves positioning the icon on the map and specifying the name of the map to be displayed when the icon is selected in CHARM.

Use the following steps to define a map location:

1. Run the CHARM editor by selecting the CHARMED icon from the CHARM group or by executing the CHARMED.EXE file from the Windows Explorer or My Computer on the desktop. The CHARMED window is displayed.
2. Select the Map Definition command on the Edit menu of the CHARMED window. The Map Definition window is displayed.

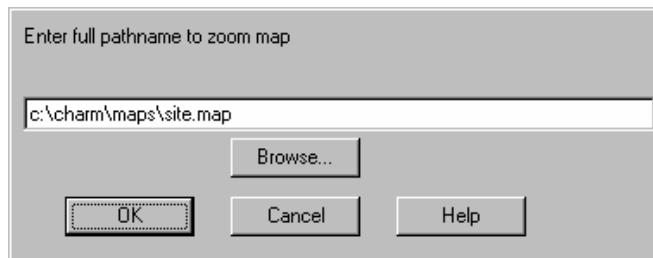
Paste an image from Windows clipboard, or use the Open command on the File menu to select and display a map.

3. While a map is displayed, select the Define Map Location command

on the Define menu.

4. Move the cursor to the point at which you want to place the icon on the displayed map.

If you are using a mouse, press the left or right mouse button to locate the icon. If you are not using a mouse, press <Enter> to locate the icon. CHARMED prompts the user for complete path and file name of the associated map file.



5. In the dialog box, enter the file name for the map that is represented by the icon. Include the full path name, including the drive, so that the file can be located anywhere in the system. Alternative, use the Browse button to scan and select the desired map file.
6. Select the OK command button or press <Enter>. CHARMED returns to the Map Definition window.

### Defining a Release Location

Use the Define Release Location command on the Define menu define and edit the location of an icon that represents the location of one or more release scenarios. The icon looks like a plume within a box.



The release scenarios must be created and stored in CHARM using the Main CHARM Input Window. Defining a release location involves positioning the icon and specifying the scenarios whose titles will be displayed when the icon is selected in CHARM.

To define a release location, use the following steps:

1. Run the CHARM editor by selecting the CHARMED icon from the CHARM group or by executing the CHARMED.EXE file from the Windows Explorer or My Computer on the desktop. The CHARMED window is displayed.



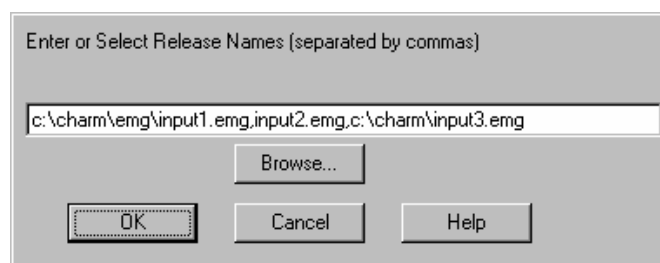
2. Select the Map Definition command on the Edit menu of the CHARMED window. The Map Definition window is displayed.

Paste an image from Windows clipboard, or use the Open command on the File menu to select and display a map.

3. While a map is displayed, select the Define Map Location command on the Define menu.
4. Move the cursor to the point at which you want to place the icon.

If you are using a mouse, press the left or right mouse button to locate the icon.

If you are not using a mouse, press <Enter> to locate the icon.



5. In the dialog box, enter the file name(s) for the release represented by the icon. Include the full path name, so that the file can be located anywhere in the system. If you want to specify more than one release, separate the file names by commas. The Browse button may be used to examine and select files currently stored on your system. DOS wildcards can be used in file names.
6. Select the OK command button or press <Enter>.

Once a map or release location is defined, you can edit the file information for an icon, reposition an icon, or delete an icon.

### Map Description

Use the Map Description command on the Define menu and CHARMED displays a text window from which the user may describe pertinent information associated with a map. For example, the user may identify the sensitive receptors that exist beyond the fenceline. The description may be viewed from CHARM when the map is displayed.

The Map Description command, Emergency Response Text command, and Site Information command all use the same text editor. However, the method by which the information is saved is different. Site information and Map Definition information is saved when you select

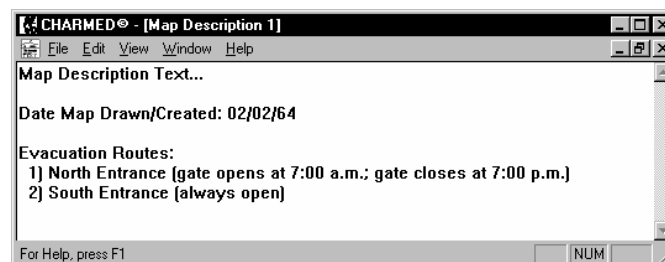
Save and Close from the File menu of the text editor window. If you select Exit from the File menu after making changes to the text, CHARMED will prompt you to save the changes, and then proceed to exit the CHARM Editor. Conversely, even though you may have saved Map Description text, the Map Description text is not really saved until you select Save and Close from the Map Definition Window.

To use the Map Description command, use the following steps:

1. Run the CHARM editor by selecting the CHARMED icon from the CHARM group or by executing the CHARMED.EXE file from the Windows Explorer or My Computer on the desktop. The CHARMED window is displayed.
2. Select the Map Definition command on the Edit menu of the CHARMED window. The Map Definition window is displayed.

Paste an image from Windows clipboard, or use the Open command on the File menu to select and display a map.

3. While a map is displayed, select the Map Description command on the Define menu. The following window is displayed.



4. In the Map Description text window, input or modify text that is pertinent to information associated with the map. Use selections from the Edit menu to copy, cut, or paste information from other Window's applications.
5. Select Save and Close from the File menu of the text editor window to save the information. Selecting Exit from the file menu closes CHARMED.

### Editing Icon File Information

The file information for an existing map or release icon can be edited. If you are using a mouse, move the cursor over the icon and double-click the left mouse button. If you are using the keyboard, select the Define Map Location or Define Release Location command to allow the cursor to move the desired icon. Then, position the cursor over the icon and

press <Enter> (or click the left mouse button). A dialog box containing the current file information is displayed. Make the necessary changes and select OK or press <Enter>.

Use the following steps to edit the file information for a map or release location icon:

1. Run the CHARM editor by selecting the CHARMED icon from the CHARM group or by executing the CHARMED.EXE file from the Windows Explorer or My Computer on the desktop. The CHARMED window is displayed.
2. Select the Map Definition command on the Edit menu of the CHARMED window. The map editor window is displayed.

Use the Open command on the File menu to select and display a map.

3. Using the mouse, you can move the cursor over the icon and double-click the left mouse button; or, select the desired type of icon to edit from the Define menu, move the cursor over the desired icon and click the left mouse button.

If you are using the keyboard, you must select the Define Map Location or Define Release Location command on the Define menu *before* you can move the cursor over the icon. When the cursor is over the icon, press <Enter> to select it.

A dialog box containing the file information is displayed.

4. Edit the file information and select OK or press <Enter>.

### **Repositioning an Icon**

You can relocate an existing map or release icon. If you are using a mouse, move the cursor over the icon, hold the left mouse button down, drag the mouse to reposition the icon, and release the left mouse button. If you are using only the keyboard, you cannot simply move the icon. You must delete the icon and then redefine the icon using the Define Map Location or Define Release Location commands.

Use the following steps to relocate a map or release location icon:

1. Run the CHARM editor by selecting the CHARMED icon from the CHARM group or by executing the CHARMED.EXE file from the Windows Explorer or My Computer on the desktop. The CHARMED window is displayed.

2. Select the Map Definition command on the Edit menu of the CHARMED window. The map editor window is displayed.

Use the Open command on the File menu to select and display a map.

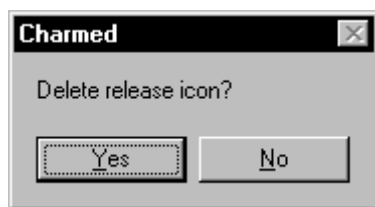
3. To move the icon with the mouse, position the cursor over the desired icon, press the left mouse button and reposition the icon by dragging it. Then, release the mouse button.

### Deleting an Icon

To delete an icon, move the cursor over the icon and press the Delete key. Select Yes in the dialog box to confirm the deletion.

Use the following steps to delete a map or release location icon:

1. While the map containing the icon is displayed, move the cursor over the icon and press <Delete>. CHARMED will verify the deletion.



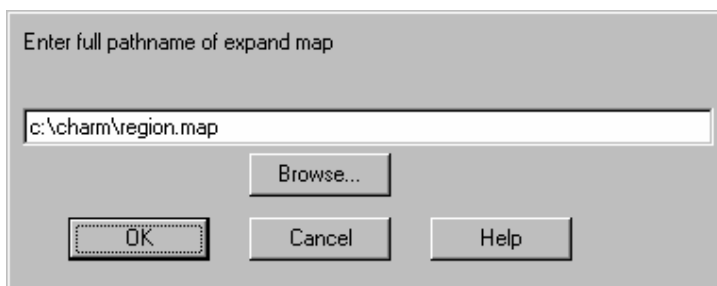
2. Select Yes in the dialog box or press <Enter> to confirm the deletion.

### Naming an Expand Map

Use the Expand Map Name command on the Define menu to specify the name of a larger-scaled map than the one being defined. Figure 4.9 shows the window in which to enter the map name. The specified map is displayed automatically by CHARM if the Auto Map Scale option is checked and the currently displayed map covers a percentage of the footprint display area which is less than the percentage defined by the Auto Map Fraction. The rectangular area used for comparison is the area in which the viewport circle is inscribed. If the current map covers less than the Auto Map Fraction of the rectangular area, CHARM will attempt to display a larger scaled map, if one has been defined. The value must be between 0.05 and 0.95. The default is 0.25.

The Auto Map Scale and Auto Map Fraction options are on the Options menu of a Plan Display window in CHARM proper.

**Figure 4.9**  
Expand Map  
Window



To name an expanded map:

1. Run the CHARM editor by selecting the CHARMED icon from the CHARM group or by executing the CHARMED.EXE file from the Windows Explorer or My Computer on the desktop. The CHARMED window is displayed.
2. Select the Map Definition command on the Edit menu of the CHARMED window. The Map Definition window is displayed.

Paste an image from Windows clipboard, or use the Open command on the File menu to select and display a map.

3. Select the Define Expand Map Name on the Define menu.
4. Enter the full path name for the expanded map, or use the Browse button to display files on your disk for selection.
5. Select OK or press <Enter>. The map editor window is displayed.

### **Saving a Map Definition**

Once you edit a map with the map definition editor, you must store it as a file for later retrieval. To save a map definition, use the Save or Save As commands on the File menu. The Save and Save As commands work the same in CHARM as in other Windows applications.

You can enter a base name and allow CHARMED to assign the default extension. CHARM uses specific extensions to identify files for selection list displays. If you do not assign an extension to the file name, CHARMED automatically assigns the default .MAP extension to the base name. When you save a map definition, another file is created with the same base name but with the .MFD extension. This file contains the map definition information.

*Caution: Since files with the .MFD extension contain the map definition information, this extension should not be used for other CHARM file names. Also, a file with the .MFD extension must not be deleted, unless*

*its corresponding map is also deleted.*

If you want a base map to display automatically when the CHARM program is started, assign the file name BASEMAP.MAP (and the associated BASEMAP.MFD file ) to one of the maps you define. This feature is especially useful for running CHARM in the emergency response mode. When CHARM is started, if no file named BASEMAP.MAP is found, the main input window displays.

For maps from the clipboard, you must assign a base name to the edited map. For maps from files, you should assign a new and unique base name to the edited map. If you use the same base name, the original file will be overwritten, thereby destroying the original metafile, TIFF, or bitmap file.

## Defining Population Files for Use With CHARM

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Use the Select Population Files command on the Edit menu of the CHARMED window to identify one or more population files which will be used to determine the approximate number of people impacted by a footprint. The population file is created from Radian's TIGERMAP Utility in the CHARM group.



The program reads U.S. Census Bureau Tiger/Line<sup>TM</sup> 1992 data and creates maps and/or population files. An icon for starting TIGERMAP is in the CHARM group box. Tiger/Line<sup>TM</sup> 1992 data (available on CD-ROM) is required before the population files can be created. Contact the U.S. Census Bureau directly for ordering the data files needed. Their number is (301) 457-4100.

Multiple files can be entered. If a full path name is given to a file, the subsequent files are assumed to be in the same subdirectory until the next full path name is given. Wild cards may be used. If no extension is given (including no '.' at the end of the file name) on a file, then the default extension (normally .TPY) will be used. If you want to select pre-existing files press the Browse button. A window allowing the multiple selection of files will appear. Any files selected will be appended to the existing list.

To define population files use the following steps:

1. Run the CHARM editor by selecting the CHARMED icon from the CHARM group or by executing the CHARMED.EXE file from the Windows Explorer or My Computer on the desktop. The CHARMED window is displayed.
2. Select the Select Population Files command on the Edit menu of the CHARMED window.
3. In the dialog box, enter the file name(s) for those desired population files.

Include the full path name, so that the file can be located anywhere in the system. If you want to specify more than one release, separate the file names by commas. The Browse button may be used to examine and select files currently stored on your system. DOS wildcards can be used in the file names.

4. Select the OK command button or press <Enter>.

## **Inputting Data for Mixtures into the Chemical Database**

---

CHARM is capable of modeling only a single substance at a time, independent of whether the substance is pure or suspended in a mixture. If a substance is a constituent within a mixture, there are three ways to model this from within CHARM.

1) The best approach for handling a mixture is to add a new chemical to the CHARM Chemical Database which contains the bulk properties of the liquid and the bulk gas properties of the mixture. The boiling point of the mixture is defined when the sum of all of the partial pressures of the constituents of the mixture equals one atmosphere. For CHARM to report the concentration of the constituent of interest, set the Reported Fraction field to the molar fraction of the constituent in the mixture. For example, if 20% of the emission were species A and 40% species B, two chemicals could be added to the database. All the parameters would be the same for the two species except the name and the Reported Fraction parameter. For species A to be reported correctly this parameter should be 0.20. For species B it should be 0.40. Most species will define the Reported Fraction as 1.0. If it is set to zero it is assumed to be 1.0.

2) The next best approach is to add a new chemical to the CHARM Chemical Database that contains the bulk properties of the liquid and the gas properties of the species in equilibrium with the liquid mixture. The critical values, triple point values, and the boiling point should be

representative of the vapor pressure curve of the constituent of interest in equilibrium with the liquid mixture. The Reported Fraction field should be set to 1.0.

3) The last method for handling mixtures in a liquid release is to use the data for the pure species and the CHARM model. Simply enter a "pseudo" pool diameter in the Pool/Lagoon release type by making the size of the pool proportionate to the percentage of constituent within the mixture. Use the emission rate from that CHARM calculation (see Source/Puff Calculation Display in CHARM) as input in the User Specified After-Release type. The puff diameter should be set to the actual pool size, not the pseudo pool size. The molar fraction of the constituent of interest in the gas state in equilibrium with the pool mixture should be subtracted from 1.0 and the result entered in the molar air fraction field (i.e. all other constituents will be assumed to be air). This method allows you to specify the initial concentration as well as the emission rate.



## Chapter 5: The Main CHARM Input Window

---

The Main CHARM Input Window provides the data that CHARM needs to simulate a chemical release. When you initially run the CHARM.EXE program, the Main CHARM Input Window is displayed, unless there is a stored map file with the name BASEMAP.MAP. In the planning mode, CHARM uses the input window to solicit release and meteorological data.

If a map file has been defined using the CHARM Editor and stored with the BASEMAP.MAP name, the map is displayed when CHARM is started. The Main CHARM Input Window will still be present, but behind the Map Window. It can be made active by selecting the Input Window from the Window menu.

*Note: The purpose of the BASEMAP.MAP file is to save time when using CHARM in the emergency response mode as described in Chapter 7, "Using CHARM for Emergency Response."*

CHARM input consists of the **release description** in the top portion of the window and the **meteorological data** in the lower portion. Figures 5.1 and 5.2 show the release description portion of the window and Figure 5.3 shows the meteorological data portion.

**Figure 5.1**  
Main CHARM  
Input Window  
(top)

Version 9.0  
Title: Standard CHARM Run - Chlorine  
Species: Chlorine  
Release type: Container/Surface Description  
Emergency response output: Plume  
X location: 0 ft Y location: 0 ft  
Isoleth Concentrations (ppm): 0.5, 5, 50  
Building Height: 0 ft Width: 0 ft  
Source to Building Distance: 0 ft Direction: 0°  
Horizontal Tank or Pipeline  
Tank Length: 10 ft  
Tank Diameter: 10 ft  
Liquid Depth in Container: 10 ft  
Liquid Amount in Container (Calculated): 5875 gallons  
Tank will not vent during pool fire  
Storage Temperature assumed to be ambient  
Storage Pressure (Calculated, gauge): 7.028 atms  
Droplet fraction of mass same as Flash fraction  
BLEVE burn efficiency (Calculated): 0.2527  
Hole Height Above Ground: 0 ft  
No Container Mitigation Time  
Hole Diameter: 1 in  
Hole facing opposite of wind direction  
Vertical Angle of Hole: 0°  
Height of Hole from Container Bottom: 0 ft  
Liquid Pool Surface Height Above Ground: 0 ft  
Maximum Pool Diameter: 25 ft  
No Pool Mitigation Time

For Help, press F1

**Figure 5.2**  
Main CHARM  
Input Window  
(middle)

Connecting Pipe  
Length: 0 ft  
Diameter: 0.5 ft  
Relative Roughness Factor (e/D, 0->1): 0  
Number of Globe Valves (100% open): 0  
Number of Gate Valves (100% open): 0  
Number of Gate Valves (75% open): 0  
Number of Gate Valves (50% open): 0  
Number of Gate Valves (25% open): 0  
Number of 90° Elbows: 0  
Number of 45° Elbows: 0  
Number of Tee Elbows-Entering Stem: 0  
Number of Tee Elbows-Entering Side: 0  
Number of Tee Straight Throughs: 0  
Number of Flush Pipe-Vessel Connections: 0  
Number of Borda Pipe-Vessel Connections: 0  
Number of Round Pipe-Vessel Connections: 0  
Water Fraction of Spill Surface (0 -> 1): 0.15  
Surface is assumed to be dirt  
Surface Specific Heat: 800 joules/kg K  
Surface Thermal Conductivity: 0.32 w/m K  
Surface Density: 1640 kg/m³  
Relative Pore Volume of Surface (0 ->1): 0.34  
Darcy Constant of Surface: 2.8e-007 m

For Help, press F1

**Figure 5.3**  
Main CHARM  
Input Window  
(bottom)

Met Data  
Relative Humidity: 50 %  
Ambient Temperature: 78 °F  
Ambient Pressure: 1 atms  
Cloud Cover (tenths): 10  
Stability Class: 0 (User supplied)  
Solar Radiation: 0 kW/m²  
No inversion present  
Surface roughness: 1 cm  
Wind measurement altitude: 10 m  
Winds Time Direction Speed  
00:00 180° 10 mph  
Add another wind

For Help, press F1

The Main CHARM Input Window guides you through the data fields that describe the toxicity of the release and the conditions under which the chemical species will disperse. Many of the input fields require an entry in order for CHARM to simulate the release. CHARM provides default values for the input fields that you can accept or change. If you leave a required field blank and try to close the dialog box, CHARM displays a message saying the field requires an entry.

The release description fields that appear in the input window vary according to the selected species and release type. Some of the fields in the input window contain default values. CHARM uses the data entered in the input window to calculate and predict 1) the dispersion, concentration, and movement of the plume; 2) thermal radiation from a jet fire, liquid pool fire, or boiling liquid expanding vapor explosion (BLEVE); and/or 3) mechanical/explosion overpressures.

Each release that is described in the input window and simulated in a CHARM run is called a **scenario**. To create a scenario, CHARM determines the number of puffs in a release and the initial characteristics of each puff. CHARM creates a variety of displays, such as the Snapshot Plan Plume View, based on the information entered in the input window. Whether you are using CHARM for emergency planning or emergency response, each scenario can be saved for later retrieval.

## Scrolling the Input Window

---

To view the contents of the entire window, the CHARM input screen can be scrolled with a mouse or the keyboard. To scroll with a mouse, use the vertical scroll bar to scroll up or down, and the horizontal scroll bar to scroll right or left. With a mouse, you can scroll one line at a time, one window full of information, or to a relative location. Refer to the Windows User's Guide for more details on scrolling with a mouse. To scroll with the keyboard, move the inverse video bar to the next item off the screen, press an arrow key until the screen moves, or use <Page Up> and <Page Down>.

## Selecting an Input Field

---

To select a field with the mouse, move the cursor over the field and double-click the left or right mouse button. To select a field with the keyboard, use the arrow keys to move the inverse video bar to the field and press the Enter key.

When you select a field, CHARM displays a dialog box in which you enter the requested information. On-line help is available from within the dialog box for each field.

## Modifying CHARM Input

---

To change the values for any of the data fields in the Main CHARM Input Window, use the following steps:

1. Move the inverse video bar to the desired field.

To move the bar with the mouse, position the cursor over the field and click the left mouse button.

To move the bar with the keyboard, use the arrow keys to position the bar over the field.

2. Select the field.

To select the field with the mouse, double-click the left mouse button while the bar is over the field.

To select the field with the keyboard, press <Enter> while the bar is over the field.

3. Make the necessary changes to the value(s) in the dialog box.

To display the on-line help that provides additional information for the requested data, select the Help command button in the dialog box.

4. Select OK to return to the Main CHARM Input Window.

Alternatively, the user has the option of viewing the input data in a folder format. For more information on inputting the release scenario and meteorological data in this form, see the Option Menu description under Main CHARM Input Window Menus later in this Chapter.

## Main CHARM Input Window Menus

---

The File, Edit, View, Window, and Help menus on the Main CHARM Input Window include the standard Windows commands plus some additional commands. The Options, MetFile, and Displays menus are exclusive to the CHARM program. Only those menu commands that are appropriate for the current release description are available for selection.

### View Menu

Use the Status Bar command to display and hide the Status Bar, which describes the action to be executed by the selected menu item, and keyboard latch state. A check mark appears next to the menu item when the Status Bar is displayed.

### Window Menu

The Window menu offers the following commands, which enable you to arrange multiple views of multiple windows in the application window:

<u>COMMAND</u>	<u>SUMMARY</u>
<b>Cascade</b>	Arranges windows in an overlapped fashion.
<b>Tile</b>	Arranges windows in non-overlapped tiles.
<b>Arrange Icons</b>	Arranges icons of closed windows.
<b>Window 1, 2, ...</b>	Goes to specified window.

### Help Menu

The Help menu offers the following commands, which provide you assistance with this application:

<u>COMMAND</u>	<u>SUMMARY</u>
<b>Help</b>	Offers you help on the current task or command.
<b>Index</b>	Provides general instructions on using help.

<b>Using Help</b>	Offers you an index to topics on which you can get help.
<b>Search for Help on</b>	Displays a list of keywords used in CHARM from which a list of related topics may be.
<b>About</b>	Displays the version number and copyright notice for CHARM.

## File Menu

The File menu on the Main CHARM Input Window provides the standard Windows file commands for creating, opening, saving, renaming, printing, and exiting CHARM. The CHARM File menu also provides a command for selecting a previously stored scenario.

The File menu of the Main CHARM Input Window has the following commands:

<b><u>COMMAND</u></b>	<b><u>SUMMARY</u></b>
<b>New</b>	Restores all the fields on the Main CHARM Input Window to their initial values when the CHARM program began. These default values may be changed via the CHARM.INI file (see CHAPTER 3: CHARM.INI File Description) or by selecting Save As Default under the File menu (see Save As Default command description below).
<b>Open</b>	Displays a dialog box requesting the name of an input file to open. The dialog box contains a selection list of the drives and any file names that match the file specification. The default extension is .EMG, which may be changed via the CHARM.INI file (see Chapter 3: CHARM.INI File Description).

<b>Scenarios</b>	Displays a selection list of release scenario titles stored previously in CHARM with the .EMG default file name extension or other file name that matches the currently specified extension. To create the list, CHARM first searches the directory specified for emergency response files in the File Location Editor of CHARMED. CHARM displays the selected scenario. For more information on this menu item, see the “Scenarios Command” topic below.
<b>Save</b>	Saves the input data from the Main CHARM Input Window. If no file name has been assigned, a dialog box is displayed in which you enter a file name.
<b>Save As</b>	Displays a dialog box in which you can enter the name of the file being saved.
<b>Save As Default</b>	Automatically saves the current scenario described in the CHARM Input Window as the default scenario stored in a file labeled CHRMDFLT.EMG; that is, upon first entering CHARM or selecting New from the File menu, the parameters stored in CHRMDFLT file are displayed.
<b>Print</b>	Print the entire contents of a window
<b>Print Preview</b>	Display the window contents on the screen as it would appear printed.
<b>Printer</b>	Allows the user to change the current printer configuration and connection.

**Exit** Exit the CHARM MDI. All windows are closed and exit the CHARM program.

### New Command

The New command on the File menu restores all the fields on the Main Input Window to their initial values when the CHARM program began. If any modifications were made to the current scenario and the current scenario has not yet been saved, CHARM will prompt the user to save changes before resetting the release input parameters back to the default values. These default values may be changed via changing the CHARM initialization file CHARM.INI (see CHAPTER 3: CHARM.INI File Description) or by simply selecting the Save As Default command from the file menu.

### Open File Command

The Open command on the File menu displays a dialog box requesting the name of an input file to open.



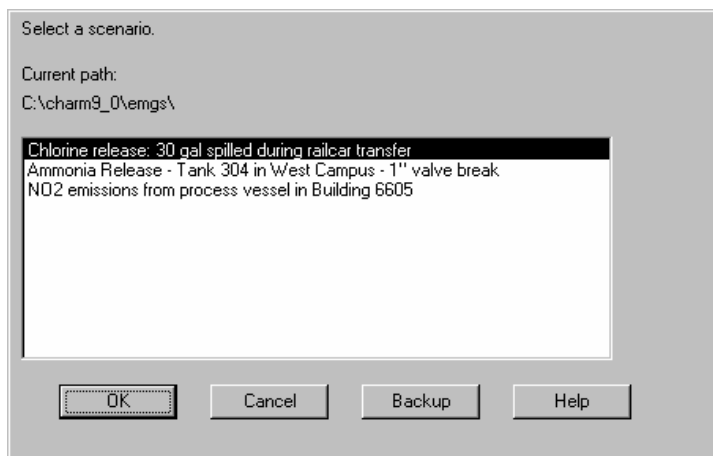
The dialog box contains a selection list of the drives and any file names that match the file specification. The default extension is .EMG, which may be changed via the CHARM.INI file (see Chapter 3: CHARM.INI File Description). Alternatively, the default extension may be changed by simply specifying a new extension in the Open or Save dialog boxes.

### Scenarios Command

The Scenarios command on the File menu displays a selection list of the run titles for release scenarios that have been previously stored. Unless you specify a different extension, release scenario files are assigned the



default .EMG file name extension by CHARM. The default may be changed via the CHARM.INI file (see Chapter 3: CHARM.INI File Description).



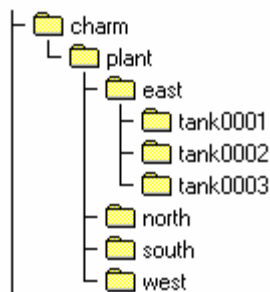
When you select a title, CHARM displays the input window containing the data for that scenario. Multiple selections, one after the other, may be required to completely select the desired scenario. The number of selections depends on the setup and location of the .IND and .EMG files. The first subdirectory in which CHARM searches for .EMG and .IND files is the directory specified for the emergency response files in the File Location editor of CHARMED. CHARM displays lists until you make the last level of selections. Then, CHARM displays the input window for the scenario described in the selected .EMG file. You can move back and forth through the scenarios as desired.

### **IND File**

A file containing subdirectory information that CHARM uses to locate .EMG files in the emergency response mode. Files with .IND extensions are created by the user with a text editor. Using the combination of .IND file and .EMG files allows the user to organize prestored data files by geography, chemical species, etc. IND files are strictly used with the Scenarios command under the file menu in CHARM proper.

### **Steps for using IND Files:**

- 1) The user must define the location of the initial .IND file under File Locations in the CHARM editor (CHARMED).
- 2) From File Manager or Windows Explorer, create subdirectories which layout, for example, geographical aspects of possible release sites.



3) From Notepad or some other text editor, create a file with the .IND extension and format the file as follows:

<u>LINE</u>	<u>TEXT</u>
1	Subdirectory Name.
2	Description of information associated with subdirectory name.
3	Subdirectory Name.
4	Description of information associated with subdirectory name.
5	Subdirectory Name.
6	Description of information associated with subdirectory name.
etc...	

#### **Example IND File**

The EXAMPLE.IND would read as follows and reside in the C:\CHARM\PLANT subdirectory:

```

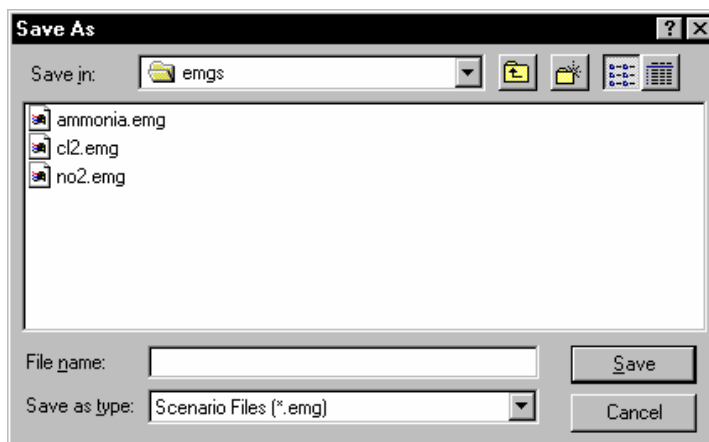
EAST
Release occurred in east side of plant
NORTH
Release occurred in north side of plant
SOUTH
Release occurred in south side of plant
WEST
Release occurred in west side of plant
  
```

NOTE: The above file should reside in the initial Emergency Response file location defined by the CHARM editor (CHARMED). NO prestored data files (.EMG) should reside in the same directory as .IND files. CHARM attempts to locate EMG files first. If EMG files are located and read, no attempt is made to locate IND files.

4) Repeat Step 3 for all directories.

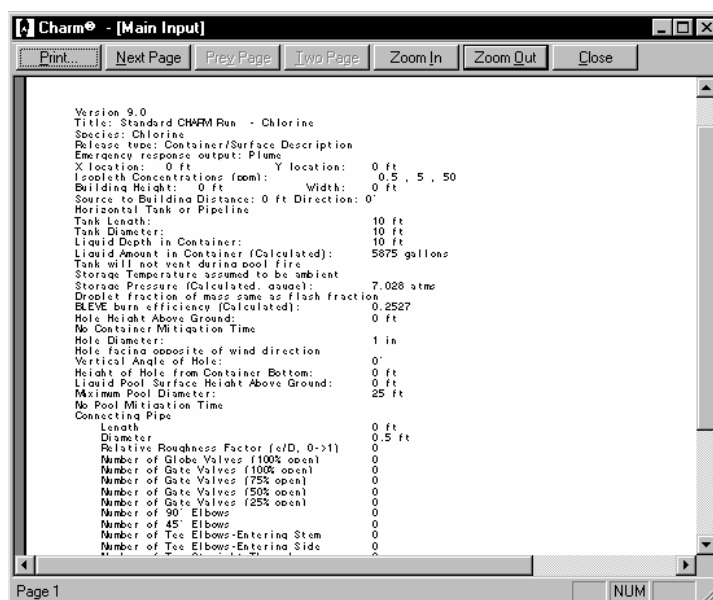
#### **Save/Save As Commands**

The Save command will save the current release description information into the currently opened file. If no current file is defined, then invoking the Save command will invoke the Save As command and display a dialog box requesting the name of an input file to save the currently defined release scenario.



## Print Preview Command

The Print Preview command on the File menu displays a dialog box illustrating how the information displayed from the Main Input Window will be printed. The user has options to zoom in or out, display the next page of information, print the existing data, or close the preview and return to the CHARM Main Input Window.



## Print Setup Command

The Print Setup command on the File menu displays a dialog box requesting printer configuration information. The user has options to specify the desired printer, portrait or landscape orientation, and paper size and source. Other options may also be available.



## Edit Menu

The Edit menu of the Main CHARM Input Window has only one command. Use the Copy command to send text from the input window to the Windows clipboard where it can be retrieved by other programs. All text in the window, visible or not, is sent to the clipboard.

## MetFile Menu

Use the Metfile menu of the Main CHARM Input Window to create, open, save, and rename files containing meteorological data. These commands are similar to the standard Windows functions. If you are set up to receive automatic information from a meteorological tower, the Metfile menu also provides the Automatic Poll command.

The Metfile menu includes the following commands:

### COMMAND

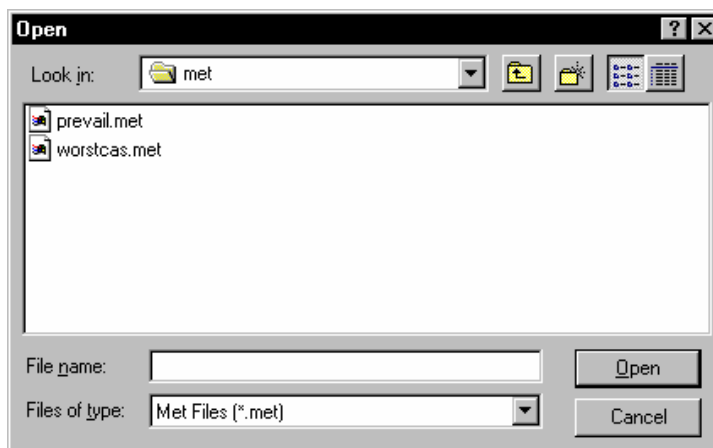
### SUMMARY

<b>New</b>	Restores all met data to the values that existed when the program began. These default values may be changed via the CHARM.INI file (see Chapter 3: CHARM.INI File Description) or by selecting the Save As Default command under the MetFile menu.
<b>Open</b>	Displays a dialog box requesting the name of a met file to open. The dialog box contains a selection list of the drives and any file names matching the file specification. The default extension is .MET, which may be changed via the CHARM.INI file (see Chapter 3: CHARM .INI File Description).
<b>Save</b>	Saves the met data. If no file name has been assigned, a dialog box is displayed in which you enter the file name. You can enter a base extension name for the file and allow CHARM to assign the extension, or you can assign the entire name.
<b>Save As</b>	Displays a dialog box in which you enter the new file name and saves the met data in that file.
<b>Save As Default</b>	Automatically saves the current met data described in the CHARM Input Window as the default met data stored in a file labeled CHRMDFLT.MET; that is, upon first entering CHARM or selecting New from the File menu, the parameters stored in CHRMDFLT file are displayed.
<b>Solar Radiation Worksheet</b>	A worksheet provided to aid the user in the estimation of solar radiation.

<b>Automatic Poll</b>	Initiates conversation between CHARM and the meteorological interface (METINTER.EXE) to automatically read stored met data. This menu item may be grayed (unavailable) if you do not have real-time met capabilities.
<b>Stop Poll</b>	Signals CHARM to stop real-time data acquisition. This option is only available after Automatic Polling has been invoked. This menu item may be grayed (unavailable) if you do not have real-time met capabilities.
<b>Use Inverse Square</b>	Available only if more than one met site is available to CHARM for real-time data acquisition. Selecting this method allows CHARM to determine meteorological conditions at a given site, using an algorithm that weights each met parameter as a function of the met parameter at every other site and their relative distances.
<b>Calculate Solar Radiation</b>	Calculate the solar radiation as real-time met data is acquired. A check beside this option indicates that CHARM will calculate the solar radiation based on user input into the Solar Radiation Worksheet. This option is only available if CHARM is configured to do real-time met data acquisition.

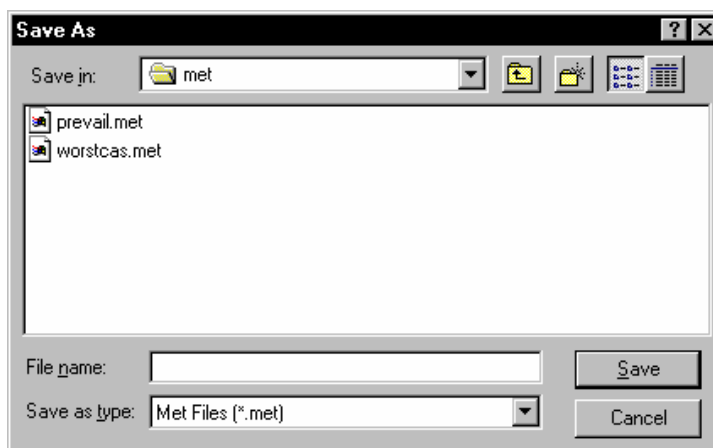
### **Open MetFile Command**

The Open command on the File menu displays a dialog box requesting the name of an input file to open containing meteorological data previously stored in CHARM.



### Save/Save As MetFile Commands

The Save command will save the current meteorological data into the currently opened file. If no current file is defined, then invoking the Save command will invoke the Save As command and display a dialog box requesting the name of an input file to save the currently defined meteorological data.



### Automatic Poll Command

Use the Automatic Poll command on the Metfile menu of the Main CHARM Input Window to read met data automatically for up to 24 hours from the specified time of release. To use this option, your system must be set up with the appropriate software program (METINTER.EXE) and communication parameters for receiving automatic data from a meteorological tower. The communications parameters can be set using the CHARM editor.

### Solar Radiation Worksheet Command

Use the Solar Radiation worksheet to estimate the amount of solar radiation as a function of the time of day, the day of the year, and location. Solar radiation is a function of latitude/longitude, cloud

cover, time of day, and the day of the year. The user must specify the +/- offset from local time to Greenwich Mean Time (GMT). CHARM will use the calculated solar radiation value to aid in the determination of the stability class if so desired. Likewise, if the user elects to let CHARM calculate the solar radiation value, it will be displayed in the meteorology conditions at the bottom of the Main CHARM Input Window. An example of the worksheet is illustrated below.

**Solar Radiation Work Sheet**

Latitude: 0° 0' North Longitude: 0° 0' West

Offset to add to computer time for GMT: 6 Hours

Date (mmddyy): 073197 Time (hhmm): 1523

Cloud Cover: 10 Tenths

Solar Radiation: 0 kW/m²

☐ Use in Stability Calculation ☐ Use as Solar Radiation value

OK Cancel Help

## Options Menu

The Options menu offers the following commands:

### COMMAND

### SUMMARY

#### **Prompt at Exit**

Toggle switch to prompt or not to prompt the user before exiting CHARM. A check by this menu item indicates that the user will be prompted before exiting; otherwise, no check indicates the user will not be prompted by the exit dialog box.

#### **Time is Minutes-Seconds**

Toggle switch to run CHARM in Minutes-Seconds mode or Hours-Minutes mode. A check by this menu item indicates that CHARM will run in Minutes-Seconds mode; otherwise, no check indicates that CHARM will run in Hours-Minutes mode.



<b>Default Metric Units</b>	Toggle switch to default CHARM to report units in metric terms or English units. A check by this menu item indicates that CHARM will use metric units; otherwise, no check indicates that CHARM will report units in English terms.
<b>Description Dialog Input</b>	Provides a means of viewing the release input data in a tabbed folder format.
<b>Met Dialog Input</b>	Provides a means of viewing the meteorological input data in a tabbed folder format.

### **Prompt At Exit Command**

Use this command to turn on/off the prompt to exit CHARM. A check by this menu item indicates that the user will be prompted before exiting CHARM; otherwise, no check mark indicates that the user will not be prompted by the exit dialog box.

### **Time is Minutes-Seconds Command**

Use this command to toggle between CHARM's two time modes. A check by this menu item indicates CHARM is running in Minutes-Seconds mode; i.e. CHARM will model a maximum of 24 minutes of dispersion. Likewise, all output will be in terms of minutes and seconds.

On the other hand, no check indicates that CHARM is running in Hours-Minutes mode; i.e. CHARM will model a maximum of 24 hours of dispersion. All output will be in terms of hours and minutes.

On output displays, this is differentiated by the following:

Hours-Minutes mode uses a colon (:) to delimit hour and minutes;

Minutes-Seconds mode uses equals (=) to delimit Minutes-Seconds.

For example, when CHARM is in the seconds mode all times will be displayed with the separator “=” instead of “:” or whatever the local time indicator is. So fifteen seconds into the release will appear as 00=15 rather than 00:15, which indicates fifteen minutes into the release. All time labels and columns will appropriately indicate seconds rather than minutes.

### **Default Metric Units Command**

Use this command to default CHARM to report units in metric terms or English units. A check by this menu item indicates that CHARM will use metric units; otherwise, no check indicates that CHARM will report units in English terms.

### **Description Dialog Input Command**

Use this command as an alternative means to view release input data rather than displaying the information from the single Main Input Window. Depending on the release type chosen from the basic information tab, the data is categorized appropriately. The basic, location, and building information tabs are always requested for any one of the three release types.

### **Basic Tab**

On the Basic tab of the folder, CHARM requests the following:

- title of the scenario;
- the release type (Container/Surface Description, Pool/Lagoon Description, or User-Specified After-Release Conditions);
- the species being modeled;
- the desired isopleth concentrations for dispersion; and
- the type of output to be displayed when/if the stored scenario is used in CHARM's emergency response mode of operation. The type of output available depends on the scenario definition.

Charm

Basic | Location | Building | Emission Rate | Puff | Velocity | Makeup

Title: Standard CHARM Run - Chlorine

Release Type: User Specified After-Release Conditions

Select Species...  
Chlorine

Isopleth Concentrations:

0.5  
5  
50

ppm

Emergency Response Output  
Plume

OK Cancel Apply Help

### **Location Tab**

On the Location tab of the folder, CHARM simply requests the x,y Cartesian coordinates associated with the source location. This is only required if the footprint generated by CHARM is to be overlaid on a map, or population impact calculations are to be performed. However, this location may be changed once the footprint has been calculated by CHARM.

Charm

Basic | Location | Building | Emission Rate | Puff | Velocity | Makeup

X: 0 feet

Y: 0 feet

OK Cancel Apply Help

### **Building Tab**

On the Building tab of the folder, CHARM requests the dimensions of the building (height and width) and the distance and direction to the source. Enter the direction you would be facing if you were at the release site looking at the building. If the release site is not downwind of the building, the building is ignored. The direction can be entered in degrees or points of the compass. Degrees refer to the 360-degree directional compass, where North is 0 or 360, East is 90, South is 180, and West is 270. Points of the compass refer to North (N), East (E), South (S), West (W), and the points between, such as Northeast (NE) and South Southeast (SSE). Also, Enter the distance from the release site to the center of the building. The units are feet or meters. If the release site is more than ten times the minimum dimension of the building (height or width), the building is ignored.

The screenshot shows the 'Building' tab of the CHARM software interface. It contains four input fields: 'Height', 'Width', 'Distance', and 'Direction', each followed by a unit selection dropdown menu currently set to 'feet'. All input fields contain the value '0'. The window has a standard Windows-style title bar and a set of control buttons (OK, Cancel, Apply, Help) at the bottom right.

For a Container/Surface Description or Pool/Lagoon Description release types, the folder is additionally categorized by pool and surface information.

### **Pool Tab**

On the Pool tab of the folder, CHARM requests the following:

- Enter the height above ground of the liquid-air interface. The units are feet or meters. Normally a released liquid falls to the ground.

- Enter the total area or equivalent circular diameter of the pool size. The units are inches, feet, centimeters, or meters. The diameter is used to calculate the surface area from which the liquid will evaporate. Larger areas tend to evaporate more rapidly than smaller areas. CHARM will calculate the pool diameter/area if given the amount released and pool depth.
- Enter the time from the beginning of the release when the pool is assumed to be covered or drained. The evaporation from the pool will stop at the Pool Mitigation Time. The time can be in units of hours, minutes, or seconds. If no mitigation time is desired the entry can be left blank or enter zero.

### **Surface Tab**

On the Surface tab of the folder, CHARM requests the following:

- Enter the fraction (by volume) of the spill surface that is water. This is the amount of water in the surface soil of the area that immediately surrounds the release site. The water fraction is used to determine whether freezing ground water may alter the heat flow into the spill.
- A value less than 0.1 is dry. A value of 0.6 indicates mud. A value of 1.0 is water. The suggested average value is 0.15. An entry is required.

- Select the type of surface on which the spill occurred. If you select User-defined surface type, you must enter values for the specific heat, thermal conductivity, density, relative pore volume, and Darcy's constant. If you select dirt, asphalt, concrete, or steel, CHARM assigns default values for the surface parameters. You can accept or change the default values. Otherwise, making a change to any of the surface parameters automatically changes the Surface Type to User-Defined.

The screenshot shows the CHARM software window with the 'Surface' tab selected. The 'Water Fraction' is 0.15. The 'Type' is set to 'Dirt'. The 'Parameters' section contains the following values:

Parameter	Value	Unit
Specific Heat	800	J/kg K
Thermal Conductivity	0.32	W/m K
Density	1640	kg/m³
Relative Pore Volume	0.34	
Darcy Constant	2.8e-007	meters

Buttons at the bottom: OK, Cancel, Apply, Help.

For a Container/Surface Description release type, the folder is additionally categorized by container, storage, hole, pipe, and fire/droplets information.

### **Container Tab**

On the Container tab of the folder, CHARM requests the following:

- the container type (horizontal tank or pipeline, vertical tank, or spherical tank);
- the appropriate dimensions based on the selected container type;
- a mitigation time indicating that the release has been mitigated by some circumstance in which the release has been halted;
- the amount of liquid in the container either by volume, weight, or depth.

The screenshot shows the 'Storage' tab of the CHARM software. The window title is 'Charm'. The menu bar includes 'Basic', 'Location', 'Building', 'Container', 'Storage', 'Hole', 'Pool', 'Surface', 'Pipe', and 'Fire/Droplets'. The 'Storage' tab is active, displaying the following fields:

- Type: Horizontal tank or pipeline (dropdown)
- Height: 10 (text box) feet (dropdown)
- Length: 10 (text box) feet (dropdown)
- Diameter: 10 (text box) feet (dropdown)
- Mitigation Time: 0 (text box) Minutes (dropdown)
- Quantity of Liquid:
  - Depth: 10 (text box) feet (dropdown) [Selected]
  - Amount: 5875.19 (text box) gallons (dropdown)

At the bottom of the window are four buttons: OK, Cancel, Apply, and Help.

### **Storage Tab**

On the Storage tab of the folder, CHARM requests storage temperature and pressure conditions just prior to release.

The storage temperature can be specified in Fahrenheit, Celsius, Rankine, or Kelvin units. Use a storage temperature that is greater than the melting point of the chemical released. The user can specify a value for the temperature, use the ambient condition specified in the meteorological conditions, or let CHARM calculate the temperature if the storage pressure is NOT calculated.

The storage pressure can be either gauge or absolute. The units are atmospheres, pounds/square inch, inches of Mercury, or millimeters of Mercury. An absolute pressure of less than one atmosphere is treated as one atmosphere in the release rate calculation. The user can specify a value for the pressure, use the ambient condition specified in the meteorological conditions, or let CHARM calculate the pressure if the storage temperature is NOT calculated.

CHARM will inform the user if the given temperature and pressure define a solid phase or if no liquid should exist but a liquid depth is specified. However, this is only a warning, and the user may proceed with the erroneous input.

### **Hole Tab**

On the Hole tab of the folder, CHARM requests the following:

- Enter the hole height above the ground of the release from the container. The units are feet or meters. For a gas release, enter the height where the gas enters the atmosphere. For most heavier-than-air gas releases, where the release height is less than 50 feet (15 meters), the release can be set to zero without loss of accuracy.
- Enter the height of the hole from the bottom of the container. The units are inches, feet, centimeters, or meters. The hole height is used to determine when the liquid release may stop and the pressurized gas release begin. It is also used to determine the amount of liquid that can be left in the tank for boil-off at a later time. An entry is required.



- Enter the equivalent area or circular diameter of the hole, or the desired release time whereby CHARM will calculate the hole size required to dump the entire liquid contents of the container. When specifying the hole size directly, the units are inches, feet, centimeters, or meters. When determining the hole size indirectly by specifying the release time, the units are hours, minutes, or seconds. An entry with a value greater than zero is required. Alternatively, CHARM will calculate the hole size if the user specifies a release duration for the material in the container.
- Enter the horizontal direction you would be facing if you were inside of the tank looking out of the hole. The direction can be entered in degrees or in points of the compass. Degrees refer to the 360-degree directional compass, where North is 0 or 360, East is 90, South is 180, and West is 270. Points of the compass refer to North (N), East (E), South (S), West (W), and the points between, such as Northeast (NE) and South Southeast (SSE). An entry is required.

For a gas release, the hole direction determines the initial direction the plume takes. It is possible for the plume to travel upwind for some period of time.

CHARM can be told to assume that the hole is facing the same direction that the wind is blowing toward. Note that wind direction is specified as the direction the wind is blowing from. This reduces the turbulence that may occur as the release enters the atmosphere. Reduced turbulence generally leads to higher concentrations reaching further downwind.

- Enter the vertical angle of the hole. This is the angle that your line of sight would make with the horizon if you were inside the tank looking out through the hole. For example, if you are looking straight up, the value is 90 degrees. If you are looking straight down, the value is -90 degrees. A hole that is parallel to the horizon has a value of 0 degrees. The vertical angle of the hole can effect the plume rise of a gas release.

### **Pipe Tab**

On the Pipe tab of the folder, CHARM requests the following:

- the pipe dimensions (length and diameter) as well as relative roughness factor. The Relative Roughness Factor ( $e/D$ ) is a measure of the resistance to flow by friction from the interior surface of the cylindrical pipe where the Roughness Factor  $e$  is a function of the piping material, and  $D$  is the diameter of the pipe. Some examples of the Roughness Factor  $e$  are given below.

<b><u>Material</u></b>	<b><u>Roughness Factor <math>e</math> (mm)</u></b>
Drawn Tubing	0.0015
Commercial Steel or Wrought Iron	0.045
Asphalted Cast Iron	0.12
Galvanized Iron	0.15
Cast Iron	0.26
Wood Stave	0.3
Concrete	0.9
Riveted Steel	3

*NOTE: Remember, the above Roughness Factors ( $e$ ) must be divided by the diameter of the pipe to determine the Relative Roughness Factor.*

- the number of pipe/vessel connections for each pipe type (Flush, Borda, Round);
- the number of valves;
- the number of elbows/tees.

### **Fire/Droplets Tab**

On the Fire/Droplets tab of the folder, CHARM requests the following:

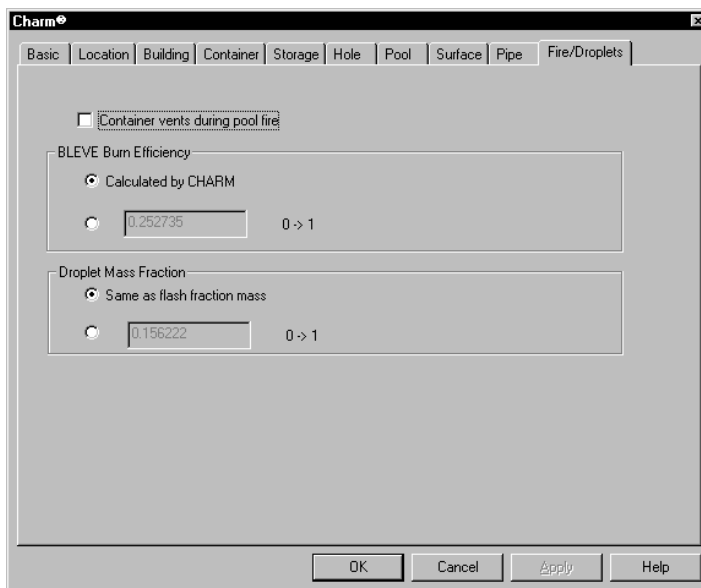
- Specify whether the tank vents during a pool fire.

Specifying that the tank will vent during pool fire signals CHARM to use 50% of the wetted tank surface area to calculate heat transfer to the stored liquid that may be released due to an increase in tank pressure and venting. The Liquid Pool Fires release type provides the information for heat calculation.

Specifying that the tank will NOT vent merely signals CHARM that no additional mass will be added to the primary source.

- Enter the efficiency (or fraction of material burned) in the BLEVE. CHARM can calculate an efficiency based on the vapor pressure of the material.

- Enter the fraction (0.0-1.0) of the total mass released that is assumed to be suspended as droplets. The default in CHARM is to assume that the same amount of mass that flashes also forms as droplets.



For a Pool/Lagoon Description release type, the folder is additionally categorized by pool temp/fire information.

### **Pool Temp/Fire Tab**

On the Pool Temp/Fire tab of the folder, CHARM requests the following:

- Enter the temperature of the pool or lagoon of liquid. The temperature can be specified in Fahrenheit, Celsius, Rankine, or Kelvin units. If selected, CHARM will assume a value for the temperature, using the ambient condition specified in the meteorological conditions, or using the boiling point of the species, whichever temperature value is lower.
- Specifying a number greater than 0 indicates that a nearby tank will vent during a pool fire. CHARM uses the user-specified tank surface area which is wetted by the chemical of interest to calculate heat transfer to the stored liquid that may be released due to an increase in tank pressure and venting. The Liquid Pool Fires release type provides the information for heat calculation.

Specifying 0 indicates that no venting will occur and signals CHARM that no additional mass will be added to the primary source.

Charm

Basic | Location | Building | Pool | Surface | Pool Temp/Fire

Pool Temperature

☒ Assume Lower of Ambient or Boiling Point

☐

Container Wetted Surface Area During Pool Fire

OK Cancel Apply Help

Finally, for User-Specified mode, the additional categories are emission rate, puff, velocity, and makeup.

### **Emission Rate Tab**

On the Emission Rate tab of the folder, CHARM requests the following:

- Click on the checkbox (if available) labeled “CHARM will calculate (vertical velocity and molar air fraction given)” if you desire CHARM to calculate the emission rate, so long as the vertical velocity under the Velocity tab and the molar air fraction under the Makeup tab are user-defined.
- If CHARM is not to calculate the emission rate, the user must specify an instantaneous release rate, or a continuous release rate (of which may be defined as constant release rate, linearly decaying release rate, or exponentially decaying release rate), or a user-defined schedule of release rates at different times since release.
- Finally, the user must specify a duration time for CHARM to use as a cut-off time for material to get into the air.

CHARM

Basic | Location | Building | Emission Rate | **Puff** | Velocity | Makeup

☐ CHARM will calculate (vertical velocity and molar air fraction given)

☐ Instantaneous Release    10000    pounds

☒ Continuous Release    Continuous release (constant)    Initial Rate: 20    lbs/hr

☐ User Specified

Time	Rate

Duration: 1    Hours

OK    Cancel    Apply    Help

### **Puff Tab**

On the Puff tab of the folder, CHARM requests the following:

- Enter the height above the ground of the release from the container. The units are feet or meters. For a gas release, enter the height where the gas enters the atmosphere. For most heavier-than-air gas releases, where the release height is less than 50 feet (15 meters), the release height can be set to zero without loss of accuracy.
- Enter the equivalent circular diameter or the area of the puff or stack. The units are inches, feet, centimeters, or meters. The puff size is required for a user-specified release type.

For an evaporating liquid, enter the surface area of the liquid pool.  
For a gas release, enter the diameter of the hole or stack.

- Enter the temperature of the initial puff in Fahrenheit, Celsius, Rankine, or Kelvin units. The puff temperature is required for a user-specified release type. If selected, CHARM assumes the ambient temperature or the boiling point of the species, whichever is lower.

For an evaporating liquid release, the puff temperature is the temperature just above the liquid pool. For a gas release, it is the temperature upon leaving the container or stack.

- It is recommended that you allow CHARM to calculate a depth that ensures mass conservation. If you enter a value, the prediction may be physically unrealistic.

### **Velocity Tab**

On the Velocity tab of the folder, CHARM requests the following:

- Enter the direction of horizontal (not vertical) movement of the initial puff. The direction is determined by release conditions, not by meteorological conditions such as wind. The puff direction is required for a user-specified release type.

The direction can be entered specifically in degrees or generally in points of the compass. Degrees refer to the 360-degree directional compass, where North is 0 or 360, East is 90, South is 180, and West is 270. Points of the compass refer to North (N), East (E), South (S), West (W), and the points between, such as Northeast (NE) and South Southeast (SSE).

For an evaporating liquid pool, the direction of horizontal movement has little meaning, since there should be no inherent horizontal movement. For a gas release, the direction should be the same as the direction that the hole or stack is facing. If the hole faces directly upward or downward, any value entered for the horizontal direction is ignored by CHARM.

This entry can be left blank. If selected CHARM will assume the puff is moving in the same direction that the wind is blowing toward. Note that wind direction is specified as the direction the wind is blowing from. This reduces the turbulence that may occur as the release enters the atmosphere. Reduced turbulence generally leads to higher concentrations reaching further downwind.

- Enter the horizontal puff speed in miles/hour, knots, meters/second, or kilometers/hour. An entry is required.

For an evaporating liquid pool, the horizontal speed is zero. For a gas release, it represents the horizontal component of the exit velocity from the hole or stack. If the hole faces directly upward or downward, enter 0 (zero) for the horizontal speed.

Use the following procedure to obtain the value for the Horizontal Puff Speed field:

1. Complete the entries for the Main CHARM Input Window. Let the Vertical Puff Speed be calculated and enter values for the Molar Air Fraction and Emission Rate fields.
2. Press the Apply button.
3. Find the value for the vertical speed (VERT SPD) on the Puff Description output, and enter this value in the Horizontal Puff Speed field.
4. Enter 0 (zero) for the Vertical Puff Speed in the same window.



- Enter the vertical speed and direction of the puff. The number indicates the speed. A positive (+) number indicates an upward direction. A negative (-) number indicates a downward direction. If selected and values for the Molar Air Fraction and Emission Rate have been entered, CHARM may calculate the Vertical Puff Speed. However, the user must specify whether the material exists as a liquid or a vapor.

For an evaporating liquid, the vertical speed is zero. For a gas release, the vertical speed represents the vertical component of the exit velocity from the hole or stack. For a puff that is directed horizontally, the vertical speed is zero.

### **Makeup Tab**

On the Makeup tab of the folder, CHARM requests the following:

- Enter the fraction of the total mass released that is assumed to be suspended as droplets. This number is the mass fraction of droplets for each puff during the emission. An entry is required.
- Enter the molar fraction of water vapor in the emission. It should not be higher than approximately 0.04, unless you are describing an extremely hot, saturated emission. An entry is required.

- Enter the molar fraction of air in the emission. This number allows the initial concentration of the gas to be specified. If you select “CHARM will calculate (emission rate and vertical velocity give)” and enter values for the vertical puff speed on the Velocity tab and the emission rate on the Emission Rate tab, then CHARM calculates the Molar Air Fraction.

CHARM

Basic | Location | Building | Emission Rate | Puff | Velocity | Makeup

Droplet Mass Fraction (0 -> 1)  
0

Molar Water Vapor Fraction (0 -> 1)  
0

Molar Air Fraction (0 -> 1)  
☒ CHARM will calculate (emission rate and vertical velocity given)  
☐ 0

OK Cancel Apply Help

## Met Dialog Input Command

Use this command as an alternative means to view/modify meteorological input data rather than displaying the information from the single Main Input Window. The required data is categorized by main information, stability class, solar radiation, and wind data.

### Main Tab

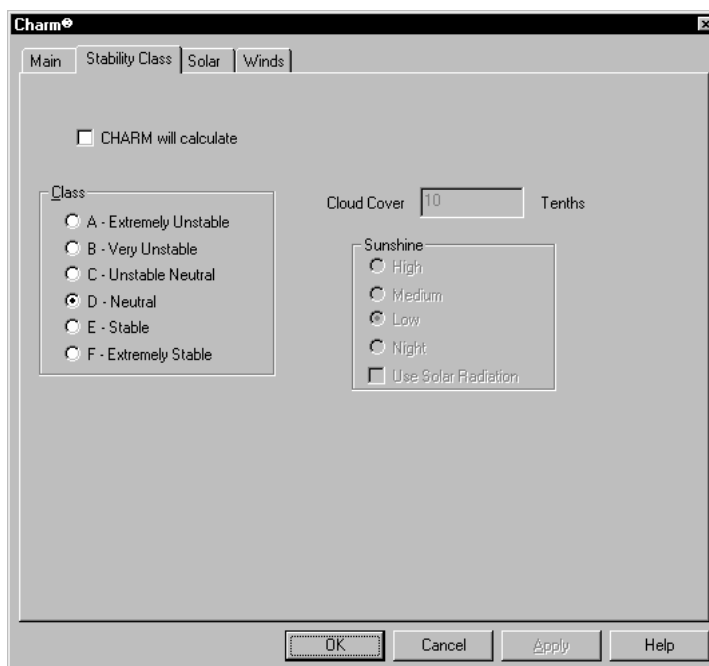
On the Main tab of the folder, CHARM requests the following:

- % Relative Humidity;
- Ambient Temperature;
- Ambient Pressure;
- Surface Roughness if it exists;
- Wind measurement height if a surface roughness is specified;
- An inversion layer height.

### **Stability Class Tab**

On the Stability Class tab of the folder, CHARM requests the following:

- Select an atmospheric stability classification (A through F), or enter the amount sunshine. If you specify the stability class, you can not make entries for the sunshine, cloud cover, or solar radiation unless you allow CHARM to calculate the stability class for. If you want CHARM to calculate the stability class, select the appropriate checkbox and then specify the sunshine, the cloud cover, and solar radiation checkbox. If the 'Use Solar Radiation' checkbox is selected, CHARM determines the amount of sunshine based on a Solar Radiation Worksheet located under the Solar tab.



### **Solar Tab**

Solar radiation is used as a source for heat transfer when calculating the evaporation of a liquid pool. The user may simply specify a value or use the worksheet provided on the Solar tab which will aid in CHARM's estimation of solar radiation.

Solar radiation is a function of latitude/longitude, cloud cover, time of day, and the day of the year. You must also specify the +/- offset from your local time to Greenwich Mean Time (GMT). CHARM will use the calculated solar radiation value to aid in the determination of the stability class if so desired. Likewise, if the user elects to let CHARM calculate the solar radiation value, it will be displayed in the meteorology conditions at the bottom of the Main CHARM Input Window.

Charm

Main Stability Class Solar Winds

☐  kW/m<sup>2</sup>

☒ CHARM will calculate

Latitude:  °  ' North

Longitude:  °  ' West

Offset to add to computer time for GMT:  Hours

Date (mmdyy):  Time (hhmm):

Cloud Cover:  Tenths

OK Cancel Apply Help

### **Winds Tab**

Enter sets of wind times, speeds, and directions. Each set represents the conditions at a specific time. At least one wind is required. If you leave one of the wind values blank, that wind is deleted. The maximum number of wind entries is only restricted by memory.

The time is the time since release in hours and minutes, up to 24 hours. The wind speed units are miles/hour, meters/second, knots, or kilometers/hour. Wind direction is the direction from which the wind is coming. The direction can be entered in degrees or in points of the compass. Degrees refer to the 360-degree directional compass, where North is 0 or 360, East is 90, South is 180, and West is 270. Points of the compass refer to North (N), East (E), South (S), West (W), and the points between, such as Northeast (NE) and South Southeast (SSE).

CHARM performs a linear interpolation between wind times to determine a wind speed and direction. Therefore, there are no instantaneous wind shifts. To model a quick wind shift, you can enter two winds that are one minute apart.

Hr	Min	Speed	Units	Direction
0	0	10	mph	180
			mph	
			mph	
			mph	
			mph	

## Displays Menu

The available commands on the Displays menu vary according to the input window. Refer to Chapter 6, “Understanding CHARM Displays,” for display samples and more information. The Displays menu of the Main CHARM Input Window provides the following displays.

### **COMMAND**

**Site  
Information**

**Chemical Data**

**Chemical  
Response**

### **SUMMARY**

Displays a text file window containing site-specific information. The text is created using the CHARM editor.

Displays thermodynamic data and default plot concentrations from the chemical database for the selected species. The chemical database can be edited using the CHARM editor.

Displays a text window containing the emergency response information for the selected chemical species. The text can be edited using the CHARM editor.

The following displays start calculations for the numerical portion of CHARM.

<b>Source/Puff Description</b>	Display numerical results of different aspects of a release associated with the current input and met data.
<b>Emission Rate</b>	Displays a plot of the emission rate as a function of time for the variables in the Main CHARM Input Window throughout the release.

The following displays are available for the appropriate species and release types.

<b>BLEVE</b>	Displays a footprint of thermal radiation resulting from a fireball/BLEVE.
<b>Pool Fire (Radiation)</b>	Display thermal radiation of a Liquid Pool Fire associated with the current input scenario.
<b>Pool Fire (Plume)</b>	Display the plume of a Liquid Pool Fire associated with the current input scenario
<b>Jet Fire Radiation</b>	Display thermal radiation of a Jet Fire associated with the current input scenario.
<b>Mechanical Overpressures</b>	Display mechanical overpressures of a pressurized vessel associated with the current input scenario.
<b>Plume</b>	Displays a snapshot view of the plume at the specified time after release. You can also generate a concentration history plot at selected points, change the position of the plume, and zoom any map location icons that are shown.

## Release Description Input

The upper portion of the Main CHARM Input Window contains input fields that describe the release. Figure 5.1 shows these fields. The release description requires the name of the chemical species, a

release type, and other pertinent information describing the release. For most release types, you can specify the proximity to a building downwind of the release, and CHARM will calculate a building wake.

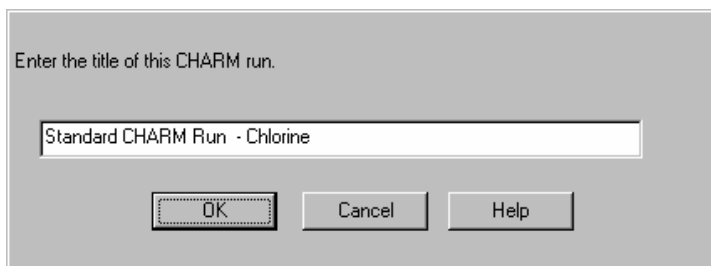
The selected chemical species and release type determine which release description fields are displayed. On-line help is available for each input field on the Main CHARM Input Window.

## Version

The version number is displayed on the most hardcopy output and is not an editable field.

## Title

The run title displays on CHARM output and in the selection list for the Scenarios command. Enter the title of the current run.

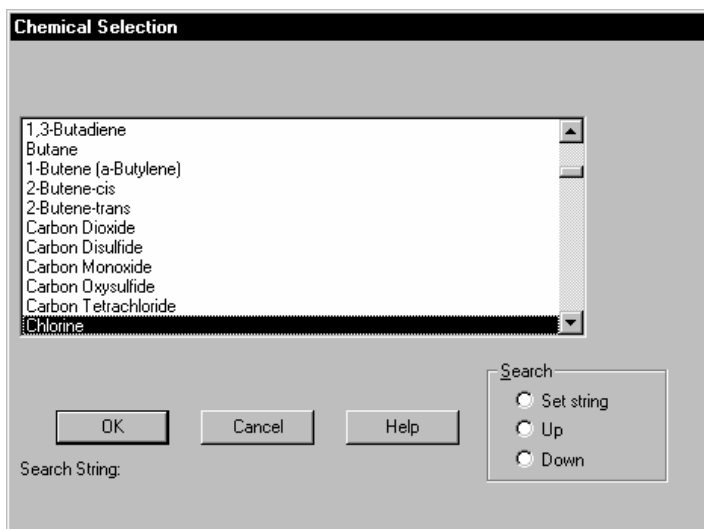


A screenshot of a Windows-style dialog box titled "Enter the title of this CHARM run." The dialog box has a light gray background. Inside, there is a text input field containing the text "Standard CHARM Run - Chlorine". Below the input field are three buttons: "OK", "Cancel", and "Help". The "OK" button is highlighted with a dashed border.

## Species

This field requires the name of the chemical whose effects you are assessing. When you select this field, CHARM displays the Chemical Selection window. You can select a species from the chemical database, which contains data for over 100 chemical compounds. The chemical database can be expanded or modified with the Chemical Database command in the CHARM editor (CHARMED.EXE). See Chapter 4, "Using the CHARM Editor," for a list of all the chemicals in the CHARM database and information on modifying the chemical database.

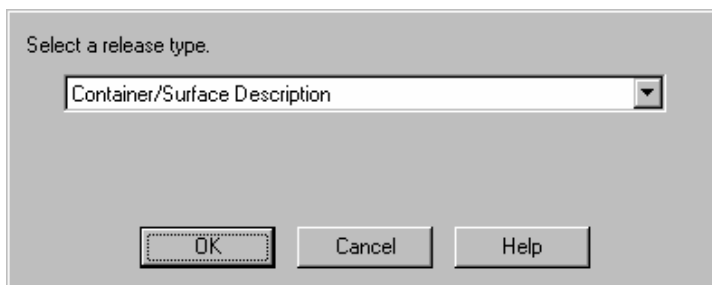




The search and scroll functions are available in the selection window. To perform a search through the chemical database, select Set String in the Chemical Selection window, enter the character string for which you want to search, and select OK or press <Enter>. Then, specify whether the search is Up (backward) or Down (forward). You can use the wild cards, \* (asterisk) and ? (question mark) in the search string. The \* wild card represents zero or more characters. The ? wild card represents a character position, rather than a special character.

## Release Type

The release type describes the conditions of the initial chemical release. A release type must be selected for each CHARM run.



The release types provided by CHARM are defined according to the conditions right at and before release, or conditions right at and after release.

The release types available in CHARM are:

### **Container/Surface Description**

A Container/Surface description requires that the user specify conditions at and before the release. The Main CHARM Input Window will change to reflect only that input which is required. Usually for a liquid release, the species escapes from a container and the generated pool is regulated by dikes or terrain. For this reason, the user must specify a maximum pool size, whereby CHARM will allow the pool to expand up to this maximum size, and then assume that the pool only becomes deeper. The remaining material of the species enters the air either as vapor or liquid droplets.

### **Pool/Lagoon Description**

A Pool/Lagoon Description requires that the user specify conditions associated with a pool or lagoon of liquid. The Main CHARM Input Window will change to reflect only that input which is required. The release rate that the species enters the air is controlled by the rate at which the liquid materials evaporates from the pool. Depending on the chemical data, the pool may be lit on fire.

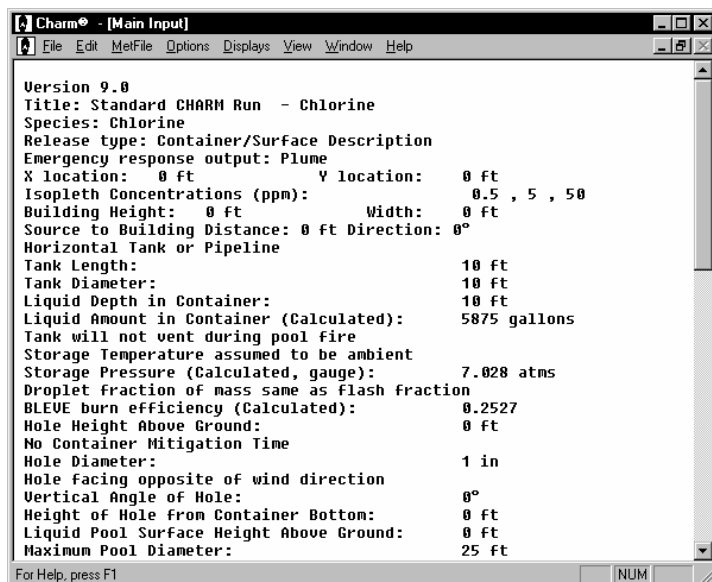
### **User-Specified After Release Conditions**

A User-Specified After Release Conditions type requires you to specify a detailed description of the conditions following a release. You must supply the emission rate as well as the temperature, dimensions, direction, speed, and makeup of the initial puff. CHARM will calculate one of three of the following inputs: initial emission rate, exit velocity, or molar air fraction. Before you run a user-specified release, it is recommended that you perform a standard CHARM run using a release type that closely resembles the release you want to define. The standard run will provide some of the necessary data to facilitate running the user-specified release. This release type is useful when assessing stack emissions.

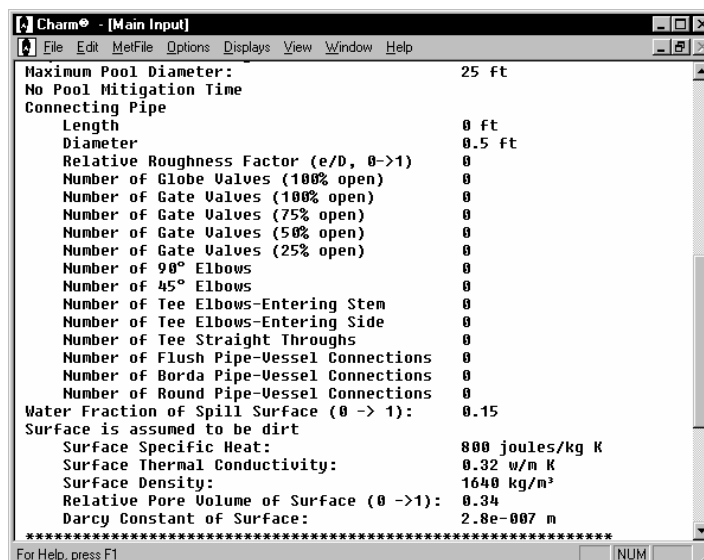
The figures on the following pages show the different input fields for various sample releases.

---

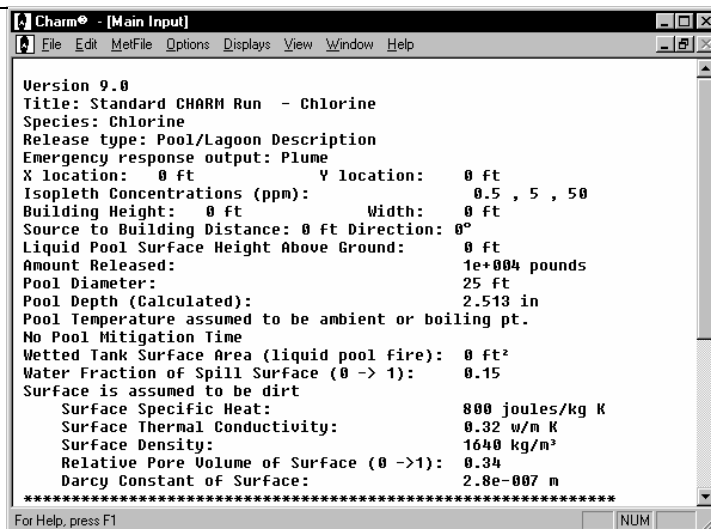
**Figure 5.3**  
Container/  
Surface  
Description  
(top)



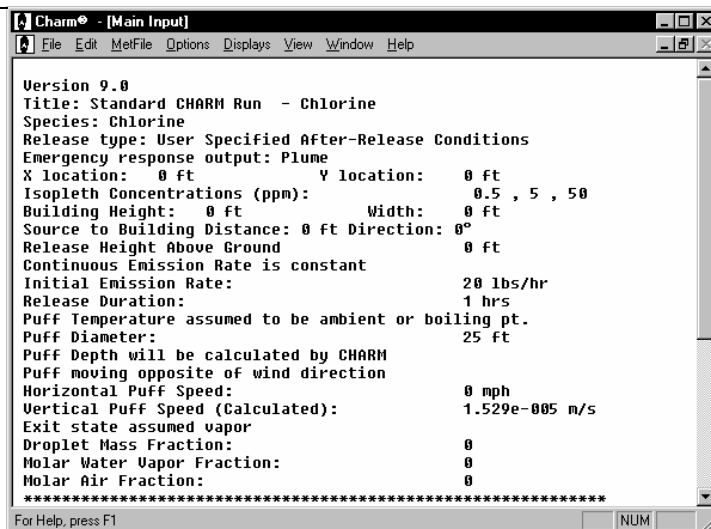
**Figure 5.4**  
Container/  
Surface  
Description  
(Bottom)



**Figure 5.5**  
Pool/Lagoon  
Description



**Figure 5.6**  
User-  
Specified  
After Release  
Conditions



## Emergency Response Output

Select from the type of output available from the drop-down list. The list is dynamic and changes depending on other scenario input. This field indicates to CHARM the type of output to generate when running from emergency response mode.

The six following choices may be available to the user:

- |                        |   |
|------------------------|---|
| <b>Plume</b>           | Shows concentration footprints of the released chemical.          |
| <b>Pool Fire Plume</b> | Shows the unburned portion of species emanating from a pool fire. |

<b>Pool Fire Radiation</b>	Shows thermal radiation footprints from a liquid pool fire.
<b>Mechanical Overpressures</b>	Shows the overpressure or shockwave footprints from a pressurized vessel failure.
<b>Jet Fire Radiation</b>	Shows thermal radiation footprints from a jet fire release.
<b>BLEVE</b>	Shows thermal radiation footprints from a fireball/BLEVE.

## X and Y Locations

The X and Y Locations are the East/West and North/South coordinates of the source location. To ensure proper placement, the point of origin should be the same as that of each map or population polygon you intend to use. Positive (+) X numbers are to the east (right) of the origin, and negative(-) X numbers are to the west (left). Positive Y numbers are to the north of the origin, and negative Y numbers are to the south.

Enter X and Y locations.

X

Y

## Isopleth Concentrations

Isopleths are the species concentrations that are plotted on the output display screens and on hard-copy graphs. CHARM uses isopleth concentrations for creating a plume plot. You can enter up to three isopleth concentrations. At least one concentration is required. The units of concentration are parts per million (ppm) or micrograms per cubic meter (ug/m<sup>3</sup>). The default values are specified in the chemical database for the selected chemical. The default isopleth values for a

species can be changed using the Chemical Database command of the CHARM editor.

Enter concentrations for plume plot

Concentration 1  Units

Concentration 2

Concentration 3

## Building Wake Input

The following information is required for CHARM to calculate a building wake.

### Building Height and Width

Enter the height and width of a building that is upwind of the release site. The units are feet or meters. CHARM uses these dimensions to calculate building wake. If either the height or width field is 0 (zero), no building is assumed to be present.

Enter the building height and width.

Height

Width

### Source to Building Direction and Distance

Enter the direction you would be facing if you were at the release site looking at the building. The direction can be entered in degrees or points of the compass. Degrees refer to the 360° directional compass, where North is 0 or 360, East is 90, South is 180, and West is 270. Points of the compass refer to North (N), East (E), South (S), West (W), and the points between, such as Northeast (NE) and South Southeast (SSE).

Enter the direction and distance from source to building.

Distance

Direction

The direction is required for the Huber-Snyder building wake effect calculations. If the release site is not downwind of the building, the building is ignored.

The distance from the release site to the building should be calculated from the release site to the center of the building. The units are feet or meters. CHARM uses the distance and direction to calculate a building wake.

If the distance to the release site is more than ten times the minimum dimension of the building (height or width), the Huber-Snyder building wake is not used in the dispersion calculation.

## Release Height Above Ground

Use this field to enter the height of the release above ground. The units are feet or meters. This field can be used to describe elevated tanks.

Enter the release height above ground.

For a liquid release, enter the height of the liquid-air interface. Normally a released liquid falls to the ground. For a gas release, enter the height where the gas enters the atmosphere. For most heavier-than-air releases, where the release height is less than 50 feet, the release height can be set to 0 (zero) without loss of accuracy. For a container release both hole height and pool height will be requested.

## Fraction of Liquid mass Suspended as Droplets

This field specifies the fraction of the total released mass that is assumed to be suspended as droplets. For a liquid release from a container, the mechanism for droplet creation is assumed to be turbulence and splashing during the release. This number is the mass fraction of droplets for each puff during the emission. For container/surface release, if this field is left blank, CHARM assumes that the droplet fraction of mass is the same as the flash fraction.

## Amount Released

The amount released can be either the volume of the container or the total amount of the species released. If you enter the volume, CHARM calculates the mass amount released. The units are cubic feet, cubic meters, pounds, kilograms, gallons, or liters. For a Pool/Lagoon release, CHARM will calculate the amount released if given the pool diameter/area and pool depth.

For a liquid release from a container, some fraction of the total amount may be released as droplets.

## Maximum Pool Diameter (Pool/Lagoon Description)



The size of the pool can be either the total area or equivalent circular diameter of the pool. The units are inches, feet, centimeters, or meters. If you enter the diameter, CHARM calculates the surface area from which the liquid will evaporate. Larger areas tend to evaporate more rapidly than smaller areas. For a Pool/Lagoon release, CHARM will calculate the pool diameter/area if given the amount released and the pool depth.

Enter the diameter or area of the pool.

25      feet

OK      Cancel      Help

### Maximum Pool Diameter (Container/Surface Description)

Usually for a liquid release from a container, the species escapes from a container and the size of the generated pool is regulated by dikes or terrain, whereby the user must specify a maximum pool size. CHARM will allow the pool to expand up to this maximum size, and then assume that the pool only becomes deeper.

Enter the diameter or area of the pool.

25      feet

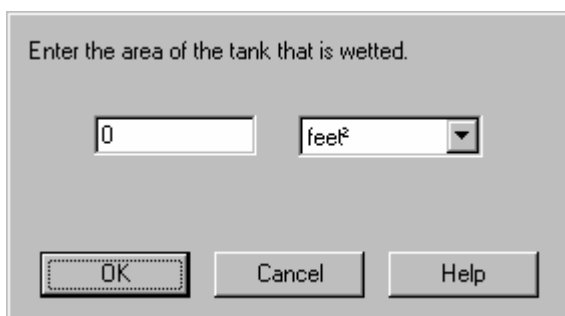
OK      Cancel      Help

### Wetted Tank Surface Area

CHARM allows venting for two of the three release types: Container/Surface and Pool/Lagoon releases. When the scenario involves a container and a liquid pool fire, CHARM will inquire as to whether or not venting from the tank will occur. Specifying that the tank will vent during pool fire signals CHARM to use 50% of the wetted tank surface area to calculate heat transfer to the stored liquid that may be released due to an increase in tank pressure and venting. The Liquid Pool Fire release type provides the information for heat calculation. Specifying that the tank will NOT vent merely signals CHARM that no additional mass will be added to the primary source.



Likewise, if the scenario involves a liquid pool fire and a pool/lagoon of liquid, CHARM will inquire as to the area of a nearby tank that is wetted by the species. The units are square feet or square meters. CHARM uses this area to calculate heat transfer to the stored liquid that may be released because of an increase in tank pressure and venting. The heat is calculated from the value entered for liquid pool fires and the tank is assumed to be surrounded by fire.

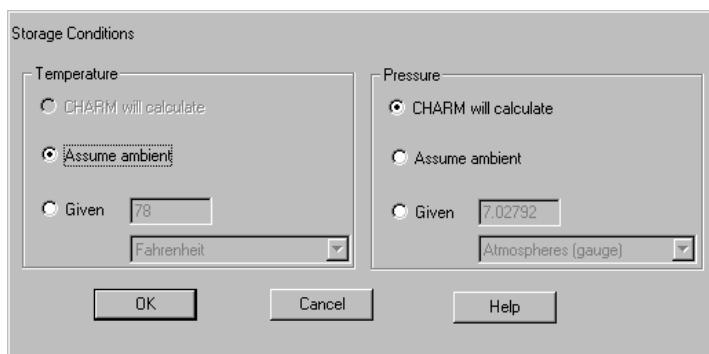


## Storage Temperature

The storage temperature is the temperature of the container just prior to the release. The temperature can be specified in Fahrenheit, Celsius, Rankine, or Kelvin units. The storage temperature should be greater than the melting point of the chemical released. The user can specify a value for the temperature, use the ambient condition specified in the meteorological conditions, or let CHARM calculate the temperature if the storage pressure is NOT calculated.

## Storage Pressure

The storage pressure is the pressure of the container just prior to release. This pressure can be either gauge or absolute. An absolute pressure of less than one atmosphere is treated as one atmosphere for the release calculation. The user can specify a value for the pressure, use the ambient condition specified in the meteorological conditions, or let CHARM calculate the pressure if the storage temperature is NOT calculated.

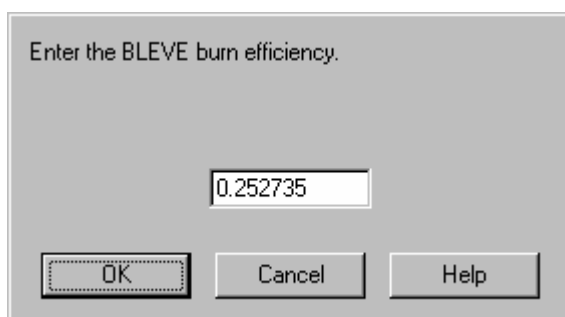


The 'Storage Conditions' dialog box is divided into two main sections: 'Temperature' and 'Pressure'. Each section contains three radio button options: 'CHARM will calculate' (selected in both), 'Assume ambient', and 'Given'. In the 'Temperature' section, the 'Given' option is set to 78 with a unit dropdown menu showing 'Fahrenheit'. In the 'Pressure' section, the 'Given' option is set to 7.02792 with a unit dropdown menu showing 'Atmospheres (gauge)'. At the bottom of the dialog are three buttons: 'OK', 'Cancel', and 'Help'.

CHARM will inform the user if the temperature and pressure indicate that the phase is solid or if no liquid should be present but a liquid depth is specified. However, this is only a warning, and the user may proceed with the non-equilibrium input.

## BLEVE Burn Efficiency

Enter the efficiency or fraction of material burned in the Boiling Liquid Expanding Vapor Explosion (BLEVE). If the field is left blank, CHARM calculates an efficiency based on the vapor pressure of the material. Calculating a BLEVE burn efficiency is only available when describing a container/surface release.



This dialog box prompts the user to 'Enter the BLEVE burn efficiency.' It features a single text input field containing the value '0.252735'. Below the input field are three buttons: 'OK', 'Cancel', and 'Help'.

## Water Fraction of Spill Surface

This field specifies the fraction (by volume) of the spill surface that is water, or the amount of water in the surface soil of the area that immediately surrounds the release site. A value less than 0.1 is dry. A value of 0.6 indicates mud. A value of 1.0 is water. The suggested average value is 0.15. The water fraction is used to determine whether freezing ground water may alter the heat flow into the spill. An entry is required.

Enter the fraction of the spill surface that is water.

0.15

OK Cancel Help

## Surface Description Input

The following information is required to describe the surface on which the spill occurred.

### Surface Type

Enter the type of surface on which the spill occurred. If you select dirt, asphalt, or concrete, CHARM assigns default values for the surface characteristics. You can accept or change the default values.

Select the surface type.

Dirt

OK Cancel Help

If you select the user-defined surface type, you must enter the surface characteristics for specific heat, thermal conductivity, density, relative pore volume, and the Darcy constant.

### Surface Specific Heat

Enter the specific heat of the surface on which the spill occurred. The units are Joules/kilogram, BTU/pound °F, or calories/gram. CHARM uses the surface specific heat for heat transfer calculations.

Enter the specific heat of the spill surface.

800 J/kg K

OK Cancel Help

### Surface Thermal Conductivity

Enter the conductivity of the surface on which the spill occurred. The units are watts/meter per degree Celsius, calories/second/centimeter per degree Celsius, or BTU/hour/foot °F per degree Fahrenheit. CHARM uses the surface thermal conductivity for heat transfer calculations.

Enter the conductivity of the spill surface.

0.32 W/m K

OK Cancel Help

### Surface Density

Enter the density of the surface on which the spill occurred. The units are kilograms/cubic meter, grams/cubic centimeter, pounds/cubic foot, or pounds/cubic inch. CHARM uses the surface density for heat transfer calculations. An entry is required.

Enter the density of the spill surface.

1640 kg/m³

OK Cancel Help

### Relative Pore Volume of Surface

Enter the porosity or relative pore volume of the surface on which the spill occurred. The unit is a fraction. CHARM uses the relative pore volume to calculate the amount of liquid that can be percolated through the spill surface.

Enter the relative pore volume of the surface.

0.34

OK Cancel Help

### Darcy Constant of Surface

Enter the Darcy constant to use for calculating the amount of liquid that can be absorbed into the spill surface. The units are feet or meters.

Enter the Darcy's constant for the spill surface.

2.8e-007    meters

OK    Cancel    Help

## Tank Description Input

The tank description fields that appear in the window are determined by the tank type. The following fields describe the tank from which the chemical was released.

### Tank Type

Select the type of container from which the species was released. The three choices are a vertical cylinder tank, horizontal cylinder tank or pipeline, and a spherical tank.

Select the tank type.

Horizontal tank or pipeline

OK    Cancel    Help

The tank dimensions are used to determine the amount of species released. A vertical cylinder has horizontal bases and requires an entry for the tank height and diameter. A horizontal cylinder requires an entry for the tank length and diameter. A railroad tank car is an example of a horizontal cylinder. A spherical tank requires an entry only for tank diameter.

### Tank Height

Enter the height of a vertical tank. The units are inches, feet, centimeters, or meters. The tank height is used to determine the amount of species released.

Enter the height of the container.

10      feet ▼

OK      Cancel      Help

Tank height refers to the physical dimension of the tank, rather than tank elevation. The calculations for elevated tanks are handled by the entry in the field named **Release Height**.

### Tank Diameter

Enter the diameter of the spherical container, or the cylindrical portion of a vertical tank or horizontal pipeline. The units are inches, feet, centimeters, or meters.

Enter the diameter of the container.

10      feet ▼

OK      Cancel      Help

### Tank Length

Enter the length of a horizontal tank or the distance between closed valves of a pipeline. The units are inches, feet, miles, centimeters, meters, or kilometers.

Enter the length of the tank or pipeline.

10      feet ▼

OK      Cancel      Help

### Liquid Depth in Container

If there is liquid inside the storage container, this field requires a value

for the depth of the liquid. The units are inches, feet, centimeters, or meters. The liquid depth is used to determine the amount and rate of liquid released.

Enter the depth or amount of liquid in the container.

☒ Liquid Depth

or

☐ Liquid Amount

For a vertical tank, the liquid depth must be less than the tank height. For a horizontal tank or pipeline, the liquid depth must be less than the tank diameter. For spherical tanks, the liquid depth must be less than the tank diameter. If you change the liquid depth to a value that is inconsistent with the values for the tank height or diameter, CHARM adjusts the tank height or diameter to accommodate the liquid depth value.

If liquid exists in the container, some may escape through the hole or some may be left in the container. Liquid left in the container may boil off after any pressurized gas escapes from the container.

### Hole Diameter

Enter the equivalent area or circular diameter of the hole. The units are inches, feet, centimeters, or meters. An entry with a value greater than zero is required.



Select the parameter to use

☒ Hole Size

or

☐ Release Time

### Hole is Facing

Enter the direction you would be facing if you were inside the tank looking out of the hole. The direction can be entered specifically in degrees or generally in points of the compass.

Enter the direction the hole faces.

Degrees refer to the 360° directional compass, where North is 0 or 360, East is 90, South is 180, and West is 270. Points of the compass refer to North (N), East (E), South (S), West (W), and the points between, such as Northeast (NE) and South Southeast (SSE).

For a gas release, the hole direction determines the initial direction that the plume takes. It is possible for the plume to travel upwind for some period of time.

### Vertical Angle of Hole

Enter the vertical angle (in degrees) that your line of sight would make with the horizon if you were inside the tank looking out through the hole. A hole that is parallel to the horizon has a value of 0 (zero).

Enter the vertical angle of the hole in degrees.

0

OK Cancel Help

For example, if you are looking straight up, the value is 90. If you are looking straight down, the value is -90. The vertical angle of the hole can effect the plume rise of a gas release. An entry is required.

### Height of Hole From Container Bottom

Enter the height of the hole from the bottom of the container. The units are inches, feet, centimeters, or meters. The hole height is used to determine when the liquid release may stop and the pressurized gas release begin. It is also used to determine the amount of liquid that can be left in the tank for boil-off at a later time.

Enter the height of the hole from the container bottom.

0 feet

OK Cancel Help

### Liquid Pool Surface Height Above Ground

Enter the height above ground of the liquid-air interface. The units are feet or meters. Normally a released liquid falls to the ground.

Liquid pool height above ground

0 feet

OK Cancel Help

## Connecting Pipe

If the release occurs within piping connected to a vessel, CHARM will account for the piping and any piping system components in the release calculation. Entries for the pipe length, diameter, relative roughness factor, and components will affect the flow rate due to pressure loss characteristics of the pipe, and therefore affect the release rate calculated by CHARM.

### Connecting Pipe Length

When specifying the pipe length, include all piping and piping components that describe the connecting pipe from the source vessel to the release point.

Connecting pipe length

0 feet

OK Cancel Help

### Connecting Pipe Diameter

When specifying the pipe diameter, CHARM will assume the diameter is uniform throughout the length of the pipe; that is, multiple piping components with varying diameters is not considered.

Connecting pipe diameter

0.5 feet

OK Cancel Help

Relative Roughness Factor ( $e/D$ ) (0-1)

### Relative Roughness Factor ( $e/D$ ) (0-1)

The Relative Roughness Factor ( $e/D$ ) is a measure of the resistance to flow by friction from the interior surface of the cylindrical pipe where the Roughness Factor  $e$  is a function of the piping material, and  $D$  is the diameter of the pipe. Some examples of the Roughness Factor  $e$  are given below.

<u>Material</u>	<u>Roughness Factor e(mm)</u>
Drawn Tubing	0.0015
Commercial Steel or Wrought Iron	0.045
Asphalted Cast Iron	0.12
Galvanized Iron	0.15
Cast Iron	0.26
Wood Stave	0.3
Concrete	0.9
Riveted Steel	3

*NOTE: Remember, the above Roughness Factors (e) must be divided by the diameter of the pipe to determine the Relative Roughness Factor.*

Connecting pipe relative roughness factor (e/D, 0->1)

0

OK Cancel Help

### Piping System Components

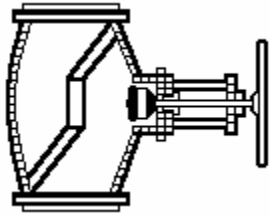
CHARM allows the user to specify any number of typical components within the piping system between the source vessel and the release point. These entries will affect flow rate due to pressure loss characteristics of the pipe, and therefore affect the release rate calculated by CHARM.

Example diagrams of each component type identified by CHARM are shown below:

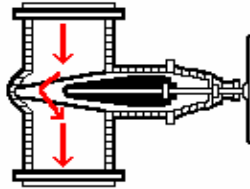
#### Piping System Components

CHARM allows the user to specify any number of typical components within the piping system between the source vessel and the release point. This entry will affect flow rate due to pressure loss characteristics of the pipe, and therefore affect the release rate calculated by CHARM.

Example diagrams of each component type identified by CHARM are shown below.



Globe Valve (100% Open)



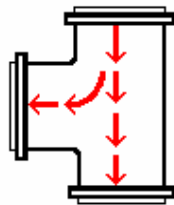
Gate Valve (50% Open)



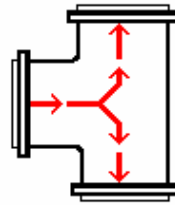
90° Elbow



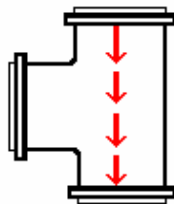
45° Elbow



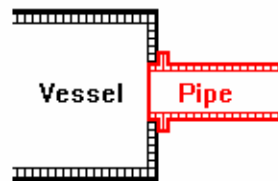
Tee Elbow-entering stem



Tee Elbow-entering side



Tee Straight Through



Flush Pipe-Vessel Connection



Borda Pipe-Vessel Connection

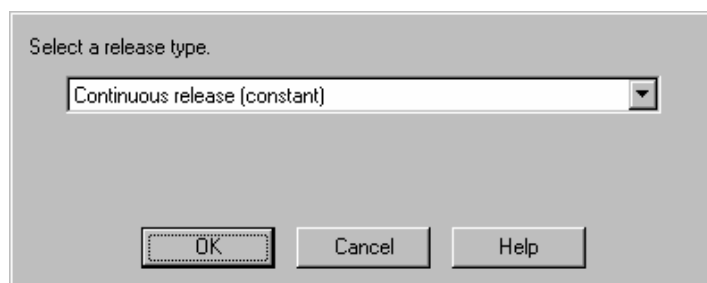
Round Pipe-Vessel Connection

## User-Specified Release Description Input

If User-Specified After-Release Conditions is selected as the release type, CHARM requires additional release information. The following information is required for a user-specified release type.

### User-Specified Release Type

An instantaneous release requires you to specify the total amount of material emitted. A continuous release requires you to specify an initial emission rate and whether the rate is constant or decreasing. A decreasing continuous release rate can be exponential or linear.



Selecting User-Specified Rate allows the user to define an emission rate schedule. Enter the time schedule for the emission rate from a source. CHARM will use this schedule for the emission for the duration of the release. If release duration is longer than the schedule the last emission rate is extended unless it is zero. Schedule entries can only be added if valid numbers are in the entry boxes. Two times can not both be the same. To delete an entry select it and press “Delete.” To change an entry select it and press “Change.”

When done changing press “Save Change.” “Clear” deletes all entries.

**Emission Rate Schedule**

Time units:  
☒ hrs  
☐ min  
☐ sec

Emission rate units:  
☒ lbs/hr   ☐ scfm   ☐ cfm  
☐ g/s   ☐ scms   ☐ cms

	Time	Emission rate
Add	15	125
Delete	0	100
	10	200
	15	125

Change  
Save Change

OK Cancel Help

### Emission Rate

Enter the mass rate of emission of the species alone or the volume emission rate, which includes the species, air, and water vapor being emitted. The units are pounds per hour, grams per second, standard cubic feet per minute, standard cubic meters per second, cubic feet per minute, or cubic meters per second.

Enter the emission rate.

20 lbs/hr

OK Cancel Help

If you leave the **Emission Rate** field blank, and enter values for the **Vertical Puff Speed** and the **Molar Air Fraction** fields, CHARM will calculate the emission rate.

### Release Time

For a constant or linearly decreasing release, the release time is the amount of time that lapsed during the release. For an exponentially decreasing release, the release time represents the amount of time before the emission rate equals one percent (.01) of the initial emission rate. The units are hours, minutes, and seconds.

Enter the release duration.

1 Hours

OK Cancel Help

However, for linearly and exponentially decreasing releases, you should enter actual times.

### Puff Temperature

The puff temperature is the temperature of the initial puff in Fahrenheit, Celsius, Rankine, or Kelvin units. If this field is left blank, CHARM assumes the ambient temperature or the boiling point of the selected species, whichever is lower.

Enter the temperature of the initial puff.

Fahrenheit

OK Cancel Help

For an evaporating liquid release, this is the temperature just above the liquid pool. For a gas release, this is the temperature upon leaving the container or stack.

### Puff Diameter

Enter the equivalent circular diameter or area of the puff or stack. The units are inches, feet, centimeters, or meters. For an evaporating liquid, enter the surface area of the liquid pool. For a gas release, enter the diameter of the hole or stack.



Enter the diameter or area of the puff.

### Puff Depth

The Puff Depth field can be left blank, and CHARM will calculate a depth to ensure mass conservation. You can enter a value, but the prediction may be physically unrealistic.

Enter the depth of the puff.

### Puff Is Moving Toward

Enter the direction of horizontal movement of the initial puff. The direction is determined by release conditions, not by meteorological conditions such as wind.

Enter the direction toward which the puff is moving.

The direction can be entered in degrees or points of the compass. Degrees refer to the 360° directional compass, where North is 0 or 360, East is 90, South is 180, and West is 270. Points of the compass refer to North (N), East (E), South (S), West (W), and the points between, such as Northeast (NE) and South Southeast (SSE).

If the hole faces directly upward or downward, any value entered for the horizontal direction is ignored by CHARM. For an evaporating

liquid pool, the direction of horizontal movement has little meaning, because there should be no inherent horizontal movement. For a gas release, the direction should be the same as the direction that the hole or stack is facing.

This entry can be left blank. If it is left blank CHARM will assume the puff is moving in the same direction that the wind is blowing toward. Note that wind direction is specified as the direction the wind is blowing from. This reduces the turbulence that may occur as the release enters the atmosphere. Reduced turbulence generally leads to higher concentrations reaching further downwind.

### Horizontal Puff Speed

This field requires a value for the horizontal puff speed in miles per hour, knots, meters per second, or kilometers per hour.

For an evaporating liquid pool, the horizontal speed is 0 (zero). For a gas release, it represents the horizontal component of the exit velocity from the hole or stack. If the hole faces directly upward or downward, enter 0 (zero) for the horizontal speed. See the following section for instructions on obtaining the horizontal speed.

### Obtaining the Horizontal Speed

To obtain the horizontal speed, use the following procedure:

1. Complete the entries for the Main CHARM Input Window. Leave the **Vertical Puff Speed** field blank and enter values for the **Molar Air Fraction** and **Emission Rate** fields. CHARM will calculate the vertical puff speed.
2. Find the calculated vertical speed (VERT SPD) in the Main CHARM Input Window, and enter this value in the **Horizontal Puff Speed** field in the Main CHARM Input Window.
3. Enter 0 (zero) for the **Vertical Puff Speed** field in the same window.

### Vertical Puff Speed

Enter the speed and direction of the puff. The number indicates the speed. A positive (+) number indicates an upward direction. A negative (-) number indicates a downward direction.

Enter the vertical speed of the puff.

1.52908e-005 m/s

OK Cancel Help

For an evaporating liquid, the vertical speed is 0 (zero). For a gas release, the vertical speed represents the vertical component of the exit velocity from the hole or stack. For a puff that is directed horizontally, the vertical speed is 0 (zero).

If you leave this field blank and enter values for the **Molar Air Fraction** and **Emission Rate** fields, CHARM will calculate the **Vertical Puff Speed**. Also, the user must specify the physical state (liquid or vapor) in the CHARM Main Input Window. the state is required to determine whether the liquid or vapor density should be used in the calculation.

### Molar Water Vapor Fraction

Enter the molar fraction of water vapor in the emission. It should not be higher than approximately 0.04, unless you are describing an extremely hot, saturated emission.

Enter the molar water vapor fraction.

0

OK Cancel Help

### Molar Air Fraction

Enter the molar fraction of air in the emission. This value allows the initial concentration of the gas to be calculated. If you leave this field blank and enter values for the **Vertical Puff Speed** and the **Emission Rate**, CHARM calculates the **Molar Air Fraction**.

Enter the molar water vapor fraction.

0

OK Cancel Help

## Meteorological Data Input

---

The lower portion of the Main CHARM Input Window contains the meteorological data fields for the current scenario. Figure 5.2 shows the Met Data input fields.

### Relative Humidity

This field requires the ambient relative humidity in percent. Acceptable values are greater than 0 and less than 99.

Enter the percent relative humidity.

50

OK Cancel Help

### Ambient Temperature

The ambient temperature is the air temperature at the release site. The temperature can be specified in Fahrenheit, Celsius, Rankine, or Kelvin units. If the ambient temperature is higher than the boiling point of the material released, the impact may become much greater.

Enter the ambient temperature at the release site.

78 Fahrenheit

OK Cancel Help

### Ambient Pressure

The ambient pressure is the atmospheric pressure at ground level at the release site. The pressure can be entered in atmospheres (atm), pounds per square inch, inches of Mercury, millimeters of Mercury, or millibars.

Enter the ambient pressure.

1      atms

OK      Cancel      Help

Normal atmospheric pressure at sea level has the following equivalents:

1 atmosphere (atm);  
 14.7 pounds per square inch (psi);  
 1013.25 millibars (mb);  
 29.92 inches of Mercury (in Hg); and  
 760 millimeters of Mercury (mm Hg).

### Cloud Cover

Specify the amount of cloud cover in tenths of sky coverage. CHARM will use the amount of cloud cover if the user wants CHARM to determine the stability class and/or solar radiation.

Enter the cloud cover in tenths.

10

OK      Cancel      Help

### Stability Class

Select an atmospheric stability classification (A through F), or enter the amount of sunshine. If you want CHARM to calculate the stability class, select the appropriate checkbox and then specify the sunshine. CHARM can also determine the amount of sunshine based on a Solar Radiation Worksheet located under the MetFile menu.

Select a stability class or have CHARM calculate.

<p><u>C</u>lass</p> <p><input type="radio"/> A - Extremely Unstable</p> <p><input type="radio"/> B - Very Unstable</p> <p><input type="radio"/> C - Unstable Neutral</p> <p><input checked="" type="radio"/> D - Neutral</p> <p><input type="radio"/> E - Stable</p> <p><input type="radio"/> F - Extremely Stable</p>	<p>Cloud Cover      10 in tenths</p> <p><input type="checkbox"/> CHARM will calculate</p> <p>Sunshine</p> <p><input type="radio"/> High</p> <p><input type="radio"/> Medium</p> <p><input checked="" type="radio"/> Low</p> <p><input type="radio"/> Night</p>
--	--

OK      Cancel      Help

CHARM calculates the stability classification from the wind speed, cloud cover, and amount of sunshine. Sunshine is strong if the skies are clear and the sun is at least 60 degrees above the horizon. A 75% middle-level cloud cover reduces strong sunshine to moderate. Sunshine is slight, if the sun is less than 35 degrees above the horizon or a 75% low cloud cover exists.

The atmospheric stability class indicates how much mixing occurs in the air. An unstable condition (such as class **A**, **B**, or **C**) tends to mix the plume quickly with the ambient air, thereby reducing concentrations quickly. Conditions are unstable if there is a layer of warm air near the ground with cooler air above it. An unstable condition is promoted by bright sun with no cloud cover and low wind. Unstable conditions rarely exist at night.

Conditions are neutral if there is little or no temperature gradient between the lower atmosphere and the upper atmosphere. A neutral condition (such as class **D**) exists when the sky is overcast.

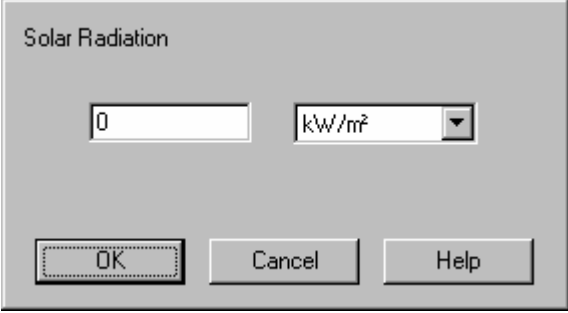
A stable condition mixes the plume more slowly and allows higher concentrations to reach farther downwind. Conditions are stable if there is a layer of cool air near the ground with warmer air above it. A stable condition (such as class **E** or **F**) can exist on a clear night with low wind speed.

For ground releases, an extremely stable condition (such as class **F**) generates the greatest ground-level impacts. For elevated releases, it is not as clear which stability will create the greatest ground-level impacts. A stable condition tends to maintain an elevated emission aloft, unless it is heavier than air. However, more unstable conditions allow mixing downward to the ground.

If an automatic meteorological interface is available and the standard deviation of the horizontal wind direction (also known as sigma theta) is one of the available data values, it will be used to determine stability class.

### Solar Radiation

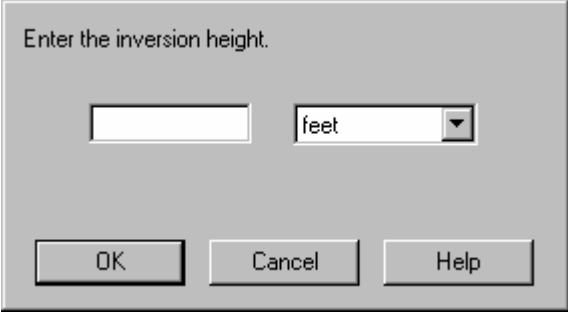
Solar radiation is used as a source for heat transfer when calculating the evaporation of off a liquid pool. A worksheet provided in the MetFile menu will aid in the estimation of solar radiation.



A dialog box titled "Solar Radiation" with a text input field containing "0" and a dropdown menu showing "kW/m²". At the bottom are three buttons: "OK", "Cancel", and "Help".

### Inversion Height

The Inversion Height is the altitude above ground at which a temperature inversion makes it difficult or impossible for a plume to traverse vertically. The units are feet, miles, meters, or kilometers. The inversion height is difficult to estimate without some form of measurement above the surface.



A dialog box titled "Enter the inversion height." with a text input field and a dropdown menu showing "feet". At the bottom are three buttons: "OK", "Cancel", and "Help".

If a height is specified, a plume is not allowed to pass through it (except for a jet). If the release height is above the inversion, the plume will remain above. If the release height is below the inversion, the plume will remain below. If this field is left blank, no inversion will be assumed.

### Surface Roughness

Surface roughness is a measure of the interaction between the wind and the surface. It affects wind speed with altitude and thus the amount of

mixing that can occur. The units are inches, feet, centimeters, or meters. If the field is left blank, no surface roughness is assumed and the wind is assumed to be constant with height.

The following table shows some examples of surface roughnesses:

Surface type	Roughness (cm)
Smooth mud flats; ice	0.001
Smooth snow	0.005
Smooth sea	0.02
Level desert	0.03
Snow surface; lawn to 1 cm high	0.1
Lawn, grass to 60 cm high	4-9
Fully grown root crops	14
Parkland, bushes	50
Large obstacles (suburb, forest)	50-100

### Wind Measurement Height

The wind Measurement Height is the height above ground at which the wind speed and direction were measured. It is used along with surface roughness to calculate the wind profile with altitude. The units are feet or meters. A value is required if a surface roughness has been entered.

### Winds

Use this field to describe wind speeds and directions that represent the conditions at specific times. At least one wind pair is required. If



you leave a wind time, direction, or speed blank, that wind will be deleted.

Enter wind time, direction, and speed.

Time since release  :

Wind direction

Wind speed

**Time** The time since release in hours and minutes, up to 24 hours.

**Direction** The direction from which the wind is coming. The direction can be entered specifically in degrees or generally in points of the compass. Degrees refer to the 360° directional compass, where North is 0 or 360, East is 90, South is 180, and West is 270. Points of the compass refer to North (N), East (E), South (S), West (W), and the points between, such as Northeast (NE) and South Southeast (SSE).

**Speed** The wind speed in knots (kts), miles per hour (mph), meters per second (m/s), or kilometers per hour (kph).

### Add Winds

Use this field to describe additional winds. You can enter wind speeds and their directions representing the conditions at a specific time. The description is the same as described in the previous section. CHARM performs a linear interpolation between wind times to determine a wind speed and direction. Thus there are no instantaneous wind shifts. If you want to model a quick wind shift, you can enter two winds that are one minute apart.

## Chapter 6: Understanding CHARM Displays

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CHARM provides various text and graphic displays to simulate a release from data entered in the Main CHARM Input Window. All CHARM displays are accessible through the Displays menus of the Main CHARM Input Window or footprint displays. The displays available for selection depend on the species and release type specified in the current input window. The Options menu provides various options for altering the CHARM displays.

Map displays are available for maps that have been read, defined, and stored with the Map Definition command of the CHARM Editor. CHARM superimposes plume, thermal radiation and overpressure displays (graphics) on a map display. If the map display has map or release location icons, you can select an icon to display the map or the release scenario list. The cursor is represented with cross hairs instead of an arrow on graphic displays.

### Main CHARM Input Window Displays

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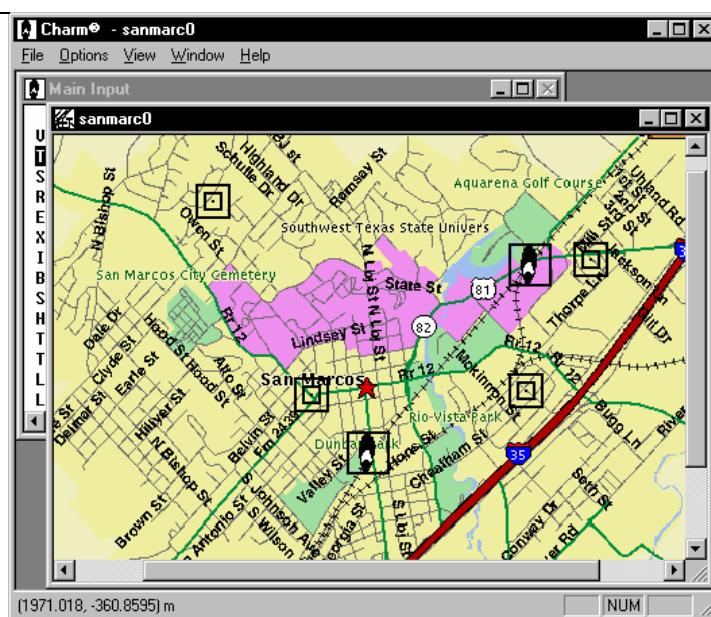
The Displays menu of the Main CHARM Input Window permits access to a variety of text and graphic displays, some of which require CHARM calculations. The Basemap command displays maps that have been predefined using the CHARM Editor (CHARMED). These maps may contain release icons that are associated with prestored data file information, whereby CHARM may be used in an emergency response mode of operation. The Site Information, Chemical Data, Chemical Response, and Source/Puff Calculation commands invoke text displays. The Emission Rate command generates a plot. The BLEVE Radiation, Pool Fire Radiation and Plume, and Mechanical Overpressures commands invoke graphic displays. When selecting the Displays menu from the Main CHARM Input Window, the cursor changes momentarily to an hourglass while CHARM performs source term calculations. During these calculations and before the menu is displayed, CHARM decides which types of output are valid for the current input scenario. For example, if the chemical being modeled, say Chlorine, does not have any flammable characteristics associated with it in the Chemical Database, then those options involving thermal radiation output (BLEVE, Pool Fire, and Jet Fire) are grayed and cannot be modeled.

### Basemap Display

Use the Basemap command on the Displays menu when the Main CHARM Input Window is activated to display a new map for use in emergency response mode. All maps used with CHARM must first be defined with the Map Definition command of the CHARM editor. Refer to Chapter 4, “Using the CHARM Editor,” for details on defining maps. When you select the Basemap command, CHARM displays a selection list of map files having the default map file name extension. Initially, this default extension is .MAP. For more information about changing this default map extension, refer to Chapter 3, “CHARM.INI File Description”. When a map is selected, CHARM displays the map and a point of reference associated with the cross hair location in the status bar at the bottom of the CHARM MDI window.

When a map is displayed, the menu bar on the CHARM MDI frame changes to reflect only those menus that are to be used with the active window; in this case, the Basemap Window. These menu items include a file menu to open and close other map files, an options menu to zoom and unzoom an area, or display a larger-scaled map, and other standard windows menus. Figure 6.0 shows a sample map from a Basemap display.

**Figure 6.0**  
Basemap  
Display

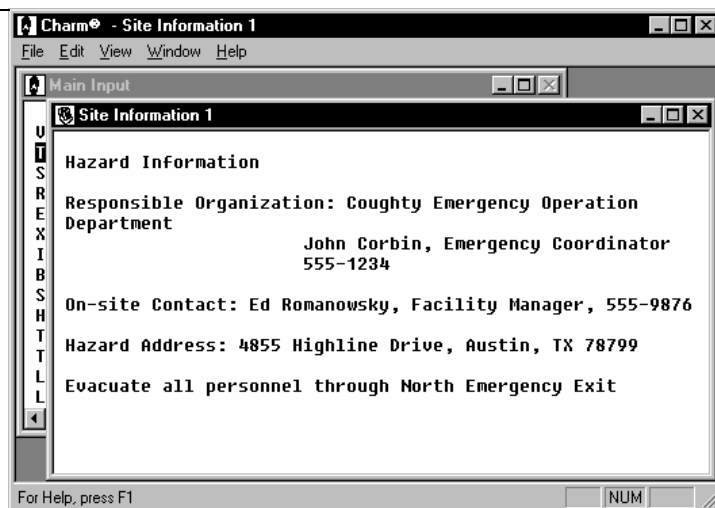


## Site Information Display

The Site Information command on the Displays menu shows a text file window created with the CHARM Editor. The text file contains information that is specific to the release site. It may contain useful information such as general response procedures, telephone numbers, and evacuation exits. Site information text can be printed

or copied to the clipboard using the File and Edit menu commands respectively. Figure 6.1 shows sample text for a Site Information display.

**Figure 6.1**  
Site Information Display



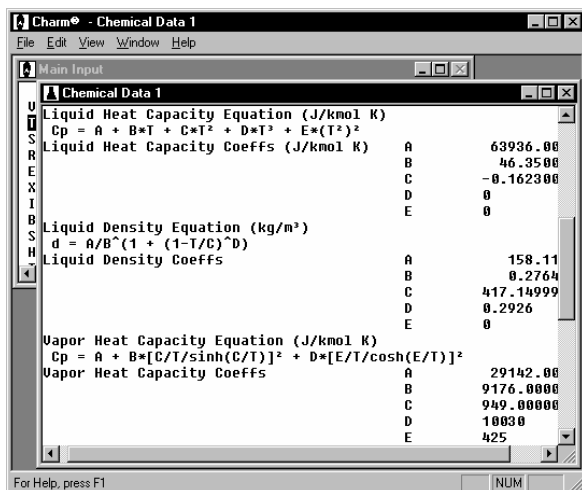
## Chemical Data Display

The Chemical Data command on the Displays menu shows a text window containing the thermodynamic data and default isopleth concentrations stored in the chemical database for the selected species. Figures 6.2, 6.3, and 6.4 show the chemical data display for Chlorine. Chemical data can be printed or copied to the clipboard using the File and Edit menu commands respectively. It can be modified using the CHARM Editor.

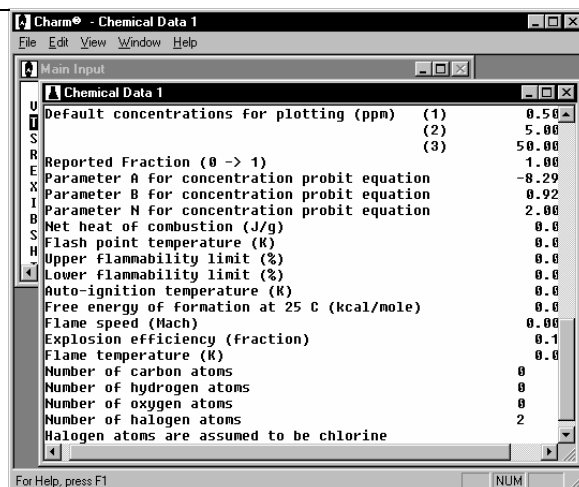
**Figure 6.2**  
Chemical Data Display (top)

Property	Value
Chlorine	
Molecular weight (kg/kmole)	70.9
Normal boiling point (K)	239.1
Melting Point (K)	172.1
Triple Point Temperature (K)	172.1
Triple Point Pressure (atmospheres)	0.013
Critical temperature (K)	417.1
Critical pressure (atmospheres)	76.0
Critical volume (m <sup>3</sup> /kmole)	0.12
Heat of vaporization at normal boiling point (J/kg)	2.88e+08
Surface tension of liquid phase at normal boiling point (N/m)	0.026
Viscosity of liquid phase at normal boiling point (kg/m s)	0.0004886
Gamma (Cp/Cv)	1.3
Energy of molecular interaction (K)	274.9
Effective diameter of molecule (Å)	5.2

**Figure 6.3**  
Chemical Data Display (Temperature Dependent Equations)



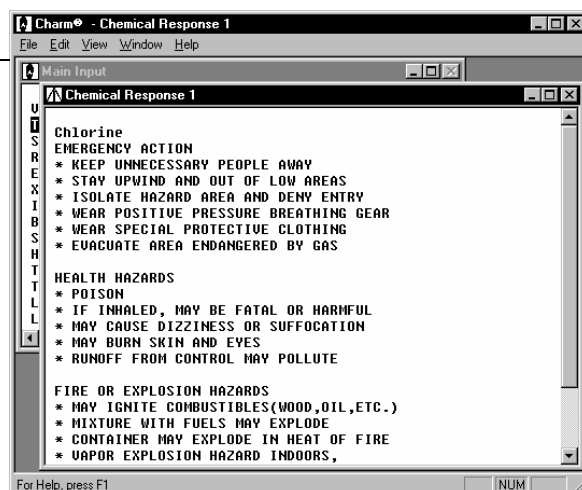
**Figure 6.4**  
Chemical  
Data Display  
(bottom)



## Chemical Response Display

The Chemical Response command on the Displays menu shows the emergency response information stored in the chemical database for the selected species. Figure 6.5 shows a sample Chemical Response display. Chemical response text can be printed or copied to the clipboard using the File and Edit menu commands respectively. It can be modified using the CHARM Editor.

**Figure 6.5**  
Chemical  
Response  
Display

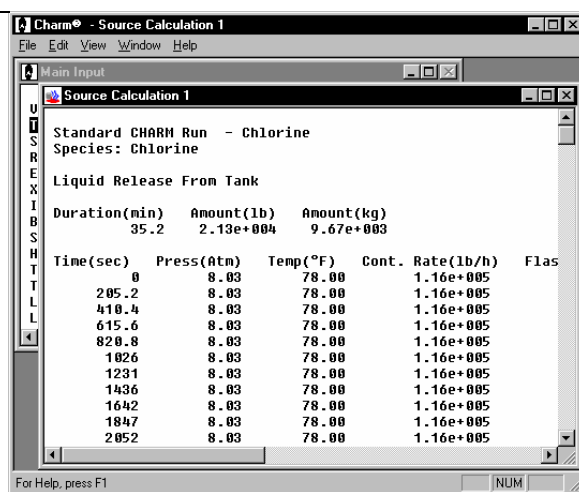


## Source/Puff Calculation Display

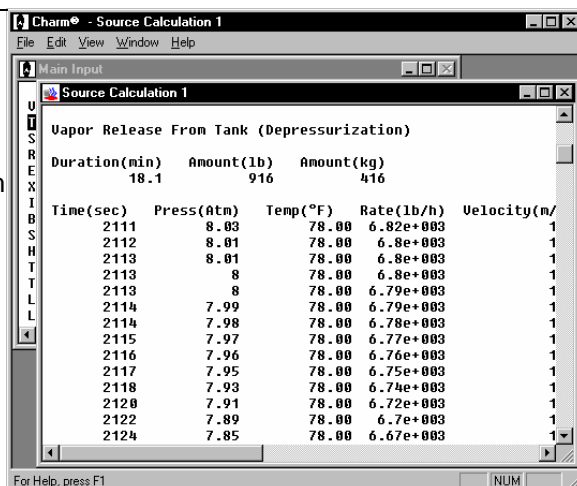
The Source/Puff Calculation command on the Displays menu shows the output of the source term calculation for a CHARM run. The Source/Puff Calculation display can be printed or copied using the File and Edit menu commands respectively. This output contains a detailed description of each portion of a release. The data consists mainly of the numbers used to describe the source term, emission out of the container, emission of each puff into the atmosphere during the release, etc.

During calculations, the release is divided into a number of puffs. The display contains, near the end of the display, the data used to describe each puff during the release. You can display the puff descriptions for several CHARM runs at the same time. Figures 6.6 through 6.9 show a sample Source/Puff Calculation display.

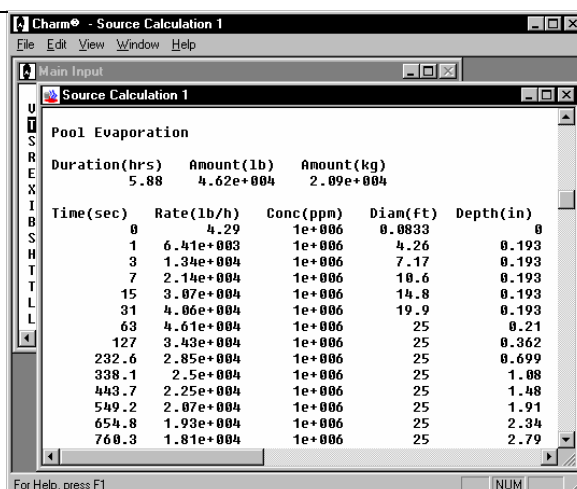
**Figure 6.6**  
Source/Puff  
Description  
Display  
(Liquid  
Release from  
Tank)



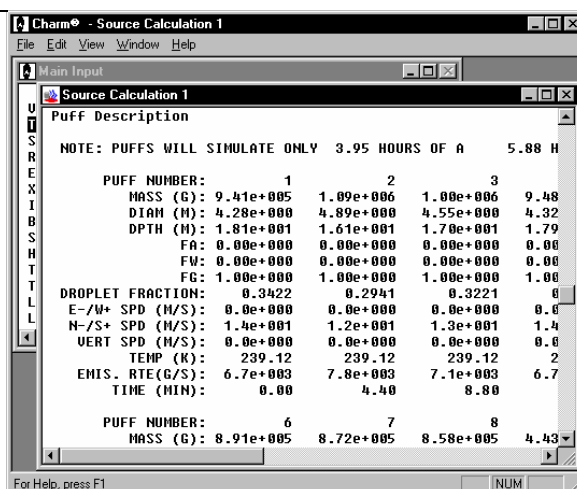
**Figure 6.7**  
Source/Puff  
Description  
Display  
(Vapor  
Release From  
Tank)



**Figure 6.8**  
Source/Puff  
Description  
Display (Pool  
Evaporation)



**Figure 6.9**  
Source/Puff  
Description  
Display (Puff  
Description)



### Using the Source/Puff Calculation for Input

Information from the Source/Puff Calculation display can be used as input for a user-specified after release scenario, which requires a complete puff description. First, using a release type similar to the

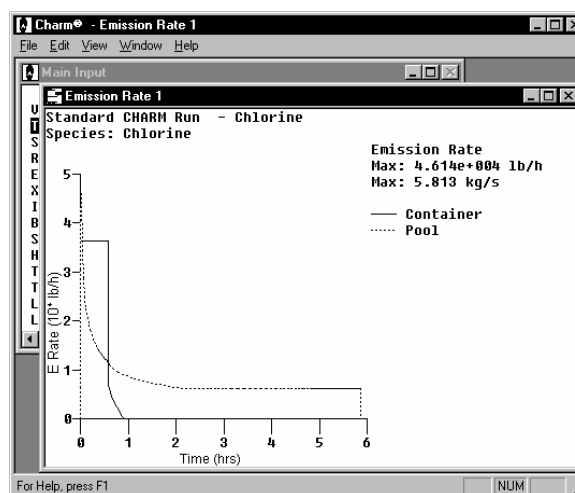
one you want to define, enter the required data in the input window. Next, display or print the Source/Puff Calculation. Then, using the User-Specified After-Release Conditions release type, perform another CHARM run using the data from the Source/Puff Calculation output as input. The data cannot be automatically inserted by the program; they must be manually entered into the Main CHARM Input Window.

## Emission Rate Display

The Emission Rate command on the Displays menu shows a plot of the emission rate as a function of time throughout the release. The Emission Rate display can be printed or copied using the File and Edit menu commands respectively.

The Emission Rate is calculated by using values from the input window. The maximum emission rate for the release is also specified. Figure 6.10 shows a sample Emission Rate display. If the emission is out of a container, CHARM displays only the emission rate of the species into the air. During a liquid release some of the liquid may fall to the ground to form a pool. If a pool is present during the release, its evaporation rate will be shown separately from the container emission rate.

**Figure 6.10**  
Emission  
Rate Display



## Thermal Radiation Displays

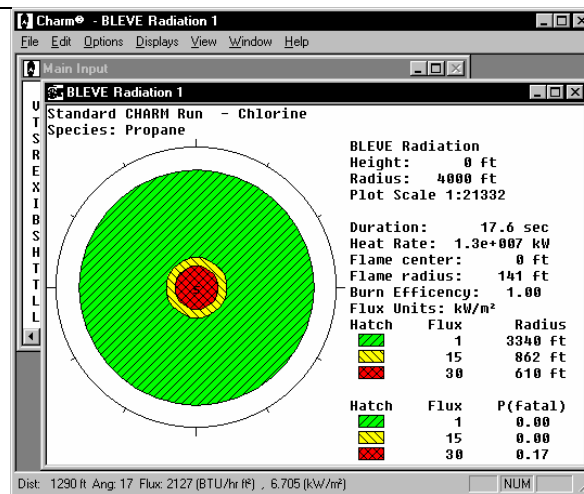
BLEVE Radiation, Pool Fire Radiation, and Jet Fire Radiation commands on the Displays menu presents three ways to generate thermal radiation displays. A BLEVE Radiation display generates a Single Point Energy Flux window as shown in Figure 6.11. This display shows the footprint of thermal radiation due to a fireball/BLEVE. The thermal radiation footprint can be repositioned within the display.

Since the display is a point source, it can be altered using the



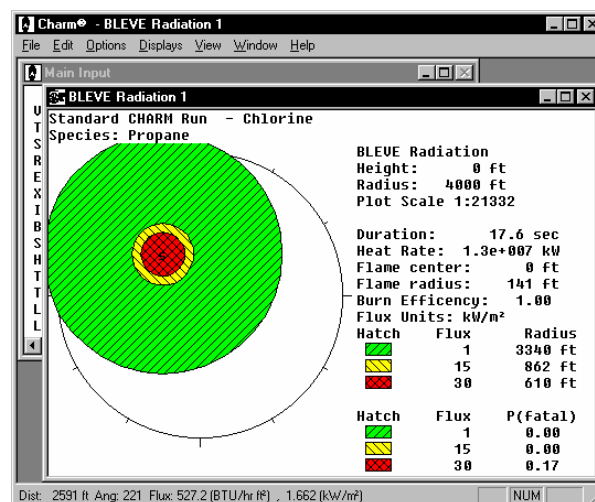
Options commands to change the energy flux values and/or the distances from the source. Use the File menu to print the graphics in the window or copy visible graphics to the clipboard.

**Figure 6.11**  
Thermal  
Radiation  
Display



## Repositioning the Radiation Footprint

To change the position of the thermal radiation footprint in the view port, press and hold <Ctrl> while you press the appropriate arrow key one or more times. Each time you press an arrow key, the footprint moves one-sixteenth of the dimension of the display area. The view port is actually the object being moved. Therefore, if you want to move the footprint down, use the <Ctrl-Up arrow> to move the view port up with respect to the footprint.



## Setting the Energy Flux Values

To change the energy flux values for the thermal radiation display, select

the Energy Fluxes command on the Options menu. You can enter up to three energy flux values in BTU/hour/square foot or kilowatts/square meter.

Enter the energy flux values.

Flux 1	<input type="text" value="1"/>	Units <input type="text" value="kW/m²"/>
Flux 2	<input type="text" value="15"/>	
Flux 3	<input type="text" value="30"/>	

OK Cancel Help

### Setting the Radiation Distances

To change the thermal radiation distances from the source on the display, select the Distances command from the Options menu. You can enter up to three distance values in feet, miles, meters, or kilometers.

Enter the distances from the source.

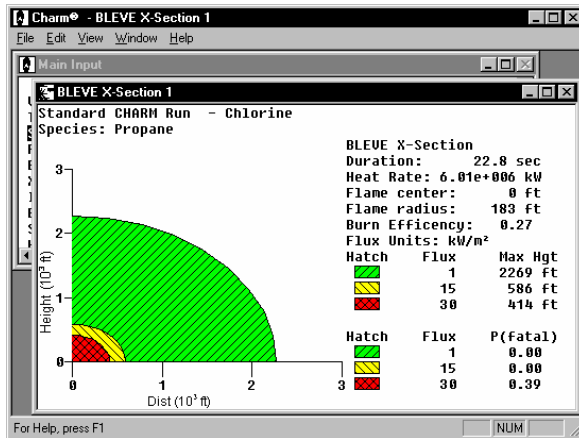
Distance 1	<input type="text" value="2268.84"/>	Units <input type="text" value="feet"/>
Distance 2	<input type="text" value="585.811"/>	
Distance 3	<input type="text" value="414.231"/>	

OK Cancel Help

### Displaying a Radiation Footprint Vertical Cross-Section

The Vertical X-section command on the Displays menu shows a vertical cross-section of the thermal radiation footprint (See Figure 6.12). The maximum vertical extent may differ from the maximum horizontal extent if the source is not at ground level.

**Figure 6.12**  
Thermal  
Radiation  
Vertical X-  
Section  
Display

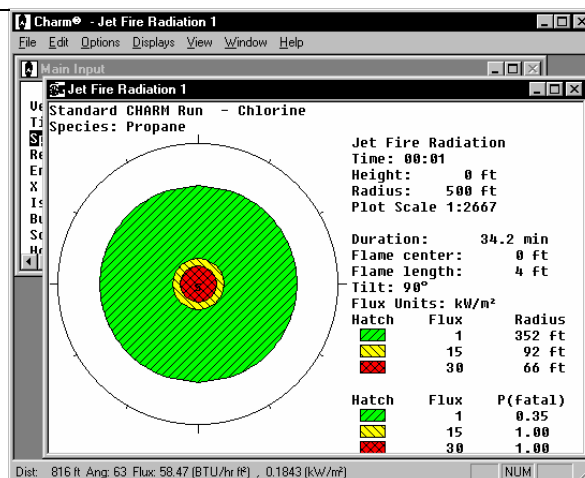


## Pool Fire and Jet Fire Displays

The Pool Fire and Jet Fire commands on the Displays menu presents a Pool or Jet Fire Energy Flux window as shown in Figure 6.13. This display is the footprint of thermal radiation due to a pool or jet fire. The jet fire footprint can be repositioned within the display.

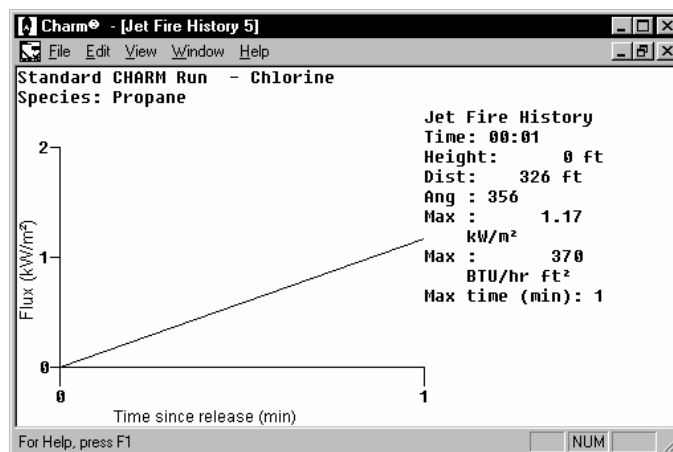
Use the File menu to print the graphics in the window or copy visible graphics to the clipboard.

**Figure 6.13**  
Jet Fire  
Display



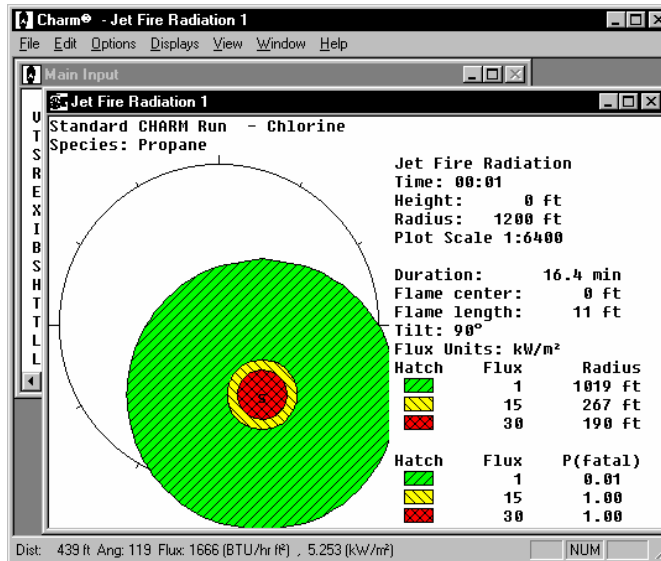
### Plotting Thermal Radiation Versus Time

To generate a plot of thermal radiation as a function of time at a selected point, move the cursor to the desired location. Then double-click the left mouse button or press <Enter>. The plot shows a time history of the thermal radiation at the specified location. The radiation values are determined only once a minute (or once a second if CHARM is operating in Minutes-Seconds Mode).



### Repositioning a Thermal Radiation Footprint

To change the position of the thermal radiation footprint in the view port, press and hold <Ctrl> while you press the appropriate arrow key one or more times. The footprint is repositioned. Each time you press an arrow key, the footprint moves one-sixteenth of the dimension of the display area. The view port is actually the object being moved. Therefore, if you want to move the footprint down, use <Ctrl-Up arrow> to move the view port up with respect to the footprint.



## Setting the Energy Flux Values

To set the energy flux values for the pool or jet fire radiation display, select the Energy Fluxes command from the Options menu. You can enter up to three energy flux values in BTU/hour/square foot or kilowatts/square meter.

Enter the energy flux values.

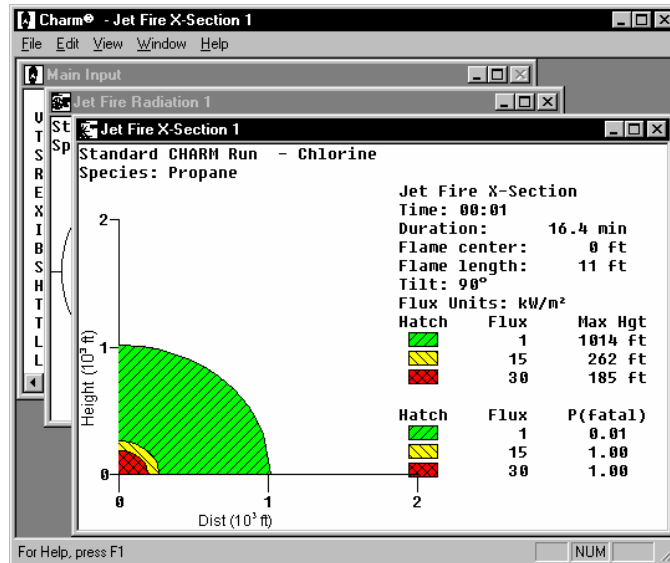
Flux 1:  Units:

Flux 2:

Flux 3:

## Displaying a Thermal Radiation Footprint Cross-Section

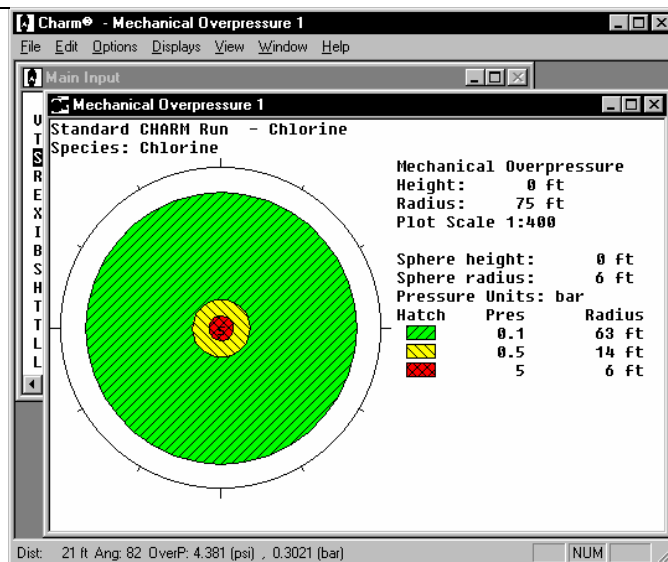
The Vertical X-section command on the Displays menu shows a plot representing the vertical cross-section of the thermal radiation footprint. The view is along the centerline of the flame as it exits the container.



## Mechanical Overpressures Display

The Mechanical Overpressures command on the Displays menu presents the Sphere Burst Overpressure window shown in Figure 6.14. This display is a footprint of the overpressures expected from a pressurized bursting sphere. The overpressures footprint can be repositioned within the display.

**Figure 6.14**  
Mechanical Over-  
pressures  
Display



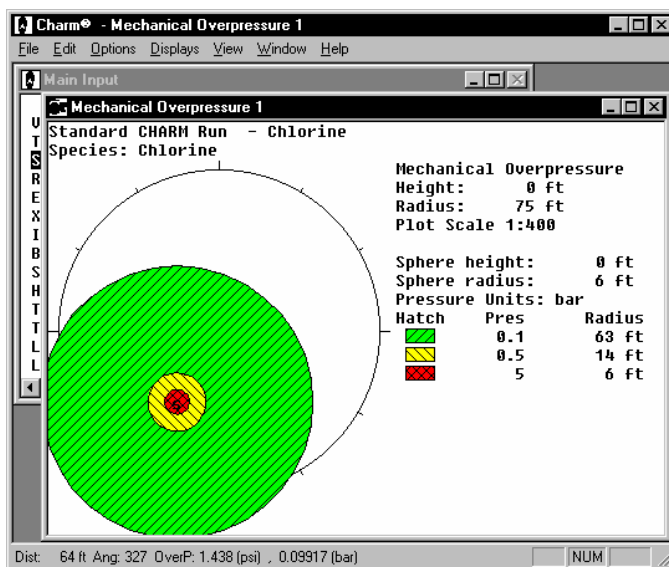
Since the display is a point source, it can be altered using the Options commands to change the overpressure values and/or the distances from the source. Use the File menu commands to save the release description

input or met data in separate files, and to print the window. Use the Copy command on the Edit menu to copy the footprint to the clipboard.

Since the sphere burst is instantaneous, no time plot can be generated. However, overpressures due to vapor cloud explosion can be plotted as a function of time.

### Repositioning the Overpressures Footprint

To change the position of the footprint in the view port, press and hold <Ctrl> while you press the appropriate arrow key one or more times. The footprint is repositioned. Each time you press an arrow key, the footprint moves one-sixteenth of the dimension of the display area. The view port is actually the object being moved. Therefore, if you want to move the footprint down, use <Ctrl> and the up arrow key to move the view port up with respect to the footprint.



### Setting the Overpressure Values

To change the overpressure values for the display, select the Overpressures command from the Options menu. You can enter up to three overpressures in pounds per square inch or bars.

The screenshot shows the 'Enter the overpressures' dialog box. It has a title bar 'Enter the overpressures.' and three input fields for 'Pressure 1', 'Pressure 2', and 'Pressure 3'. The values entered are 0.1, 0.5, and 5 respectively. To the right of these fields is a 'Units' dropdown menu currently set to 'bar'. At the bottom of the dialog are three buttons: 'OK', 'Cancel', and 'Help'.

## Setting the Overpressure Distances

You can set the overpressure distances from the source for sphere burst overpressures display. To set the distances, select the Distances command from the Options menu. You can enter up to three distance values in feet, miles, meters, or kilometers.

Enter the distances from the source.

Distance 1: 106.306

Distance 2: 22.8277

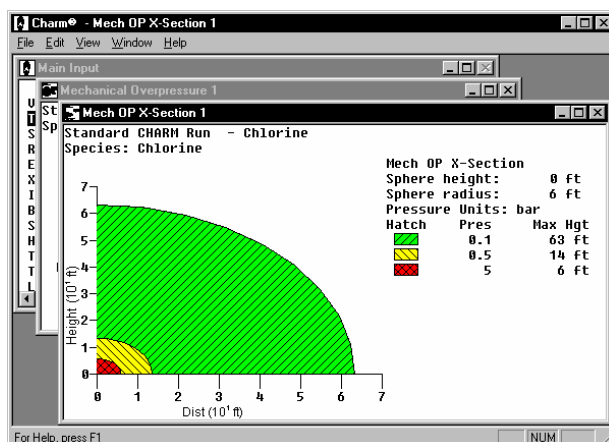
Distance 3: 5.72367

Units: feet

OK Cancel Help

## Displaying an Overpressures Footprint Vertical Cross-Section

The Vertical X-section command on the Displays menu presents the Vertical Sphere Burst Overpressure window, which is a vertical cross-section of the overpressures footprint. The maximum vertical extent may differ from the maximum horizontal extent if the sphere is not at ground level.

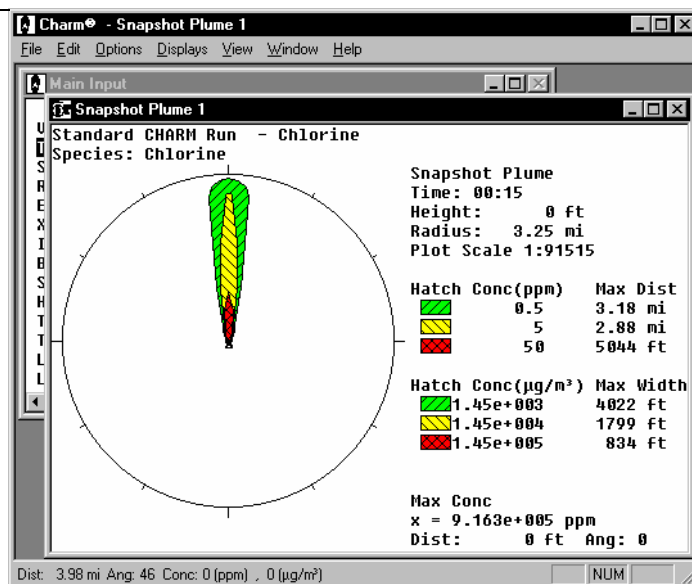


## Plume Display

The Plume command on the Displays menu of the Main CHARM Input Window presents a Snapshot Plan Plume View display, which is shown in Figure 6.15. This display is an instantaneous view of the plume at a specified time. In Figure 6.15, the display represents a snapshot of the plume 15 minutes after the release began.



**Figure 6.15**  
Plume  
Display



### Generating a Plume Display

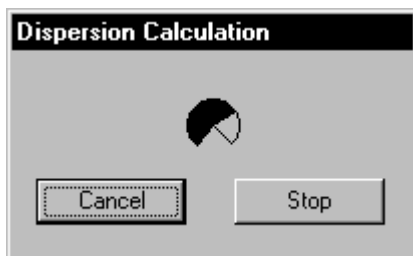
To generate a plume display, select the Plume or Pool Fire (Plume) command from the Displays menu of the main CHARM Input Window. CHARM prompts the user to enter the desired time of the Snapshot Plan Plume View in hours and minutes since the release. This time is used as the maximum time plotted for displays such as the Dose Display, Integrated Plume View, and Maximum Distance.

Enter time of plot.

Time since release 0 : 15

OK Cancel Help

After the plot time is entered, a message box appears momentarily while CHARM performs the necessary calculations for creating the plume. Select the Cancel button to abort the dispersion calculations and return to the Main CHARM Input Window. Select the Stop button to stop the dispersion calculation at the next calculated time interval. For example, if the user requested 15 minutes of dispersion calculation, and the user opted to press the Stop button before the calculation was complete, CHARM would only display dispersion calculations up to, perhaps, minute 11.



If calculations have been run with the current input for a previous display, they are not run again. Once the calculations have been completed or stopped, a plume display is generated similar to the display in Figure 6.15.

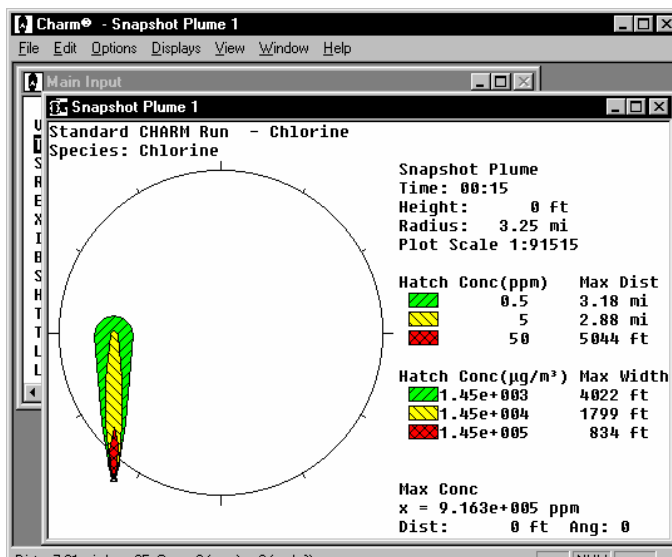
As the cross hair cursor is moved across the plume display, the concentration, distance, and angle from the source are reported at each point in the status bar at the bottom of the display. The plan plume view window does not scroll. If the legend at the right or bottom of the window is not visible, the window can be maximized. CHARM can show more than one plume display at a time.

Use the File menu commands to save the release description input or the met data in separate files, or plot the display to a printer or plotter. Since the Options and Displays menus of the Snapshot Plan Plume View and the Integrated Plan Plume View are very similar, these menus are discussed in detail in the following section titled "Plan Plume View Displays."

### Repositioning the Source

To reposition the source within the viewport of a plume display, press <Ctrl> and the appropriate arrow key. Each press of an arrow key moves the plume one sixteenth of the distance across the area in which the plume is displayed. When you release the arrow key, the screen is updated.

The direction of the selected arrow key is the direction in which the view port (solid circle) is moved. For example, <Ctrl-Up arrow> moves the view port up, thereby moving the plume and map display (if any) down. When the source is not at the center of the view port, automatic scaling is turned off.



To reset the position of the source to the center of the view port, use the Reset Source command on the Options menu.

### Generating a Dose Display Plot

The Dose Display shows a plot of the concentration versus time at a selected location. Figure 6.16 shows a sample Dose Display. The plot is initially one of instantaneous concentrations calculated at each minute versus time.

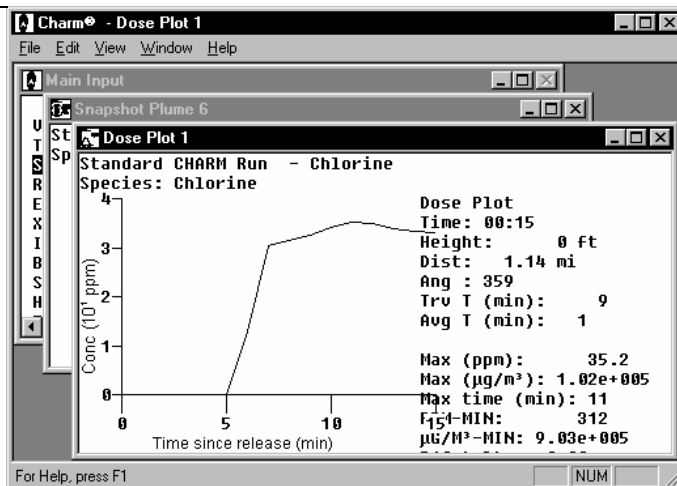
To generate a Dose Display plot, move the cursor to a desired location, and double-click the left mouse button or press <Enter>. You can generate dose plots for multiple locations by repeating this procedure.

The default averaging time is one minute, but the time can be changed using the Averaging option on the File menu from the Dose Display plot. Use the File and Edit menu commands to print and copy the Dose Display respectively. You can also display the dose information in tabular form using the Table command on the File menu.

Since the concentration at a location is calculated only once a minute, short duration releases (single puffs) may not be represented correctly. For a point near the source, the maximum concentration of a puff may move over the point not on the minute, but perhaps on a half minute. The maximum is then lost. As a puff moves further downwind, it spreads out and the problem is reduced. A single spike display is often an indication that this problem occurred. With single puffs or short duration releases, it may be better to use the Maximum Concentration command on the Displays menu and interpolate the actual maximum

concentration at the selected location, or use the Minutes-Seconds mode from the Options menu of the Main CHARM Input Window.

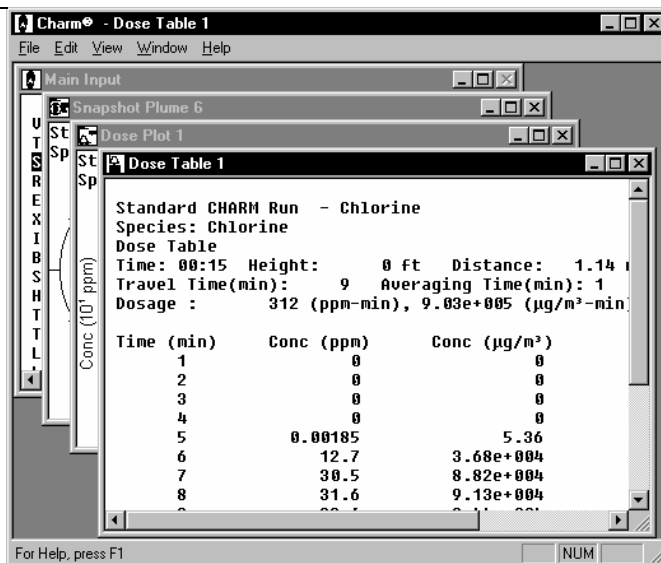
**Figure 6.16**  
Dose Display



### Generating a Dose Display Table

To generate a Dose Display table, first generate a Dose Display plot and then select the Table command on the File menu. The Dose Display table shown in Figure 6.17 is a tabular time history of the concentration at the selected location. The averaging time for the dose display is the number of minutes that are averaged to determine the display. Since the concentrations are calculated at the specified location only once a minute, the default is one minute. To change the averaging time, use the Averaging option from the File menu.

**Figure 6.17**  
Dose Display  
Table



### Setting the Averaging Time for a Dose Display

To reset the averaging time, select the Averaging menu from the File menu of the Dose Display window, and enter the averaging time in minutes from 1 to the present plot time. The default time is 1 minute. The average taken is the running average. The concentrations at a specific point are averaged over time to determine a time-weighted average. For example, if the averaging time is 5 minutes the concentration given at time 0 minutes is the average for minutes 0, 1, 2, 3, and 4. For minute 1, the average is for minutes 1 through 5. For minute 2 the average is for minutes 2 through 6. The averages result from summing instantaneous minute predictions, not averages over each minute.

The dialog box contains the text 'Enter the averaging time in minutes.' and a text input field with the value '1'. At the bottom are three buttons: 'OK', 'Cancel', and 'Help'.

## Plan Plume View Displays

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The plan plume view displays are the Snapshot Plan Plume View (Figure 6.15), the Integrated Plan Plume View (Figure 6.30), the Grid Averaged Plume View (Figure 6.31), Mechanical/Explosion Overpressure Views (Figure 6.35), and the Population Visual Verify (Figure 6.32). A Snapshot Plan Plume View display is an instantaneous view of the plume at a specified time. The Plume command on the Displays menu of the Main CHARM Input Window generates the snapshot view. An Integrated Area Plan Plume View is a minute by minute calculation of the plume display that shows all areas affected by the plume. The Integrated Area command on the Displays menu of the Snapshot Plan Plume View window generates the integrated plume. Selecting the Time-Averaged Plume command from the Displays menu of the Snapshot Plume generates a time-averaged plume based on a user-defined averaging interval and a user-defined grid size. The Mechanical Overpressures option shows a footprint of the overpressures expected from a pressurized bursting sphere. It is only available if the release type is Container/Surface Description. On the other hand, if flammability characteristics are right and concentration levels are sufficient, a plume may be ignited from the Explosion Overpressures command on the Displays menu from a Snapshot Plume View. Finally, the user may visually verify how a footprint (plume, overpressures, or thermal radiation) impact population tracts. This option is only available after the population impacts have been calculated from the Displays menu of any type of footprint.

Use the Options menu on the plan plume views to alter the appearance of a display. The Options menu and the Displays menu of the integrated view are similar to those of the snapshot view. The selections for both menus are discussed in the following sections.

### Plume View Options Menu

The Options menu of the Snapshot Plan Plume View provides selections for altering the appearance of the plume display, showing a new map, setting and resetting the source location, and specifying a new release time. The Options menus for the Snapshot Plan Plume View and the Integrated Plume View have many of the same selections.

#### Isopleths Option (Plume Footprint Display)

Use the Isopleths command on the Options menu to change the species concentrations that are plotted on plume displays and graphs. Enter the isopleths in parts per million or microgram per cubic meter. At least one concentration is required.

Enter concentrations for plume plot

Concentration 1	<input type="text" value="0.5"/>	Units <input type="text" value="ppm"/>
Concentration 2	<input type="text" value="5"/>	
Concentration 3	<input type="text" value="50"/>	

OK Cancel Help

### Overpressures Option (Mechanical/Explosion Overpressures Display)

Use the Overpressures command on the Options menu to change the desired overpressures that are plotted on the displays and graphs. Enter the overpressures in psi or bar. At least one overpressure is required.

Enter the overpressures.

Pressure 1	<input type="text" value="0.1"/>	Units <input type="text" value="bar"/>
Pressure 2	<input type="text" value="0.5"/>	
Pressure 3	<input type="text" value="5"/>	

OK Cancel Help

### Distances Option (Explosion Overpressures Display)

Enter up to three distances from the source. The units are feet, meters, miles, or kilometers. CHARM displays the default values. You can accept or change the default values. A value is required for at least one distance. CHARM uses the distances to calculate overpressures to create the footprint display.

Enter the distances from the source.

Distance 1	<input type="text" value="63.24"/>	Units <input type="text" value="feet"/>
Distance 2	<input type="text" value="13.5006"/>	
Distance 3	<input type="text" value="5.72367"/>	

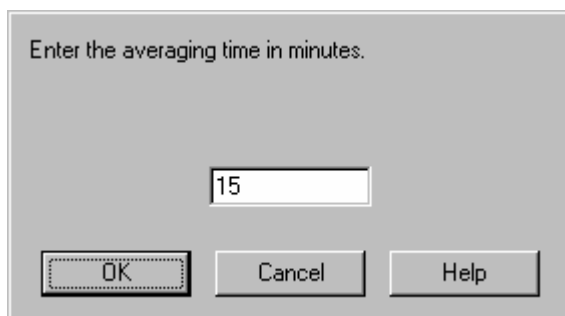
OK Cancel Help

### Averaging Time Option (Time-Averaged Footprint Display)

You may change the averaging time associated with a Time-Averaged Footprint. Enter the averaging time in minutes from 1 to the present plot time. The average taken is the running average. The

concentrations at a specific point are averaged over time to determine a time-weighted average.

For example, if the averaging time is 5 minutes, the concentration given at time 0 minutes is the average for minutes 0, 1, 2, 3, and 4. For minute 1, the average is for minutes 1 through 5. For minute 2 the average is for minutes 2 through 6. The averages result from summing instantaneous minute predictions, not averages over each minute.



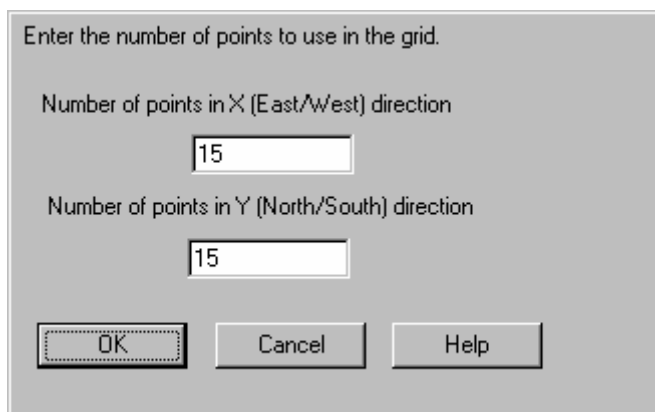
Enter the averaging time in minutes.

15

OK Cancel Help

### Grid Size Option (Time-Averaged Footprint Display)

You may change the grid size associated with a Time-Averaged Footprint. Enter the number of points to be used in the grid when generating a Time-Averaged Plume. The grid is 2-dimensional and, therefore, the user must enter the number of points in the X direction (East/West) and the Y direction (North/South).



Enter the number of points to use in the grid.

Number of points in X (East/West) direction

15

Number of points in Y (North/South) direction

15

OK Cancel Help

### Show Grid Option (Time-Averaged Footprint Display)

This option simply turns on or off the currently defined grid for a Time-Averaged Footprint. A check mark by the option indicates the grid is shown, while no check mark indicates that the grid is not shown.

### Grid Display Option (Time-Averaged Footprint Display)

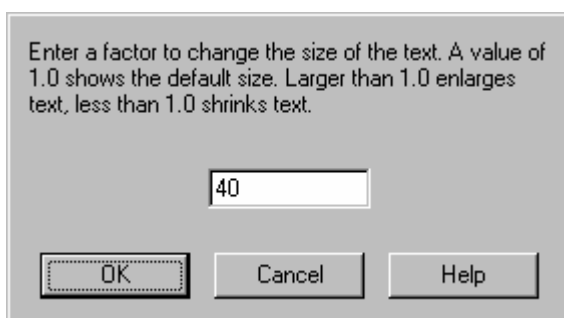
If the Show Grid option is on, this option displays the user-defined grid for the Time-Averaged Plume as a series of points or a wire mesh, whichever submenu item is selected. A check by the menu item



indicates this option is turned on, whereas no check by the menu item indicates the option is not active and the grid points are not visible.

### **Text Size Option (Population Impact Visual Verify Display)**

From the Population View, the user may adjust the size of the text describing the population number for each tract. Increasing the number enlarges the current size of the text, and decreasing the number reduces the current size of the text. Each population tract is described by two numbers, one on top of the other. The top number is usually lower if any type of impact was encountered in the tract. This number indicates the number of people impacted in the tract. The lower number is the total number of people located in that particular tract.



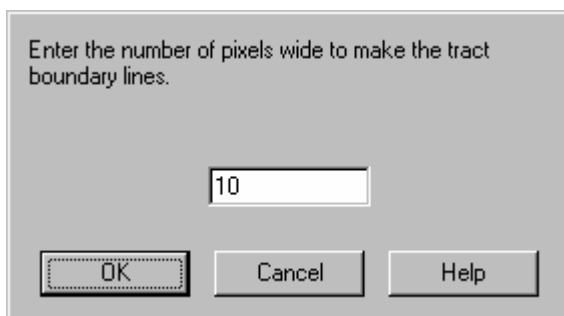
Enter a factor to change the size of the text. A value of 1.0 shows the default size. Larger than 1.0 enlarges text, less than 1.0 shrinks text.

40

OK Cancel Help

### **Line Width Option (Population Impact Visual Verify Display)**

From the Population View, the user may adjust the line width describing the population tracts. This is helpful when differentiating the population tracts from lines drawn by overlaying maps. Increasing the number enlarges the current line width, and decreasing the number reduces the current size of the line width.



Enter the number of pixels wide to make the tract boundary lines.

10

OK Cancel Help

### **Monochrome Option (3D Plume Display)**

Use this option in the 3D Plume Display to remove the color from the concentration being viewed. This menu item is switched either on or off. A check mark beside the menu item indicates that no color is used with the plume and no check mark indicates the plume is filled with color.

### **Scale Radius Option (Any Footprint Display)**

Use the Scale Radius command on the Options menu to change the radius of the view port (solid circle) on the plume display. A scale change alters the overall display area. Enter the radius of the view port in feet, miles, kilometers, or meters. A value greater than 0 (zero) must be entered. If you want CHARM to determine the radius of the view port, you can specify the scale ratio using the Scale Ratio command on the Options menu.

Enter the radius of the solid circle on display.

5 miles

OK Cancel Help

### Scale Ratio Option (Any Footprint Display)

Use the Scale Ratio command on the Options menu to enter a ratio for which CHARM will determine the view port radius on the plume display. When you set the scale ratio, the plume display will approximate the plot that will be sent to the printer/plotter. The display itself will not be set to scale, but the output of a plot sent to the printer/plotter will be scaled. Enter the scale ratio of the current plume display. Assume a 1:scale relationship. The center of the plot will be at the center of the view port. The total area plotted is determined by the scale specified, not necessarily by what is visible on the screen.

Enter the scale ratio (1:ratio).

24000

OK Cancel Help

### Distance Circles (Any Footprint Display)

To supplement the displays of the plan view, additional circles can be drawn within the large circle with tick marks. Enter the radius increment to use.

Enter radius of supplemental circles.

### Receptor Height Option (Any Footprint Display)

Use the Receptor Height command on the Options menu to change the height of the display above the ground. The plan plume view represents a horizontal slice through the atmosphere. Enter the height above ground in feet or meters. This value is used for all calculations and displays that require a receptor height.

Enter the receptor height.

### Transparency Option (Any Footprint Display)

The Transparency command on the Options menu is a toggle that changes the display between a colored, opaque plume and a "ghost" plume that is denoted only by concentration hatch marks. When a map and plume are displayed, this feature allows the map areas beneath the plume to be seen. The transparency option was used to create the plume figures shown in this chapter.

### No Hatch Option (Any Footprint Display)

Use the No Hatch command to remove the hatch marks from the legend and the footprint so that only color may be seen. The command is merely a switch. A checkmark next to the command indicates that No Hatch is active. Alternatively, no checkmark by the command indicates the No Hatch is inactive.

*NOTE: The No Hatch command does not work in accordance with the Transparency command selected.*

### Use Auto Scale Option (Any Footprint Display)

Use Auto Scale command works in accordance with selecting an option (e.g. New Time, Receptor Height, etc.) for generating a new display. If the Use Auto Scale command is checked and active, then CHARM will automatically rescale the current display so that the resulting footprint is completely described in the viewport (i.e. large circle). On the other hand, if the Use Auto Scale command is unchecked and inactive, then the resulting display will remain at the current scale just before the user requests a option for display.

### Decay Option (Plume Footprint Display)

Use the Decay command on the Options menu to specify the time (half-life) required for half of the emitted material to decay into neutral products. This option simulates the decay of the material in the air. Enter the decay time in hours, minutes, or seconds. Any previous windows produced for the current scenario are not updated with the effects of the half-life data, but all subsequent windows are.

Enter the decay half-life.

0 Hours

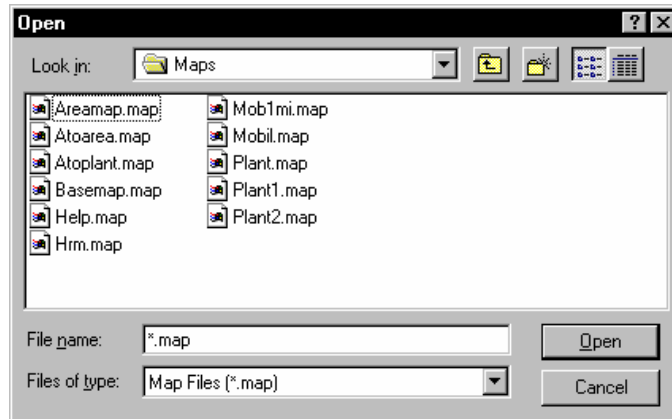
OK Cancel Help

If you enter a decay time, the downwind concentrations will be decreased.

*NOTE: Use this option with caution, because the predicted concentrations will be lower than they would be with no decay.*

### Map Option (Any Footprint Display)

The Map command on the Options menu opens a dialog box in which you can select a map for display. Any maps that have been edited with the CHARM Editor and stored with the default .MAP file name extension are displayed. The default map name is BASEMAP.MAP. Select the name of the map to display. For more information on map displays, see the section of this chapter titled "Map Displays."

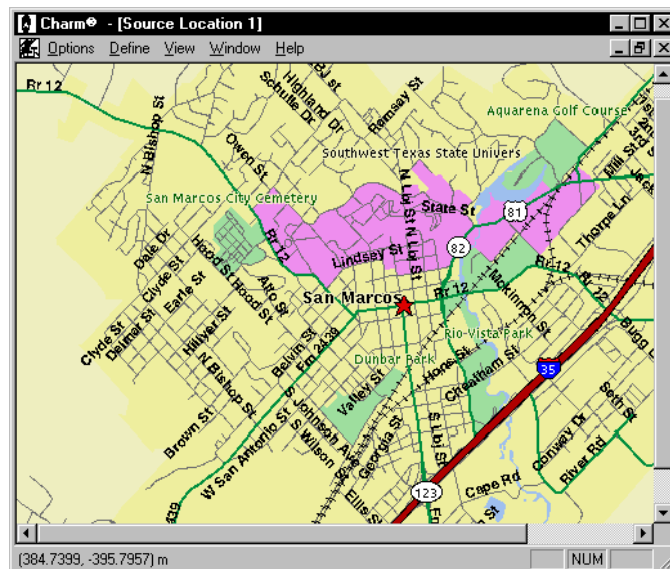


### No Map Option (Any Footprint Display)

The No Map command on the Options menu quickly and easily removes the current map from the display when selected.

### Location Option (Any Footprint Display)

Use the Location command on the Options menu to relocate the source of the release on the current map. This option displays the map on a separate screen where the source location can be changed.



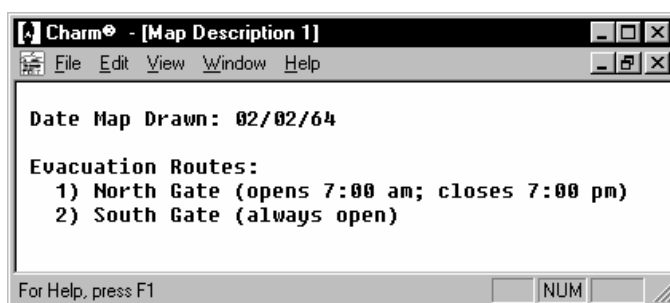
To change the source location, first select the new location on the map display. If you are using a mouse, move the cursor to the new location and double-click the left mouse button. With a mouse, you can achieve the same result by selecting the Define Point option in the Define menu, moving the cursor to the new location, and then clicking the left mouse button. If you are using the keyboard, select the Define Point option in

the Define menu of the map display, move the cursor to the new location by holding down <Shift> while pressing the arrow keys, and then press <Enter>.

To scroll the map display with a mouse, use the scroll bars. To scroll the map with the keyboard, use <Page Up> or <Page Down>.

### Map Description (Any Footprint Display)

Selecting this option allows the user to view pertinent information describing the currently displayed map. This text is defined in the Map Definition Editor within CHARMED. For more information, refer to “Map Description” in Chapter 3.



### Reset Source Option (Any Footprint Display)

If the plume has been repositioned within the view port, the Reset Source command on the Options menu resets the position of the source to the center of the view port.

### Auto Map Change Option (Any Footprint Display)

Use the Auto Map Change command on the Options menu to enable CHARM to automatically display a larger-scaled map when the scale of the current map display is not large enough to cover a significant portion of the plot area (defined by the Auto Map Fraction command). In order for CHARM to identify and automatically display a larger-scaled map, the map must be edited with the CHARM Editor and assigned an Expand Map Name. The Auto Map Change command is a toggle.

### Auto Map Fraction Option (Any Footprint Display)

Use the Auto Map Fraction command to define the fraction of the footprint display area which must be covered by a map to preclude CHARM from trying to go to a larger scale map. The rectangular area used for comparison is the area in which the viewport circle is inscribed. If the current map covers less than the Auto Map Fraction of the rectangular area, CHARM will try to go to the larger scale map defined for the map. The value must be between 0.05 and 0.95. The default is 0.25.

Enter the Auto Map Fraction

0.25

OK Cancel Help

### Larger Scale Map Option (Any Footprint Display)

Use the Larger Scale Map command on the Options menu to display a larger-scaled map when the scale of the current map display does not cover a significant portion of the plot area. The larger-scaled map must be edited with the CHARM Editor.

### New Time Option

Use the New Time command on the Options menu to change the time since release for the Plan Plume View. If the requested time has already been calculated, the display is immediately updated. This dialog box is also requested when first generating the plume or footprint from the Plume command of the Main CHARM Input Window.

Enter time of plot.

Time since release 0 : 30

OK Cancel Help

### Time Circles Option (Any Concentration Footprint Display)

The Time Circles command on the Options menu draws dashed circles around the source, the radii of which are determined by the time specified in the dialog box. Time circles indicate the locations to which the current wind speed can move a parcel of air from the source in the number of minutes specified.

Enter a time (minutes) for spacing dashed circles on display.

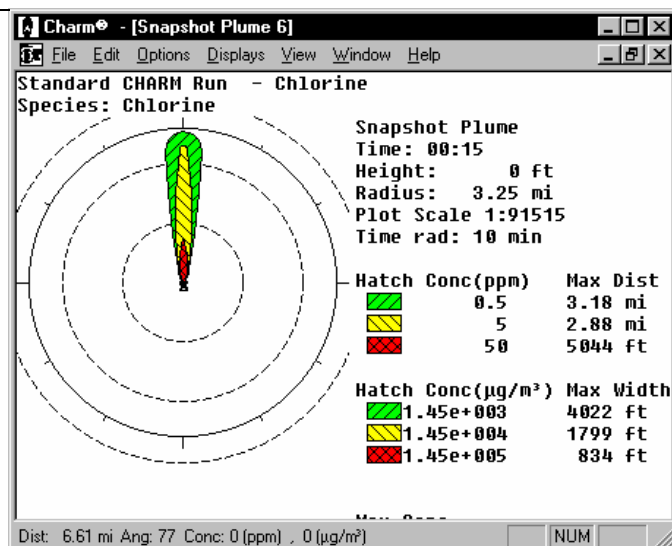
10

OK Cancel Help

Enter the time in minutes. A time greater than 0 (zero) is required to display time circles. If you enter 0 or leave the field blank, CHARM

does not display time circles. Figure 6.18 shows a sample Time Circles display.

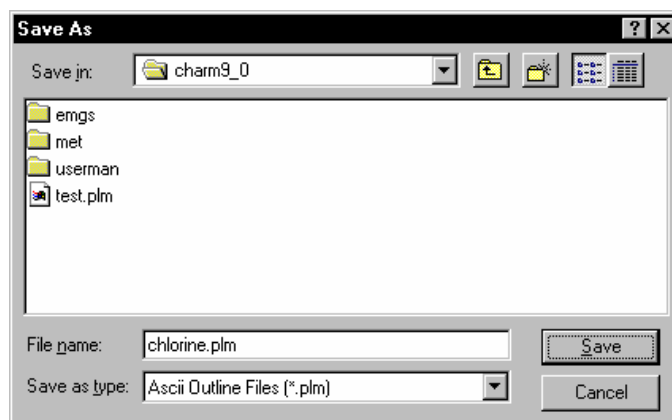
**Figure 6.18**  
Time Circles  
Display



The wind speed at the release site, current height, and the time of the Snapshot Plan Plume View are used to determine the radii of the circles. Spatial and temporal variations of the wind speed are not used. As the wind speed changes, the radii change. Wind speed changes with time also affect the radii of time circles.

### Create ASCII File Option (Any Footprint Display)

Create ASCII File command on the Options menu enables the user to generate a file to hold a description of a footprint that can be transferred to other programs. CHARM requests the name of the file through a standard windows Save As dialog box. Select the drive, the directory, and the file name to store the text file. The default ASCII file extension (.PLM) is defined by the AsciiExt variable in CHARM.INI.





This option was designed to be used with the other programs, such as Computer Aided Design software (CAD), which should have options to import the data.

### ASCII File Format

The ASCII file contains the real world coordinated (in meters from source) of the currently displayed footprint. The file contains what is envisioned as the minimum required for the general case. The points given describing the location of an isopleth are not necessarily close enough to give a smooth display of an isopleth.

<u>RECORD</u>	<u>VARIABLES</u>	<u>MEANING</u>	<u>FORTTRAN FORMAT</u>
1	HRO MINSO SECO	Time of release: hours minutes seconds	315
2	HRP MINP SECP	Time of plot: hours minutes seconds	
3	HEIGHT	Height above ground of plot (meters)	E15.4
4	NCON  IUNITS	Number of isopleth values following; Units of isopleths; Type of calculation	315
5	ITYPE CONV (1 TO NCON)	Isopleth values	3E15.4

In the above if IUNITS is 0 or mission the isopleth values are in ppm. If IUNITS is 1, the isopleths are in kilowatts per square meter (thermal radiation). If IUNITS is 2 the isopleths are in pounds per square inch (overpressures).

The type of calculation indicated how the isopleths were generated:

#### ITYPE   Source

- 1   Snapshot Plume concentration.
- 2   Pool fire or BLEVE radiation.
- 3   Thermal Radiation.
- 4   Overpressures from a failure of a pressurized vessel.
- 5   Overpressures from a vapor cloud explosion.
- 6   Integrated Plume concentration.
- 7   Time-Averaged Plume

These first five records will be followed by NCON groups of records. Each group will consist of: first, a record containing the number of isopleths for one of the CONV values (NISO, format I5), followed by up to three subgroups of records. Each subgroup will have the following format:

SUB- GROUP <u>RECORD</u>	<u>VARIABLES</u>	<u>MEANING</u>	FORTTRAN <u>FORMAT</u>
1	NPTS	Number of X/Y pairs following	15
2 - NPTS+1	X,Y,R	Points describing an isopleth; R is always 0. R is never used and is only present for backward compatibility.	

An example of records 6 and onward may help. Assume NCON is three and that the three isopleths following are 1, 10, and 100 ppm. Further assume there are two distinct and separate isopleths for the 100 ppm concentration. This can happen if the emission rate has varied over time. The other concentrations will be assumed to only have a single isopleth each.

<u>Record</u>	<u>Value</u>
7	1 (only one isopleth for 1 ppm conc.)
8	NPTS1
9 to 8 + NPTS1	NPTS1 pairs of X/Y points describing 1 ppm isopleth
9 + NPTS1	1 (one isopleth for 10 ppm conc.)
10 + NPTS1	NPTS10
11 + NPTS1 to	NPTS10 points pairs describing 10 ppm
10 + NPTS1 + NPTS10	isopleth
11 + NPTS1 +NPTS10	2(two isopleths for 100 ppm conc.)
12 + NPTS1 +	NPTS100A

NPTS10

```
...          NPTS100A point pairs for first
              100 ppm isopleth
...          NPTS100B
...          NPTS100B point pairs for
              second 100 ppm isopleth
```

Minimum and maximum numbers that can be expected for each of the variables which may dictate the use of arrays are:

- NCON (1 to 3)
- NISO (0 to 3)
- NPTS (unlimited)

### Transferring Footprints via DDE to other Windows Programs

A (Dynamic Data Exchange) DDE interface is available to send a footprint of impact (concentration, thermal radiation, or overpressure) data in a real-time manner to other Windows programs while CHARM is running. To set up the DDE a client program must initialize a conversation with the server, CHARM. The following values are needed to set up the communication.

Server Name: CHARM

Topic: EISI

Item: PLUME\_CHARM

CHARM only performs Advise services (use XTYP\_ADVSTART). After a conversation has been established, whenever a plan view is created or changed it will be sent out to all clients. Changing receptor heights, isopleth values, time, etc. change the plume. The block of data sent out is identical to creating an ASCIIFile except that a line is added to the beginning of the block. This first line is to be used as a scenario indicator. The first line is to be used as a scenario indicator. The first line will look like:

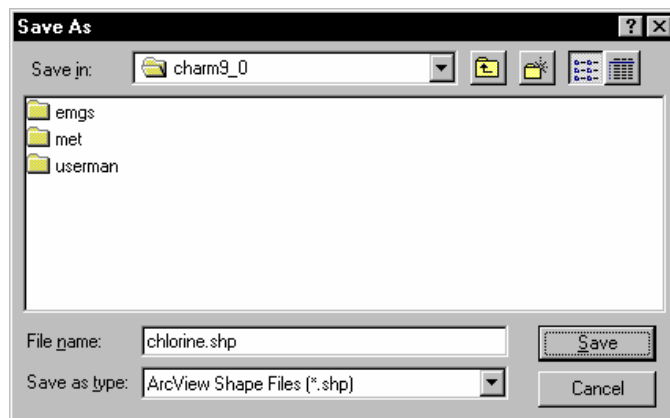
CHXXXXXX

where XXXXXX is a six digit number from 0 on up (leading 0s are used). Every data block sent with the same first line where created from the same input. This is actually only true if CHARM is not stopped and the re-started. Whenever CHARM begins the value of XXXXXX starts at 0. If the value of CHXXXXXX is identical to that in a previous data block and IYPEs are the same the new data block is an update to the previous footprint (possibly at a new time, height, etc.).

### Create Shape File Option (Any Footprint Display)

This command enables the user to generate a file that describes a footprint of impact (concentration, thermal radiation, or overpressure) which can be transferred to ArcView for display. Whenever a plan view of an impact is displayed, this option becomes available on the Options menu. The default shape file extension (.SHP) is defined by

the ShapeFileExt variable in CHARM.INI. It is set to SHP and should not be changed since ArcView expects that extension.



An ArcView shape file is actually three files: the main file, an index file, and a dBase file with attributes. These three files all have the same names and locations except for their extensions. The main file extension is .SHP. The index file extension is .SHX. The dBase file extension is .DBF.

The main file contains the real world coordinates (in meters from source) of the currently displayed footprint. The file contains what is envisioned as the minimum required for the general case. The points given describing the location of an isopleth are not necessarily close enough to give a smooth display of an isopleth. The index file has pointers to the footprints in the main file so that ArcView can find the data properly. The dBase file has the following attributes for each isopleth of the footprint: REL\_TIME, PLOT\_TIME, X\_SRC, Y\_SRC, HEIGHT, CONT\_VALUE, UNITS, and SOURCE.

REL\_TIME is the time of release. Usually 00:00 except for emergency response. Then it is clocktime of release.

PLOT\_TIME is the display time which is given as time since release.

X\_SRC, Y\_SRC define the location of the source in meters. The footprint vertices are given in meters from the source.

HEIGHT is the height above ground of the footprint.

CONT\_VALUE is the numeric value defining the isopleth.

UNITS is a flag for the units of CONT\_VALUE

If UNITS is 0 the isopleth values are in ppm. If UNITS is 1, the isopleths are in kilowatts per square meter (thermal radiation). If UNITS is 2 the isopleths are in pounds per square inch (overpressures).

The type of calculation used to generate the isopleths is indicated by the SOURCE attribute:

<b><u>SOURCE</u></b>	<b><u>Source</u></b>
1	Snapshot Plume concentration.
2	Pool fire or BLEVE radiation.
3	Jet fire radiation.
4	Overpressures from a failure of a pressurized vessel.
5	Overpressures from a vapor cloud explosion.
6	Integrated Plume concentration.
7	Time-Averaged Plume

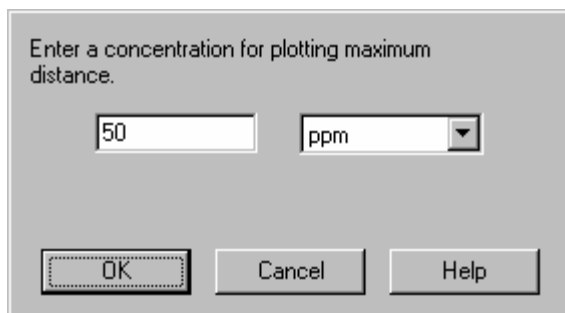
## Plume View Displays Menu

The Displays menu of the Snapshot Plan Plume View window provides selections for plotting maximum distances, vertical cross-sections, centerline concentrations, explosion overpressures, population impacts, Time-Averaged plumes, and integrated area plumes. CHARM also creates table displays for maximum distances and concentrations. Met data, release data, puff description, and emission rate displays are also available from the plan plume view.

The Displays menu of the other Plan Displays have selections that are similar to the snapshot plume displays menu. The Displays menu for an integrated plume does not provide a vertical cross-section, centerline concentration, or meteorological data. The integrated plume has additional menu selections for recalculating a plume or continuing the current calculation.

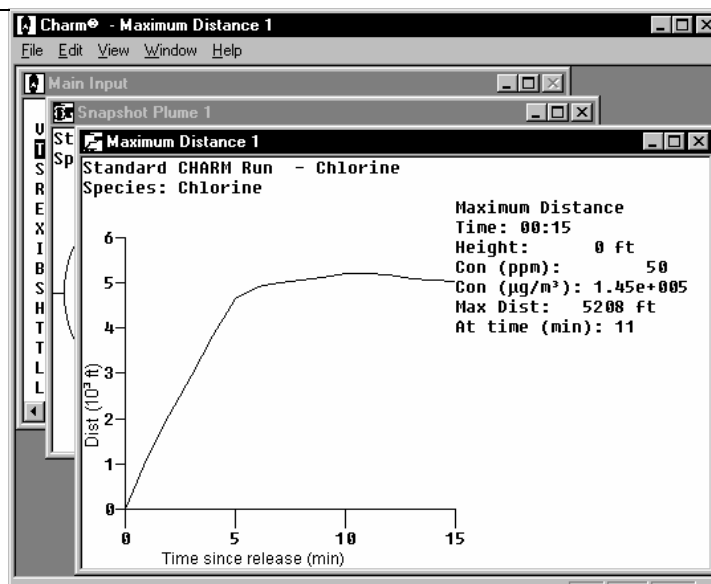
### Maximum Distance Display

The Maximum Distance command on the Displays menu plots the maximum distance downwind of the specified concentration as a function of time.



Enter the concentration in parts per million or micrograms per cubic meter. The time interval for the plot depends on the time specified for the current Snapshot Plan View Plume view display. Figure 6.19 shows a sample Maximum Distance Plot.

**Figure 6.19**  
Maximum  
Distance Plot



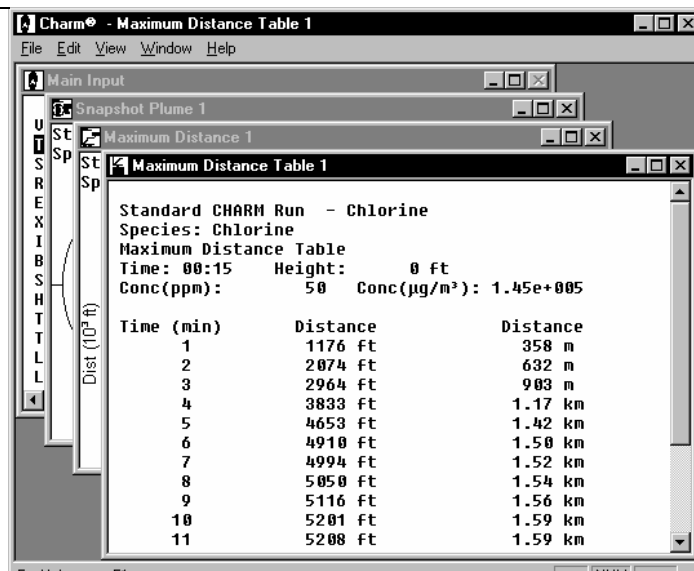
Use the Copy command from the Edit menu to copy the contents of the window to the clipboard. Use the File menu commands to print the Maximum Distance plot, or display the maximum distance information in the form of a table.

### Maximum Distance Table

To display the maximum distance information in tabular form, first display the Maximum Distance plot and then select the Table command from the File menu. The table shows the distance downwind that a concentration has reached as a function of time. The distance is reported in feet, miles, meters, and kilometers for each minute since the release time specified for the plume. Figure 6.20 shows a sample

Maximum Distance table.

**Figure 6.20**  
Maximum  
Distance  
Table



### Maximum Width Display

The Maximum Width command on the Displays menu plots maximum crosswind width of a user-specified concentration as a function of time.

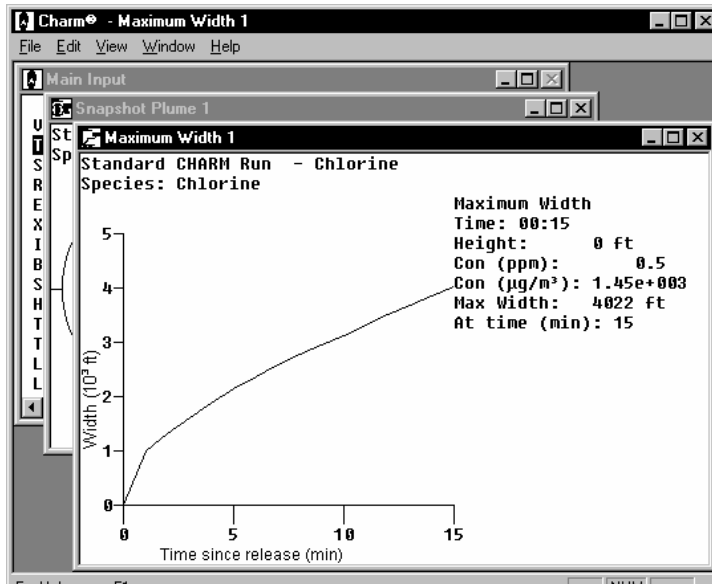
Enter a concentration for plotting maximum width.

0.5 ppm

OK Cancel Help

Enter the concentration in parts per million or micrograms per cubic meter. The time interval for the plot depends on the time specified for the current Snapshot Plan View Plume view display. Figure 6.21 shows a sample Maximum Width Plot.

**Figure 6.21**  
Maximum  
Distance  
Table



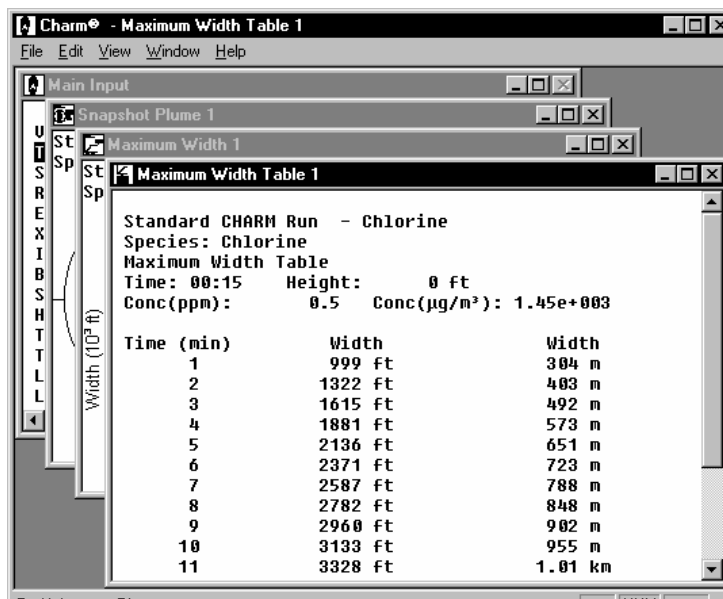
Use the Copy command from the Edit menu to copy the contents of the window to the clipboard. Use the File menu commands to print the Maximum Width plot, or display the maximum width information in the form of a table.

### Maximum Width Table

To display the maximum width information in tabular form, first display the Maximum Width plot and then select the Table command from the File menu. The table shows the crosswind width of a user specified concentration as a function of time. The distance is reported in feet, miles, meters, and kilometers for each minute since the release time specified for the plume. Figure 6.22 shows a sample Maximum Width table.



**Figure 6.22**  
Maximum  
Width Table



### Maximum Concentration Display

Use the Maximum Concentration command on the Displays menu to enter a minimum distance from the release source beyond which CHARM will tabulate and display all maximum concentrations as a function of time.

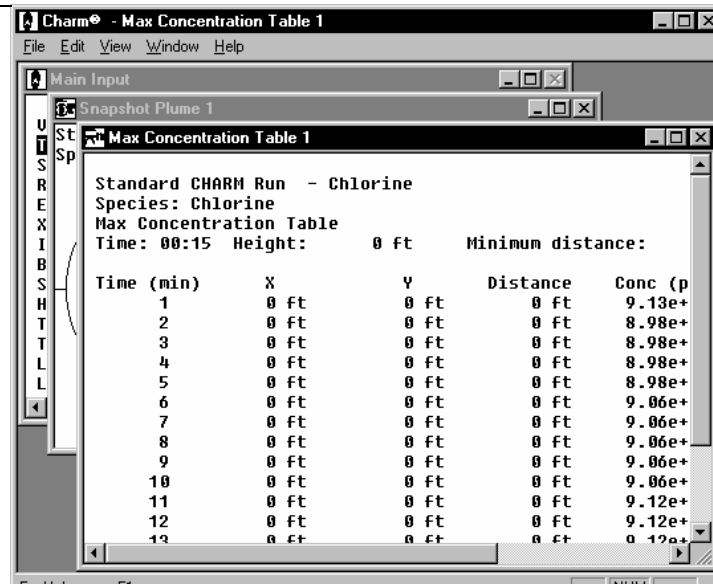
Enter the minimum distance from the source for maximum concentration plot.

0 feet

OK Cancel Help

Enter the distance in feet, miles, meters, or kilometers. Figure 6.23 shows a sample Maximum Concentration Table. Use the File menu commands to print or copy the table.

**Figure 6.23**  
Maximum  
Concentra-  
tion Table

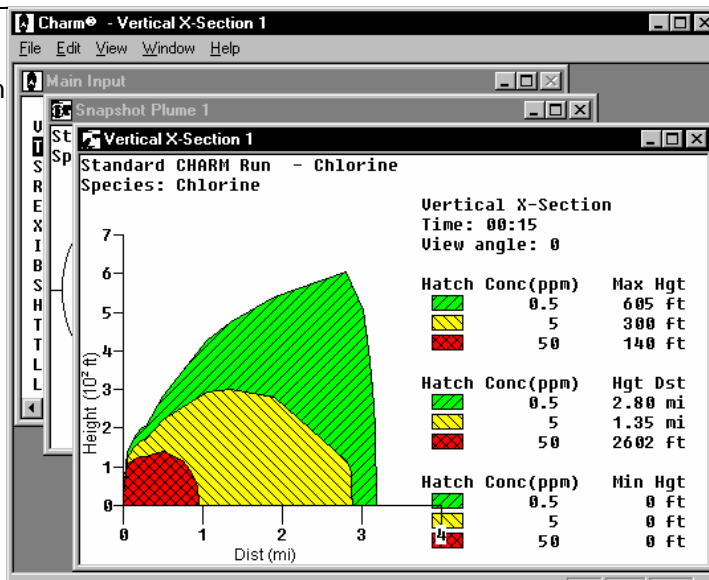


The table shows the maximum concentration of the species in parts per million and micrograms per cubic meter as a function of time. A maximum concentration is calculated for every minute since release. The X and Y locations and the downwind distance of the maximum concentrations are also reported. Use the File and Edit menu commands to print or copy the Maximum Distance table respectively.

### Vertical Cross-Section

The Vertical X-section command on the Displays menu plots a vertical cross-section through the middle of the plume. The view is from the source through the middle of the first puff released. Since this display involves one of the longest calculations in the model, it may take some time before the cross-section is displayed. Figure 6.24 shows a sample Vertical Cross-Section display. Use the File menu commands to print, plot, or copy the cross-section display. The Monochrome command on the File menu creates a colorless vertical cross-section whose isopleth concentrations can be printed or plotted.

**Figure 6.24**  
Vertical  
Cross-Section  
Display



### Centerline Concentrations Display

The Centerline Concentrations command on the Displays menu plots the concentrations down the centerline of the plume as a function of distance. The concentrations are listed for the specified height and may not include the maximum concentration.

**Centerline Concentrations**

Beginning Distance  Ending Distance

Distance Units

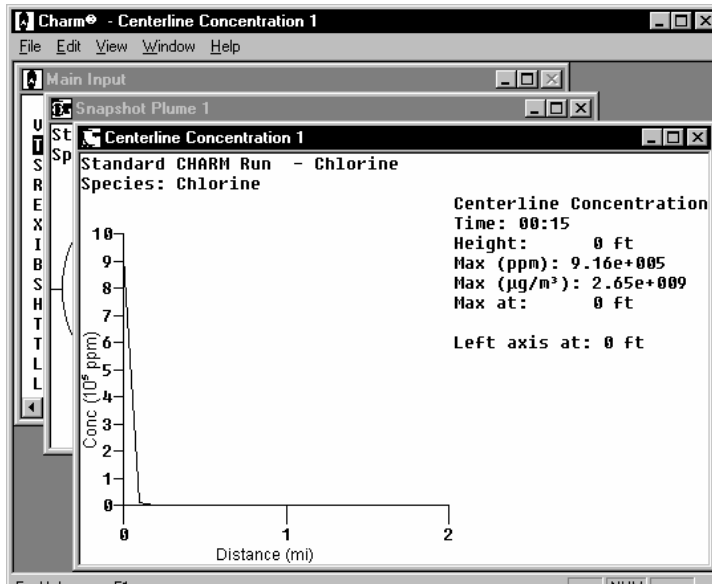
Interval Size

☐ Log Plot

OK Cancel Help

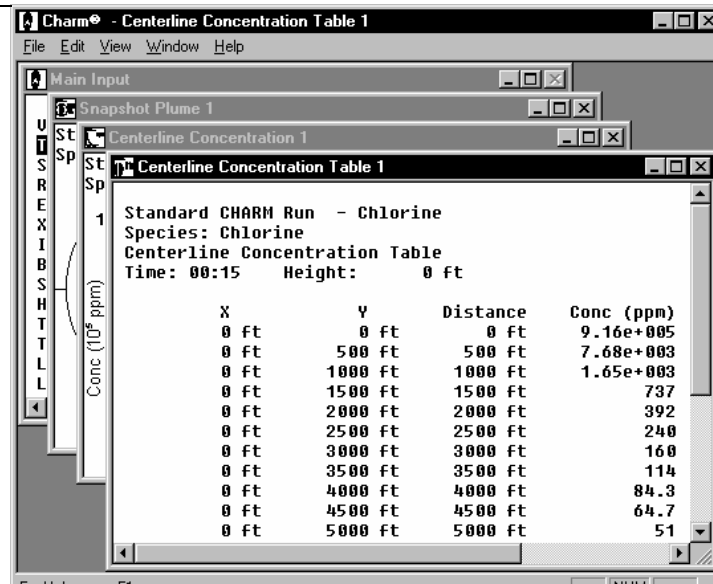
Enter the beginning and ending points of the line to lie along the centerline of the plume. You can also specify the concentration interval by which to show concentrations along the centerline. Figure 6.25 shows a sample Centerline Concentrations display. Use the File and Edit menu commands to print or copy the display respectively.

**Figure 6.25**  
Centerline  
Concentra-  
tion Plot



To display a centerline concentration table instead of a graph, select the Table command from the File Menu. To plot the log concentration instead of the actual value check the Log Plot option in the dialog box that contains the line and interval information. Figure 6.26 shows a sample Centerline Concentrations Table. Use the File and Edit menu commands to print, or copy the display respectively.

**Figure 6.26**  
Centerline  
Concentra-  
tions Table



If the concentrations are expected to vary over orders of magnitude, a centerline concentration table of values or log plot for the actual concentrations may be more informative than a linear graph. The centerline concentration table lists the concentrations (parts per million and micrograms per cubic meter) down the centerline of the plume as a function of distance (feet or meters). The table lists the X and Y positions, the distance from the source, and the concentration at each point. A positive X value indicates East and a negative X value indicates West. Similarly, a positive Y value indicates North a negative Y value indicates South. The concentration units are parts per million and micrograms per cubic meter. The concentrations are listed for the specified receptor height and do not necessarily include the maximum concentration.

### Plume Half-Widths Display

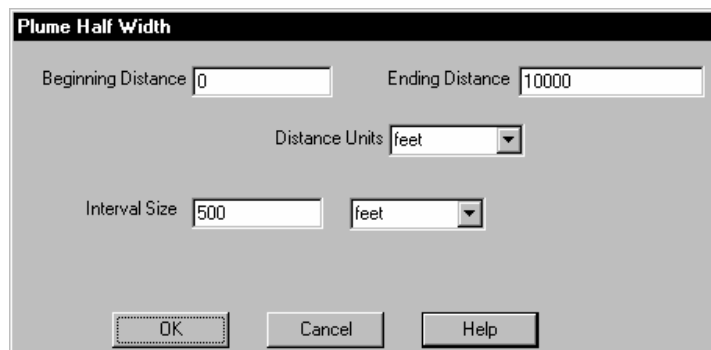
The Plume Half-Widths command on the Displays menu determines the crosswind half-width down the centerline of plume as a function of concentration. The user will be prompted for the downwind spacing of the points along the centerline for the half-width calculations.

Enter a concentration for plotting plume half-widths.

0.5 ppm

OK Cancel Help

Enter the desired concentration in parts per million or micrograms per cubic meter.

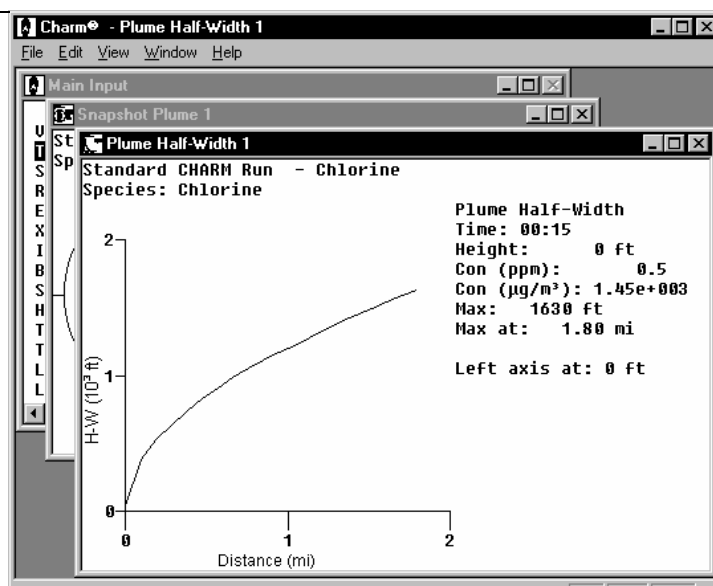


The image shows a software dialog box titled "Plume Half Width". It contains four input fields and three buttons. The "Beginning Distance" field is set to 0, and the "Ending Distance" field is set to 10000. The "Distance Units" dropdown menu is set to "feet". The "Interval Size" field is set to 500, and its corresponding dropdown menu is also set to "feet". At the bottom of the dialog are three buttons: "OK", "Cancel", and "Help".

Field	Value
Beginning Distance	0
Ending Distance	10000
Distance Units	feet
Interval Size	500
Interval Units	feet

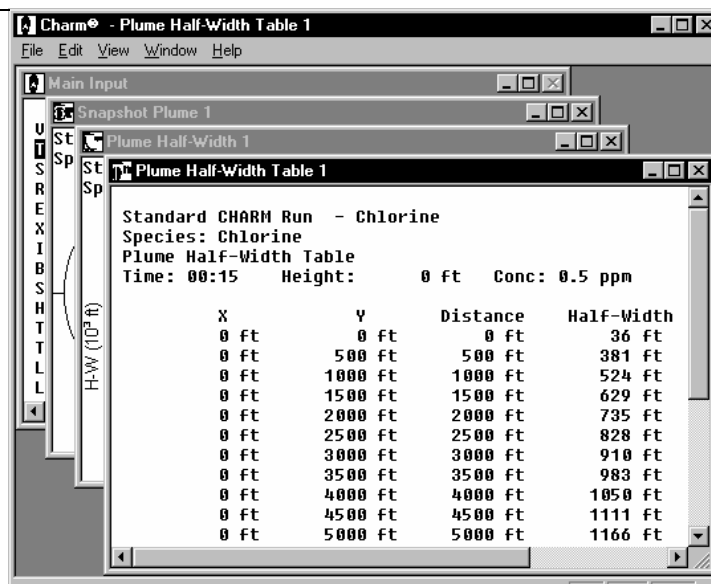
Enter the beginning and ending points of the line to lie along the centerline of the plume. Figure 6.27 shows a sample Plume Half-Width plot. Use the File or Edit menu commands to print or copy the graph.

**Figure 6.27**  
Plume Half-Width Plot



To display a plume half-width table instead of a graph, select the Table option from the File menu. Figure 6.28 shows a sample Plume Half-Width Table. Use the File and Edit menu commands to print or copy the display respectively.

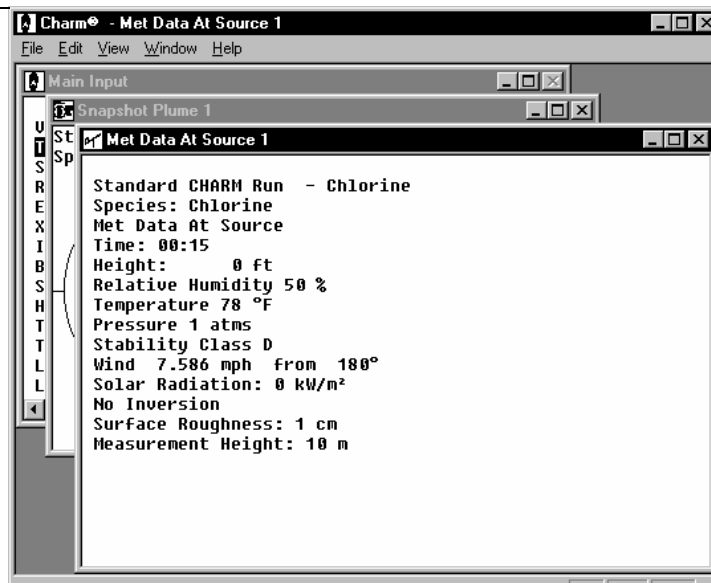
**Figure 6.28**  
Plume Half-Width Table



### Met Data Display

The Met Data command on the Displays menu shows the meteorological data at the source location. The values for the current receptor height and the time since release specified for the Snapshot Plan Plume View display are used. Figure 6.29 shows a sample Met Data display. Use the File and Edit menu commands to print or copy the display respectively.

**Figure 6.29**  
Met Data Display



### Integrated Area Display

The Integrated Area command on the Displays menu starts a minute by minute calculation of the snapshot plume and displays the Integrated Plan Plume View. The integrated plume display shows all areas

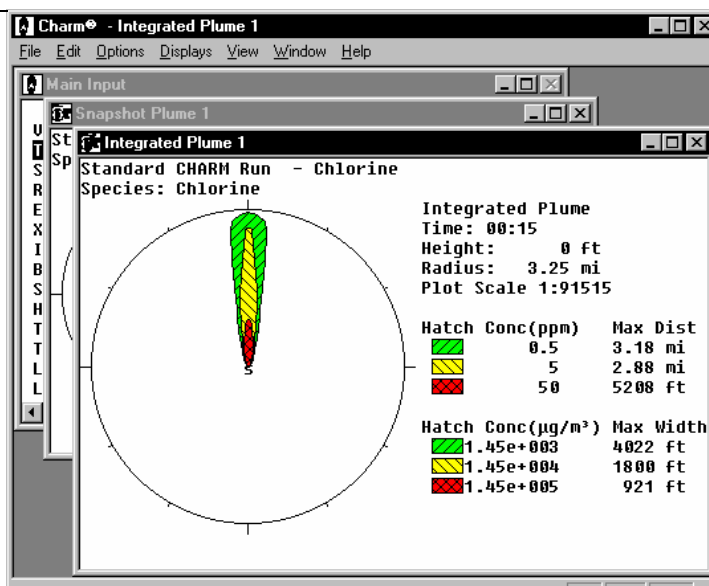


affected by the plume.

The integrated display looks similar to the Snapshot Plume View and has most of the same menus and commands. Refer to the previous section titled "Plan Plume View Displays" for descriptions of the commands on the Options and Displays menus.

The current isopleth concentrations are used for plotting at any time during the release and up to the most recent time requested. The time shown on the integrated plume display is the time currently being calculated. The calculation of area impacts are performed for every minute of the simulation. If the changes in the plume are much more rapid than every minute, the display may not be a smooth representation. Figure 6.30 shows a sample integrated plume.

**Figure 6.30**  
Integrated  
Plan Plume  
View



Since the calculation requires time, you can stop the calculation by selecting the Cancel button that appears in the plume window. A cancel takes effect after the latest minute's calculations are complete. Therefore, there may be some lag time before you see a cancel response.

The maximum concentrations at each area are displayed. If the wind shifts or the emission rate varies, the areas impacted can also vary. Once an integration calculation has been performed, moving between the Snapshot and Integrated Area plumes does not require new time calculations.

To continue the integration using the same time, select the Continue menu item from the Options menu. To create an integrated plume

using a different time, select the Recalculate menu item from the Options menu.

To generate a Dose Display plot (concentration history) at a specific point, move the cursor to the desired location. Then, double-click the left mouse button or press <Enter>.

To reposition the source within the view port, hold <Ctrl> while you press the appropriate arrow key one or more times. When you release <Ctrl>, the plume is repositioned. Each time you press an arrow key, the plume moves one-sixteenth of the dimension of the display area.

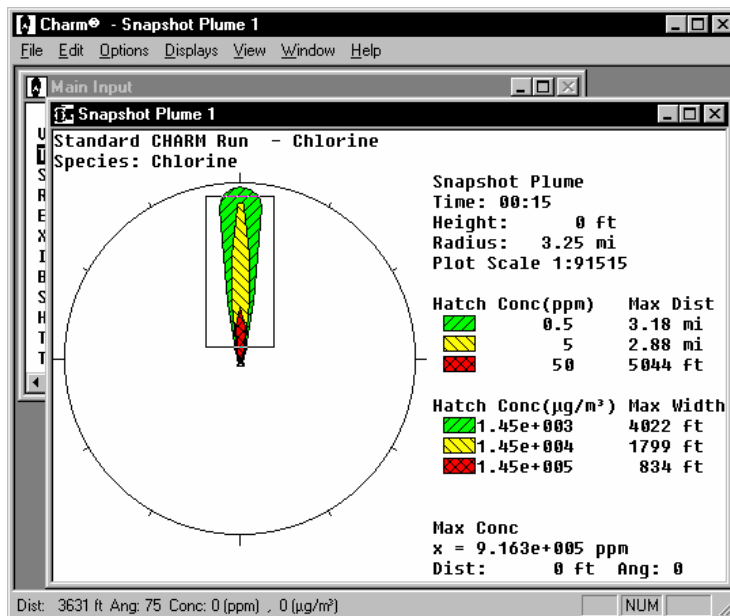
Use the File menu commands to save the release description input or met data in separate files, print the window, or plot the plume. Use the Copy command on the Edit menu to copy the display to the clipboard.

### **Time-Averaged Footprint**

The Time-Averaged Footprint command on the Displays menu shows a view of averaged concentrations at the specified time. The plume is a result of the source term and transport/dispersion calculations averaged over a user-specified time within a user-defined grid (see Averaging Time and Grid Resolution). The isopleth concentrations are represented by differing hatch marks and colors. The user has the option of selecting the entire plume for averaging or a user-defined area of the plume for averaging.

## Selected Area of a Time-Averaged Footprint

Selecting the Selected Area submenu on the Time-Averaged Footprint command of the Displays menu changes the cursor to a magnifying glass and requires the user to draw a rubberband box around the area of interest. To do this, find a point on the plume display, click and hold down the left mouse button, drag the mouse to create a rubberband box, and then release the left mouse button. CHARM will only consider those concentrations within the extents of the rubberband box for averaging.



## Averaging Time and Grid Resolution for a Time-Averaged Footprint

Selecting the Entire Plume Area or Select Area command from the Time-Averaged Footprint command requires the user to input the desired averaging time and the desired grid size.

**Averaging Time And Resolution**

Enter an averaging time and number of points in grid.

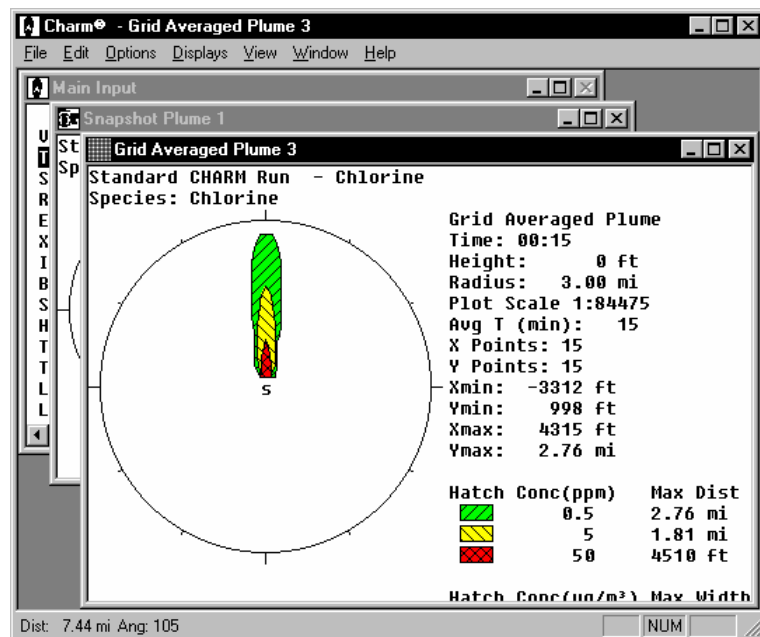
Averaging Time  Minutes

X Grid Points

Y Grid Points

The resulting display is a Time-Averaged plume based on this user-defined averaging interval and the user-defined grid size. See Figure 6.31 for example output of a Grid Averaged Plume.

**Figure 6.31**  
Grid  
Averaged  
Plume View



## Circular Population Impact

This command calculates the number of people affected by the listed concentrations, radiation fluxes, or overpressures within a user-

specified radius from the source. The user is initially prompted for the desired radius.

Enter the radius of the circle around the source for population calculation.

20 miles

OK Cancel Help

The number of people is normally determined from the population information available on US Census Bureau Tiger/Line™ 1992 Data.

If a population number is enclosed in brackets, that means that a failure occurred during calculation and the number given is a lower limit of the number of people impacted. This calculation failure occurs when CHARM can not resolve the intersection between the plume outline and a population tract. Often, however, it can be alleviated by changing the source location minutely. If the population number is -1 this indicates that only one population tract was impacted but an error was encountered.

The resulting display is independent of the footprint and only described by the population impacts within the user-specified radius from the source.

Standard CHARM Run - Chlorine  
Species: Chlorine  
Snapshot Plume  
Actual plume and population tract boundaries used  
Time: 00:15 Radius from source: 20 mi  
x: 0 ft, y: 0 ft

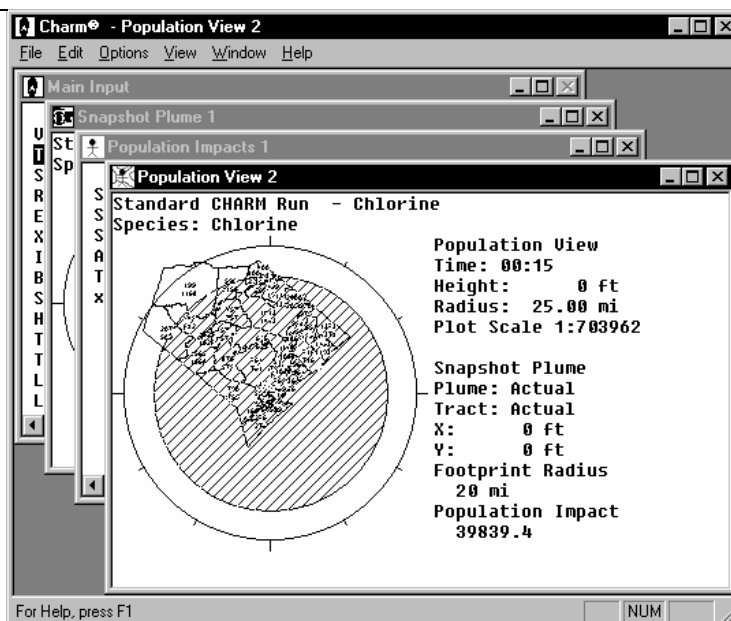
Population	Number
Total	3.98e+004
0 to 4	2.98e+003
5 to 9	3.38e+003
10 to 19	5.73e+003
20 to 49	1.87e+004
50 to 64	4.45e+003
65 and up	4.57e+003
White	3.24e+004
Black	2.95e+003

For Help, press F1

### Visual Verify (Population Impact)

From a Population Impact display, use the Visual Verify command on the Displays menu to illustrate overlaying the radius or footprint on to the population tracts that have been preprocessed in the TigerMap Utility and defined in the CHARM Editor (see Figure 6.32).

**Figure 6.32**  
Population  
Visual Verify  
View

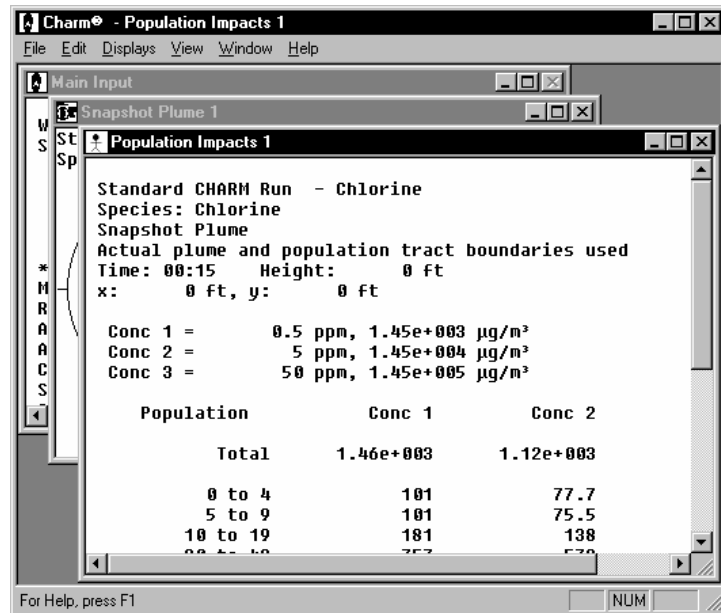


## Population Impact

Use the Population Impact command to calculate the number of people affected by the listed concentrations, thermal radiation, or overpressures. The number of people is normally determined from the population information available on U.S. Census Bureau Tiger/Line™ 1992 Data (see CHAPTER 8: Using the TIGERMAP Utility).

If a population number is enclosed in brackets, that means that a failure occurred during calculation and the calculated value is a conservative estimate of the number of people impacted. If the population is -1 then this indicates that only one population tract was impacted but a failure in the calculation was encountered. This failure occurs when CHARM can not resolve the intersection between the plume outline and a population tract. Often, however, the failure can be alleviated by slightly changing the source location. CHARM breaks down the impacted population by age, race, families, households, owners, and renters. Figure 6.33 show the results of a population calculation impact.

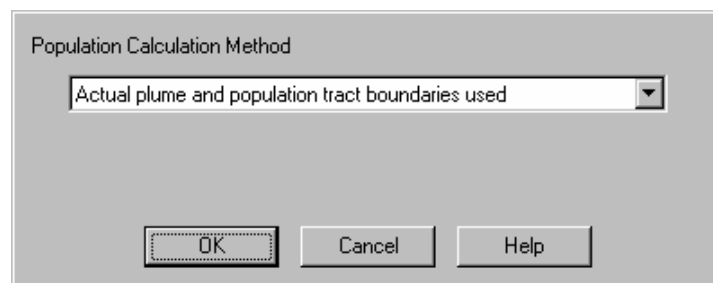
**Figure 6.33**  
Population  
Impact  
Display



The method of calculation can be changed by selecting the Population Calculation command from the Displays menu. Likewise, you can visually verify overlaying the footprint on to the population tracts that were preprocessed in the TigerMap Utility and defined in the CHARM Editor.

### Population Calculation

The method of calculating the population impacts can be selected from the Population Calculation command from the Displays menu. There are three methods of calculation.



#### I. Actual footprint and population tract boundaries used

Both the footprint and population tract boundaries will be used in the calculation. The calculated area of impact is the intersection of the footprint and the tract. This is the most accurate method. It can take the longest time and is the most prone to a failure in the calculation to determine intersection between the plume outline and the population tracts.

## II. Footprint rectangle and actual population tract boundaries used

The footprint is represented as its bounding rectangle. The tract boundary is used as determined from the Tiger/Line™ data. The calculated area of impact is the intersection of the footprint rectangle and the tract. This is the second most accurate method. It is designed to take less calculation time than the actual plume boundary being used. However, this is not always the case. It can also produce a failure in the calculation when determining the intersection between the rectangle inscribing the footprint and the population tract.

## III. Footprint and population tract rectangles used

Both the footprint and population tract are represented by their bounding rectangles. The calculated area of impact is the intersection of the footprint and tract rectangles. This is the least accurate method. It is the fastest calculation for determining population impacts and will never fail when determining the intersection between the rectangle inscribing the footprint and the rectangles inscribing the population tracts.

To invoke the selected population calculation method, select Population Impacts command in the Displays menu.

## Explosion Overpressures Display

The initial step in generating an explosion overpressure display is to first generate a plume containing sufficient lower explosive concentration limits to allow for deflagration or detonation of the plume. Deflagration occurs when the flame speed is slower than mach 1. Detonation occurs when flame speed is mach 1 or greater.

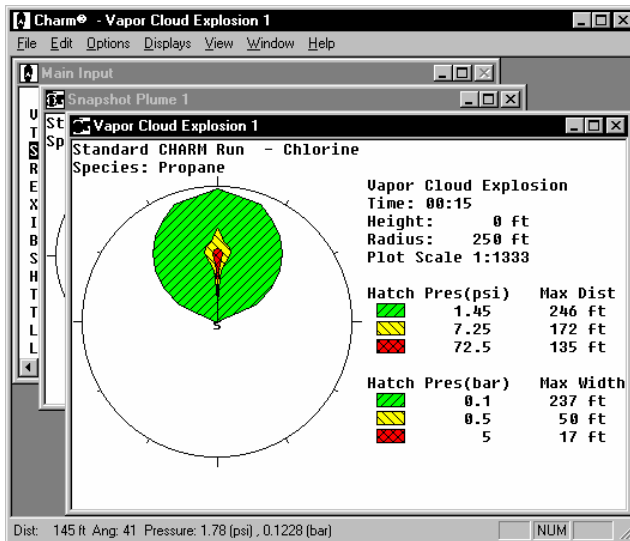
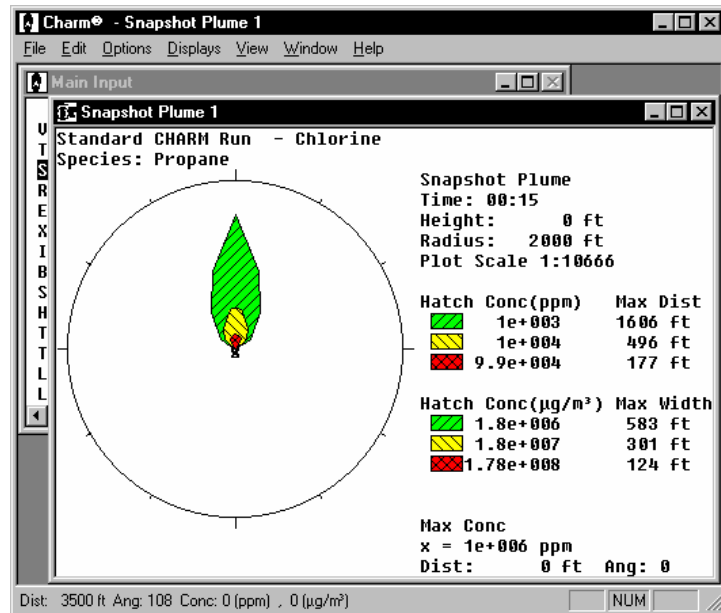
### Displaying Explosion Overpressures

Once a plume has been generated, selecting the Explosion Overpressures command on the Displays menu of the Snapshot Plan Plume View window shows the overpressure footprint resulting from ignition at the specified release time. It is an instantaneous view. Figure 6.34 illustrates a propane plume calculated by CHARM. Figure 6.35 shows the explosion overpressures resulting from the ignition of the plume.

---

**Figure 6.34**  
Plume View  
prior to  
Ignition





**Figure 6.35**  
Explosion  
Overpressure  
after Ignition

### Changing Potential Overpressures

This command is similar to modifying the isopleths from a Snapshot Plan Plume Display. However, in this case, the user has the option of modifying those potential overpressures which are displayed from the resulting explosion. Select Overpressures from the Options menu and the following dialog box appears.

Enter the overpressures.

Pressure 1	<input type="text" value="0.05"/>	Units <input type="text" value="bar"/>
Pressure 2	<input type="text" value="0.1"/>	
Pressure 3	<input type="text" value="0.5"/>	

### Changing Flame Speed

This command allows the user to use the default flame speed defined in the chemical database, modify that flame speed, or specify explosion characteristics from a table by specifying the Expansion Dimension, Mixture Reactivity, and Obstacle Density. If changes are made, the user has the option to reset the flame speed to the default in the chemical database.

**Flame Speed**

☒  Mach

☐ Specify Explosion Characteristics

Expansion Dimension

☒ 1-D ☐ 2-D ☐ 3-D

Mixture Reactivity

☒ High ☐ Medium ☐ Low

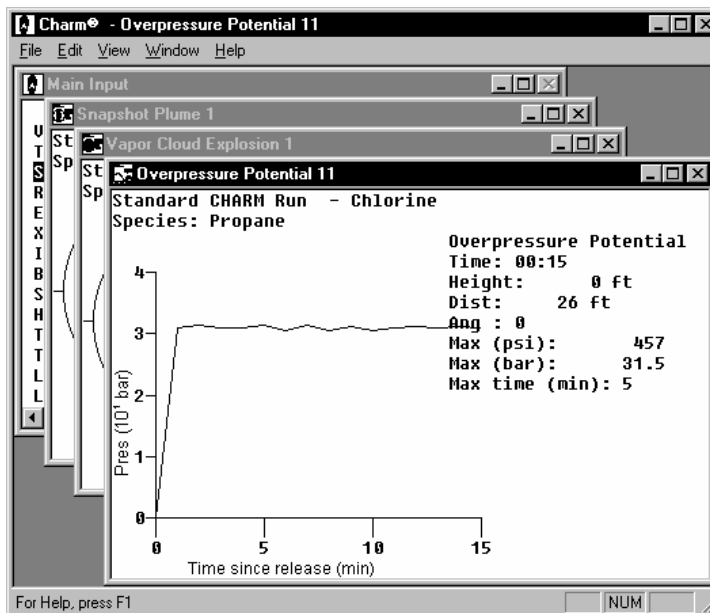
Obstacle Density

☒ High ☐ Medium ☐ Low

### Plotting Potential Explosion Overpressures Versus Time

To generate a plot of potential overpressures as a function of time at a specific location, move the cursor to the desired location. Then double-click the left mouse button or press <Enter>. An example is illustrated in Figure 6.36.

**Figure 6.36**  
Explosion  
Overpressure  
Potential



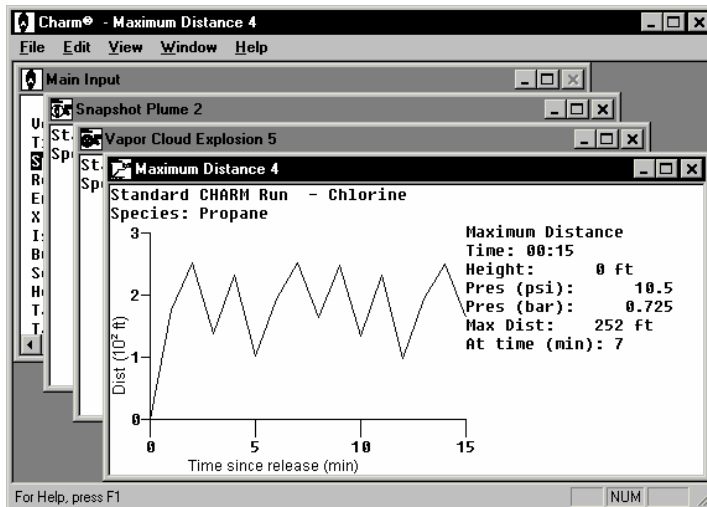
### Maximum Distance Overpressure Display

From the Explosion Overpressures display, you can display a maximum distance for an overpressure as a function of time. From the Displays menu, select Max Distance and CHARM will request a single overpressure value and unit for plotting.

The dialog box contains the text 'Enter an overpressure for plotting maximum distance.' Below this text is a text input field containing '0.05' and a dropdown menu showing 'bar'. At the bottom of the dialog are three buttons: 'OK', 'Cancel', and 'Help'.

Figure 6.37 shows the resulting Maximum Distance Overpressure Plot. The plot is also a function of the time calculated since release.

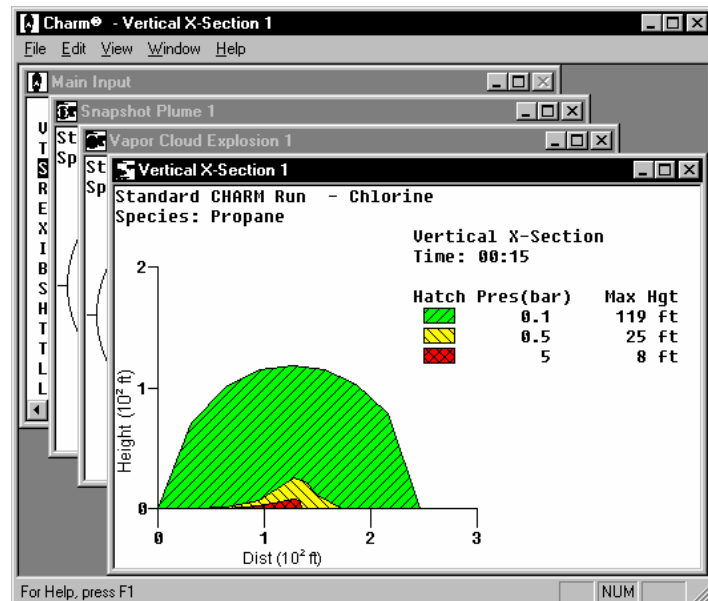
**Figure 6.37**  
Maximum  
Distance plot  
for Explosion  
Overpressures



### Displaying an Explosion Overpressures Footprint Cross-Section

From the Explosion Overpressures display, you can display a cross-section of the potential overpressures by selecting the Vertical X-section command from the Displays menu. Figure 6.38 shows the resulting X-section.

**Figure 6.38**  
Vertical  
Xsection of  
Explosion  
Overpressures



### Overpressure Damage Estimates

The following are the peak pressures formed in excess of normal atmospheric pressure by blast and shock waves:

<b>Overpressure (psi)</b> <b><u>Note: 1 bar = 14.5 psi</u></b>	<b><u>Expected Damage</u></b>
0.03	Occasional breaking of large windows already under stress.
0.04	Loud noise (143 dB); sonic boom glass failures.
0.10	Breakage of small windows under strain.
0.15	Typical pressure for glass failure.
0.30	Some damage to house ceilings; 10% window glass breakage.
0.40	Limited minor structural damage.
0.50-1.0	Windows usually shattered; some window frame damage.
0.7	Minor damage to house structures.
1.0	Partial Demolition of houses; made uninhabitable.
1.0-2.0	Corrugated metal panels fail and buckle. Housing wood panels blown in.
1.0-8.0	Range for slight to serious injuries due to skin lacerations from flying glass and other missiles.
1.3	Steel frame of clad building slightly distorted.
2.0	Partial collapse of walls and

**Overpressure (psi)**  
**Note: 1 bar = 14.5 psi**

**Expected Damage**

	roofs of houses.
2.0-3.0	Non-reinforced concrete of cinder block walls shattered.
2.3	Lower limit of serious structural damage.
2.4-12.2	Range for 1-90% eardrum rupture among exposed populations.
2.5	50% destruction of home brickwork.
3.0	Steel frame building distorted and pulled away from foundation.
3.0-4.0	Frameless steel panel building ruined.
4.0	Cladding of light industrial buildings ruptured.
5.0	Wooded utility poles snapped.
5.0-7.0	Nearly complete destruction of houses.
7.0	Loaded train wagons overturned.
7.0-8.0	8-12 in. thick non-reinforced brick fail by shearing of flexure.
9.0	Loaded train box cars demolished.
10.0	Probable total building destruction.
15.5-29.0	Range for 1-99% fatalities among exposed populations

**Overpressure (psi)****Note: 1 bar = 14.5 psi****Expected Damage**

due to direct blast effects.

Source: Lees, F.P, Loss Prevention in the Process Industries, Vo., 1, Butterworths, London and Boston, 1980.

**Input Display**

The Input command on the Displays menu shows the input data for the current CHARM run just as it appears in the Main CHARM Input Window. This display is for viewing only and no changes can be made. Use the File menu commands to print or copy the display. This menu item becomes very important when viewing or comparing different sets of output for different input parameters. An Input command under the Displays menu of many output displays will yield those input parameters used to obtain the given calculations.

**Source/Puff Description Display**

The Source/Puff Description command on the Displays menu shows the output of the source term calculation for the current CHARM run. This output contains a detailed description of each portion of a release. See Figures 6.6, 6.7, 6.8, and 6.9 for illustrations of the Source/Puff Description output.

During calculations, the release is divided into a number of puffs. The display includes the data used to describe each puff during the release. You can display the puff descriptions for several CHARM runs at the same time. use the File menu commands to print or copy the display.

Information from the Source/Puff Description display can be used as input for a user-specified release scenario, which requires a complete puff description. First, using a release type similar to the one you want to define, enter the required data in the input window. Next, display or print the Source/Puff Description. Then, using the User Specified After-Release Conditions release type, perform another CHARM run using the data from the Source/Puff Description printout as input. The data cannot be automatically inserted by the program; they must be manually entered into the Main CHARM Input Window.

**Emission Rate Display**

The Emission Rate command on the Displays menu shows a plot of the emission rate as a function of time throughout the release. The plot results from calculations using values from the CHARM run that created the current plan plume view. The Emission Rate display is the same as the display shown in the Main CHARM Input Window with the command of the same name. (see Figure 6.6 earlier in this chapter).

Use the File and Edit menu commands to print or copy the display respectively.

### **Site Information Display**

The Site Information command on the Displays menu shows a text file window created with the CHARM Editor. The text file contains information that is specific to the release site. It may contain useful information such as general response procedures, telephone numbers, and evacuation exits. The Site Information display is the same as the display shown in the Main CHARM Input Window (see Figure 6.1 earlier in this chapter). Site information text can be printed or copied to the clipboard using the File and Edit menu commands respectively.

### **Chemical Data Display**

The Chemical Data command on the Displays menu shows a text window containing the thermodynamic data and default isopleth concentrations stored in the chemical database for the selected species. The Chemical Data display is the same as the display shown in the Main CHARM Input Window with the command of the same name (see Figures 6.2, 6.3, and 6.4 earlier in this chapter). Chemical data can be printed or copied to the clipboard using the File and Edit menu commands respectively. It can be modified using the CHARM Editor.

### **Chemical Response Display**

The Chemical Response command on the Displays menu shows the emergency response information stored in the chemical database for the selected species. The Chemical Response display is the same as the display shown in the Main CHARM Input Window with the command of the same name (see Figure 6.5 earlier in this chapter). Chemical response text can be printed or copied to the clipboard using the File and Edit menu commands respectively. It can be modified using the CHARM Editor.

## **Displaying a Map**

The Basemap command on the Displays menu of the Main CHARM Input Window offers one way to display a map. When you select the Basemap command, CHARM displays a dialog box in which you can select the map to display. Press F1 or press the 'Help' button to display the on-line help screen.

To scroll a map display with a mouse, use the scroll bars. To scroll a map with the keyboard, use <Page Up>, <Page Down>, and arrow keys.

The Basemap display has menus that provides commands for zooming and unzooming a specified area, displaying another map,



displaying a larger scale map (if one is available), and displaying a map description.

### **File Menu**

The File menu for a map displayed with the Basemap command of the Main CHARM Input Window provides additional commands to those provided by the Options menu of the input window.

The commands available on the File menu for a map display are:

<b><u>COMMAND</u></b>	<b><u>SUMMARY</u></b>
<b>Open</b>	Displays a selection list of maps for display.
<b>Close</b>	Closes the Basemap display window.
<b>Larger Scale Map</b>	Displays a larger-scaled map that has been defined with the Map Definition command and named with the Expand map name command of the CHARM Editor.
<b>Exit</b>	Exits CHARM.

### **Options Menu**

The Options menu for a map displayed with the Basemap command of the Main CHARM Input Window provides additional commands to those provided by the File menu.

The commands available on the Options menu for a map display are:

<b><u>COMMAND</u></b>	<b><u>SUMMARY</u></b>
<b>Zoom</b>	Displays an enlargement of a specified map area.
<b>Unzoom</b>	Returns a zoomed map display to its original size when the window was opened.
<b>Map Description</b>	Displays a text description associated with the current map display. This text is for display only as it is editable from within the CHARM Editor.

## Zooming a Map Area

To zoom a portion of a map display, you must mark the area to be zoomed. First, select the Zoom option on the Options menu. The cursor changes from a pointer to a magnifying glass. Next, move the cursor to one corner of the area to be zoomed. If you are using a mouse, hold the left mouse button down, move the cursor to the opposite corner of the area to be zoomed, and release the button.

If you are not using a mouse, press <Enter> to mark the first corner of the zoom box, expand the box with the arrow keys, and press <Enter> again to complete the zoom box. The zoom display may not have a one-to-one correlation to the marked area. To return to the initial map display, select the Unzoom command from the Options menu.

## Displaying a Map From the Plan View Displays

Plumes, thermal radiation footprints, and overpressure footprints are considered plan view displays. The Map command on the Options menu of a plan view offers another way to display a map.

When the Auto Map Change command on the Options menu is selected, and the map display covers less than the fraction of the display area defined by the Auto Map Fraction command, CHARM automatically switches to a larger-scaled map (if one is defined). To turn off this feature, deselect Auto Map Change in the Options menu by clicking on it.

When the Auto Map Change command is not selected, you decide when to display the larger-scaled map. Use the Larger Scale Map command on the File menu to manually display the expanded map. In this case, the map must be defined and assigned an expanded map name using the CHARMED editor. Use the Expand Map Name command in the Map Definition editor to identify the larger-scaled map.

## Selecting an Icon on a Map

The map display may show icons that represent other map locations or possible release locations. These icons are positioned and defined with the Map Definition command of the CHARM editor. A map location icon looks like boxes within boxes.



A release location icon looks like a plume within a box.



Selecting an icon displays another map of the location or a selection list of releases at the location. To select an icon on a map in the Basemap display, move the cursor over the icon. If you are using a mouse, click either button. If you are not using a mouse, press <Enter>. To select an icon on a map in a footprint display, press and hold <Shift> while you move the cursor over the icon, and select the icon by double-clicking the left mouse button or pressing <Enter>.

When you select a map location icon, CHARM displays the map that has been defined for that location. This map may also have selectable icons representing other maps and releases.

When you select a release location icon on a map in the Basemap display, CHARM checks for automatic meteorological data from the time of the release to the present time. If no met data are available, CHARM displays a message that allows you to stop the run. If the run continues, CHARM performs calculations in one of two ways, depending on the mode of operation defined by the EmergencyMode variable in the CHARM.INI file. If EmergencyMode = 1 or is not defined, then CHARM will display a real-time footprint, updating the display minute by minute. If EmergencyMode = 0, CHARM calculations continue for the duration of the emission plus 30 minutes. Then the time used for the footprint display is the time at which the lowest value of interest (e.g. concentration) has maximum aerial extent.

### 3-Dimensional Plume

The 3D Plume command on the Displays menu of the Plan Plume View offers a method to view a concentration in 3 dimensions. CHARM initially requests a single concentration to display.

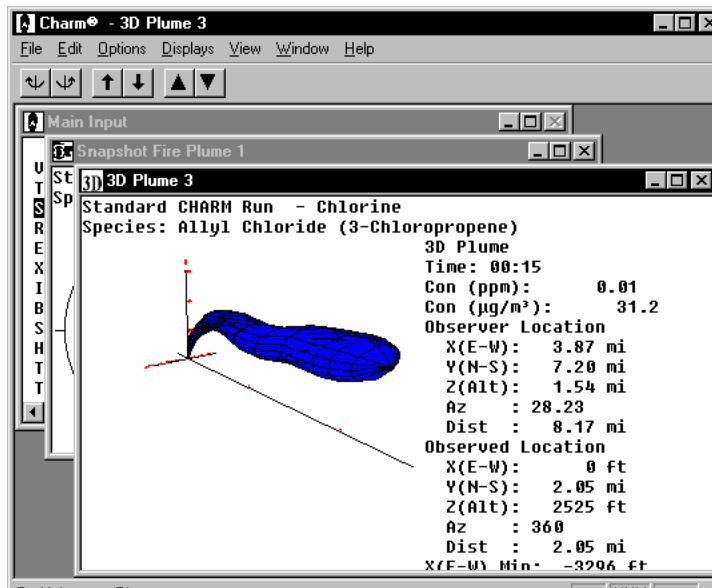
Enter a concentration for a 3D display.

0.01 ppm

OK Cancel Help

Once the concentration of interest has been entered, press the OK button and CHARM displays the 3D Plume Window. Figure 6.39 illustrates the 3D Plume Display

**Figure 6.39**  
3D Plume  
Display



This window presents a three-dimensional view of a concentration plume. Only one concentration may be viewed at a time. The observer location and observed location may be changed. The observed location is the point at the center of the observer's view. Tools can be used to move the observer around or away and towards the observed location. The observer can also go up and down. The tools are available either as icons on the toolbar or keystrokes.

### **Moving the Observer**

The observer can be moved with respect to the observed location. The observer can be moved around the point, closer to the point, and farther from the point. The observer can also move up and down. The observer can not move below surface level ( $z=0$ ). The observer can be moved via the mouse or keyboard.

#### **Moving via the Mouse**

Press the button icons on the toolbar. The tools represent up, down, near, far, left, and right.

#### **Moving via the Keyboard**

<b><u>Direction</u></b>	<b><u>Key</u></b>
Up	<Ctrl> + Up Arrow
Down	<Ctrl> + Down Arrow

Left	Left Arrow
Right	Right Arrow
Near	Up Arrow
Far	Down Arrow

### Setting the Observer Location

This dialog box allows you to change the location of the observer. The observer will continue to look at the same observed location from a different position. The observer's location can be specified in either Cartesian or cylindrical coordinates. Select the appropriate button for the desired coordinate system. When one coordinate system is selected, the other ignores user input although it will update as new coordinates are entered.

The x,y coordinate system is with respect to the release location. That is, the release location is (0,0) in Cartesian coordinates. The release location is at zero distance in cylindrical coordinates. The z or altitude value is with respect to ground level. The azimuth is given in the meteorological sense from the release location. The direction can be entered in degrees or in points of the compass. Degrees refer to the 360-degree directional compass, where North is 0 or 360, East is 90, South is 180, and West is 270. Points of the compass refer to North (N), East (E), South (S), West (W), and the points between, such as Northeast (NE) and South Southeast (SSE).

If you want to reset the location to what it was when the plume was initially drawn press the "Reset to Default" button.

### Setting the Observed Point

This dialog box allows you to change the location of the observed point. The observer will stay at the current position and look at this new observed location. The observed location can be specified in

either Cartesian or cylindrical coordinates. Select the appropriate button for the desired coordinate system. When one coordinate system is selected, the other ignores user input although it will update as new coordinates are entered.

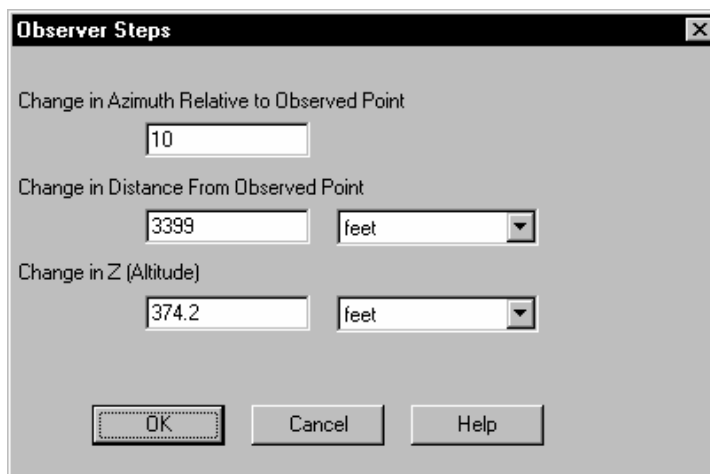
The image shows a dialog box titled "Observed Location" with a close button (X) in the top right corner. It contains two radio buttons: "Cartesian Coordinates" (selected) and "Cylindrical Coordinates". Under "Cartesian Coordinates", there are three input fields: "X(E-W)" with a value of "-0.00781", "Y(N-S)" with a value of "1.084e+004", and "Z(Altitude)" with a value of "2525". Each of these fields has a unit dropdown menu set to "feet". Under "Cylindrical Coordinates", there are three input fields: "Azimuth" with a value of "360", "Distance from Source" with a value of "1.084e+004", and "Z (Altitude)" with a value of "2525". Each of these fields also has a unit dropdown menu set to "feet". At the bottom of the dialog box, there are three buttons: "Reset To Default", "OK", "Cancel", and "Help".

The x,y coordinate system is with respect to the release location. That is, the release location is (0,0) in Cartesian coordinates. The release location is at zero distance in cylindrical coordinates. The z or altitude value is with respect to ground level. The azimuth is given in the meteorological sense from the release location. The direction can be entered in degrees or in points of the compass. Degrees refer to the 360-degree directional compass, where North is 0 or 360, East is 90, South is 180, and West is 270. Points of the compass refer to North (N), East (E), South (S), West (W), and the points between, such as Northeast (NE) and South Southeast (SSE).

If you want to reset the location to what it was when the plume was initially drawn press the "Reset to Default" button.

### Setting the Observer Step Distances

This dialog box allows you to change the stepsizes of the observer. There are three dimensions the observer can move in. The observer can move vertically (up and down from the ground), radially (closer or farther from the observed location), or azimuthally about the observed location. The values given in this dialog box define the increment to be taken every time a movement tool or appropriate key is pressed.



**Observer Steps**

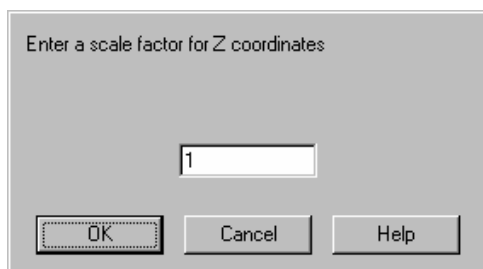
Change in Azimuth Relative to Observed Point

Change in Distance From Observed Point

Change in Z (Altitude)

### Setting the Z Scale

This dialog box allows the user to enter a dimensionless number to scale the plume z coordinates. Normally, a plume is much larger in the horizontal than the vertical direction. To make viewing easier the z values of the plume can be increased to make the vertical distribution easier to discern. CHARM attempts to provide a scale factor determined on plume dimensions. This scale will be seen when the scale factor given here is 1.0.

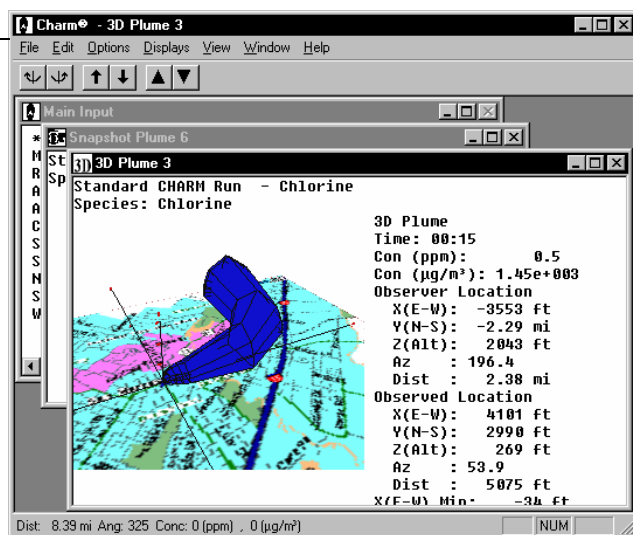


Enter a scale factor for Z coordinates

### Displaying a 2D Map in the 3D Plume View Display

Use the Map section of the Options menu from the 3D Plume Display to display a map. CHARM allows the user to overlay a 3D plume on a 2D map (see Figure 6.40).

**Figure 6.40**  
3D Plume  
Overlayed on  
2D Map





## Chapter 7: Using CHARM for Emergency Response

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Use CHARM's emergency response mode to quickly display stored maps of the release site, input data, plumes or footprints, tables, graphs, and other useful information. The emergency mode displays data resulting from input and calculations stored in the planning mode.

### Emergency Response Files

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CHARM's emergency response mode requires a map that has been edited with the CHARM Editor (CHARMED) and at least one release scenario that has been created and saved with CHARM. If CHARM was allowed to assign file name extensions when the files were stored, the default extension for map files is .MAP and the default extension for release scenario files is .EMG. The default extensions may be changed (see section 'CHARM.INI File Description' in CHAPTER 3: Getting Started). However, extensions other than these may have been assigned to the file name. For discussion purposes, this document refers to these files as .MAP and .EMG files.

### Map Files

When the CHARM program starts, it searches for a map file with the name BASEMAP.MAP and its corresponding definition file BASEMAP.MFD. If such files exist, the map is displayed immediately and the CHARM considers this to be in the Emergency Response Mode. If these files do not exist, CHARM automatically displays the Main CHARM Input Window in Planning Mode. From the Main CHARM Input Window, you can enter Emergency Response Mode by selecting a map display using the Basemap command on the Displays menu.

### Map Requirements

All maps used in CHARM must first be edited using the Map Definition command of the CHARM Editor (CHARMED.EXE). A point and scale must be specified for each map. To be useful in the emergency response mode, a map must be defined with at least one release location icon. This icon identifies the release scenarios that are defined at the location. The map may also have map location icons that point to smaller-scaled maps. A map may also have a larger-scaled map associated with it and also text information describing attributes associated with the map (e.g. the date that the map was last updated).

## Release Location Icons

If the map display has one or more release location icons, you can select an icon and display a list of stored scenarios. A release location icon looks like a plume within a box.



The scenario contains the input data. If the map has no release location icons, you can select a release using the Scenarios command on the File menu of the input window. For more information on creating, moving, and deleting release location icons, see 'Defining a Release Location' in CHAPTER 4: Using the CHARM Editor.

## Map Location Icons

If the map display has map location icons, you can select a map location icon and display a smaller-scaled map. A map location icon looks like boxes within a box.



Each map can point to another map. If the map has no map location icons, you can select a map using the New Map command on the Basemap menu of the input window. It is important the user define the larger-scale map of the map associated with the map icon such that it points back to the map utilizing the map icon. This will allow the user to go back and forth between larger-scaled and detailed maps. For more information on creating, moving, and deleting map location icons, see 'Defining a Map Location' in CHAPTER 4: Using the CHARM Editor.

## Release Scenario Files

The emergency response data files typically have the default .EMG file name extension. Files with the .EMG extension contain stored input data from a CHARM run, which is called a release scenario.

In the emergency response mode, CHARM displays the titles in a scenario selection list (.EMG files) when you click on a release icon on a map display. In planning mode, you can display the titles by selecting the Scenarios command from the File menu of the Main CHARM Input Window. You can select from the list in the dialog box.

## Emergency Response Mode Procedures

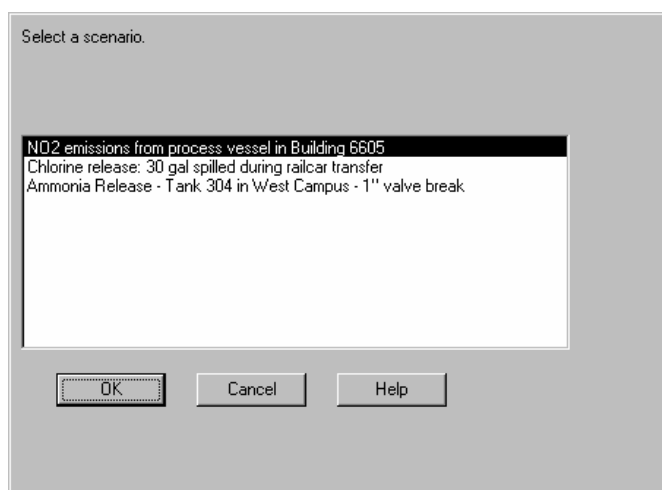
---

CHARM's emergency response mode is useful only when a base map has been defined with at least one release location icon. The emergency response mode requires that the input for at least one release has been previously stored in a scenario file.

To use the emergency response mode:

8. Start the CHARM program. The method you use to start CHARM depends on the system and the version of Windows you are using. Refer to Chapter 3, "Getting Started", for a description of these methods.
9. CHARM displays a base map (BASEMAP.MAP) if one is defined. Otherwise, CHARM displays the Main CHARM Input Window.

If the base map is displayed, look for release or map location icons. If the map has a release icon at the release site, select the icon to display a list of release scenarios. Since more than one map may define the release area, the base map may not have a release icon. Instead, the map may have one or more map location icons that you can select to display a smaller-scaled map of the area. Continue selecting map icons and looking for a release icon at the site. Select the icon to display a scenario selection list.

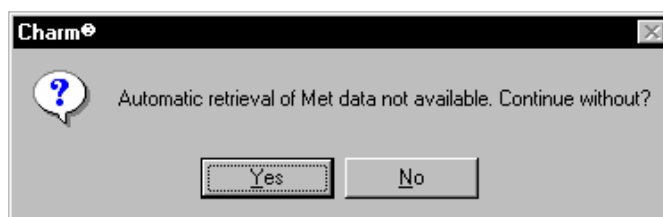


If the base map has no release or map location icons, select the Main Input from the Window menu to display the input window. Then, select the Scenarios command from the File menu to display the selection list.

If the Main CHARM Input Window is displayed instead of a map, you can select a map using the Basemap command on the Displays

menu. Then follow the procedures described previously, as if a base map was initially displayed.

10. If the Auto Met Polling command on the MetFile menu is not enabled, CHARM displays a dialog box indicating that automatic met data are not available.



Select OK or press <Enter> to continue calculations without automatic data, or select Cancel to stop. You may want to go to the Main CHARM Input Window and change the default met parameters.

If automatic met polling is available, CHARM displays a dialog box requesting the time of release in 24-hour clock time. Then CHARM begins performing the calculations. Depending on the mode of operation defined by the EmergencyMode variable in CHARM.INI, CHARM will proceed to calculate in one of two manners. If EmergencyMode = 1 or is not defined, then CHARM will display a real-time footprint, updating the display minute by minute. If EmergencyMode = 0, CHARM calculations continue for the duration of the emission plus 30 minutes. Then, the time used for the footprint display is the time at which the lowest value of interest (e.g. concentration) has maximum areal extent.

11. Use the commands on the Options and Displays menus to show the desired information. More than one display can be viewed on the same screen at a time. Refer to CHAPTER 6, "Understanding CHARM Displays," for detailed information.
12. Press the F1 key to access on-line help. CHARM displays those commands and procedures available for the Basemap window. Refer to Chapter 8, "Menu and Command Reference" for detailed information.

## **Real-Time Met Data Acquisition (METINTER)**

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METINTER.EXE is a separate standalone program which provides the interface between external meteorological data and the CHARM program. The program is represented by an icon with the sun, cloud, and rain in the CHARM group.

Each MetInter program has been customized for the specific meteorological data logger of file to be accessed. There are only a few options available in the program.

CHARMED must be run before MetInter will operate properly. CHARMED is used to define the Communications Parameters to be used by MetInter. See section “Setting the Communications Parameters” in CHAPTER 4: Using the CHARM Editor for more information.

MetInter uses the concepts of station and site. A station is a location which can be directly accessed or dialed up. A station may have data for multiple sites. MetInter can interface to a single station at any one time. The data from all the sites will be collected and stored. The data from only one site will be displayed in the MetInter Data Window. If the User Inverse Square command is selected from the MetFile menu in CHARM, then the data from all sites are used to determine the meteorological parameters at a specific point. Otherwise, only the data in the MetInter Data Window will be used by CHARM.

## The METINTER Window

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The METINTER window has only two menus: the Help Menu for acquiring on-line help, and the Options menu.

The Options menu provides a command for each of the following:

<b>Data Window Visible</b>	Makes the Data Window visible or invisible.
<b>Data Window on Top</b>	Forces the Data Window to always be displayed in front of all other windows.
<b>Select Met Station</b>	Allows the selection of which station MetInter should connect to.
<b>Select Met Site</b>	Allows the selection of which site at a station will have its data displayed in the Data Window.
<b>Exit</b>	Exits Metinter.

## Data Window Visible Command

This option toggles whether the Data Window is visible or not. If active the Data Window will be visible. If the Data Window on Top option is selected, then the Data Window will always be forced in front of all other windows. Otherwise the Data Window may be hidden by other windows. If the Data Window has been selected to be visible, then this option will have a check mark next to it.

## **Data Window on Top Command**

This option toggles whether the Data Window is always in front of all other windows or not. If active, the Data Window will be in front of all other windows, even those in another application. The Data Window Visible command must also be selected to see the Data Window. If the Data Window has been selected to be on top, then this option will have a check mark next to it.

## **Select Met Station Command**

Select the station for MetInter to connect to. See the section “Defining Stations ID’s” in CHAPTER 4: Using the CHARM Editor for more information on defining stations to be used with MetInter. Only one station can be connected with MetInter at any one time. The data from all other met stations may be lost (depending on the data logger at the station).

A station may have one or more sites connected to it. If the Use Inverse Square command from the MetFile menu has been selected in CHARM, the data from all the sites will be used to determine the meteorological data at any point. The data from one site can be displayed in the Data Window. The site which will have its data displayed is selected using the Select Met Site command.

## **Select Met Site Command**

Select which met site at the current station will have its data displayed in the Data Window. See the section “Defining Site ID’s” in CHAPTER 4: Using the CHARM Editor for more information on defining sites to be used with MetInter. Only one station can be connected with MetInter at any one time. Only one site at that station can have its data displayed in the Data Window. The station to connect to is selected by the Select Met Station command.

A station may have one or more sites connected to it. If the Use Inverse Square command from the MetFile menu has been selected in CHARM,

then the data from all the sites will be used to determine the meteorological data at any point. Otherwise, CHARM will use the data in the Data Window.

## Chapter 8: Using the TIGERMAP Utility

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CHARM has the capability of predicting population impacts based on U.S. Census Bureau Tiger/Line™ 1992 data. The TIGERMAP utility is a preprocessor which is used to extract only the information necessary for use with CHARM. The program reads U.S. Census Bureau Tiger/Line™ 1992 data (available on CD-ROM) and creates maps and/or population files. An icon for starting TIGERMAP is in the CHARM Group box.



Contact the U.S. Census Bureau directly for ordering the data files needed. Their number is (301) 457-4100. Once the TigerLine data has been preprocessed, files for use with CHARM must be selected in CHARMED (see section “Defining Population Files for Use With CHARM” in CHAPTER 4 “Using the CHARM Editor”). Once the files have been selected in CHARMED, select the Population Impacts command from the Displays menu on a footprint display in CHARM (see section “Population Impacts” in CHAPTER 6 “Understanding CHARM Displays”).

### The TIGERMAP Window

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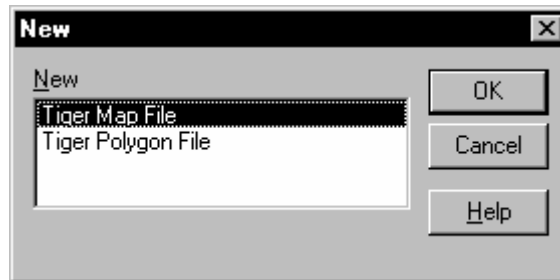
Like CHARM, the main TIGERMAP window is an MDI frame with several menus. The View and Help menus contain the standard commands found in other CHARM related programs. The File menu contains the following commands:

<b>New</b>	Creates a Map or Population window.
<b>Open</b>	Opens a preprocessed TigerMap Map or Population file.
<b>Recent File</b>	Shows up to the last four files used.
<b>Exit</b>	Exits TigerMap.

Selecting the New command will prompt the user for the type data to pre-process - geographical information or population data. Selecting



Tiger Map File will process geographical information while selecting Tiger Polygon File will process population tracts.



## Processing Tiger/Line Geographical Data

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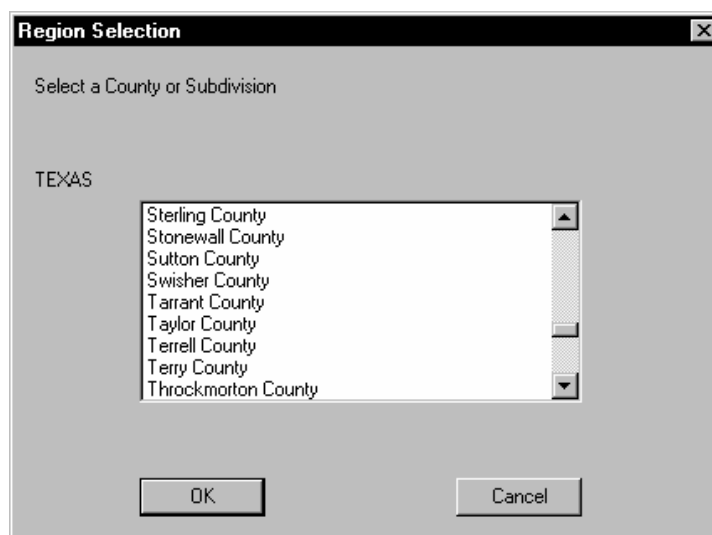
### File Menu

Once the New command has been selected or a data file has been opened with the Open command on the File menu, the TIGERMAP MDI menu bar changes appropriately. The following menu commands become available from the File menu for Tiger Map File:

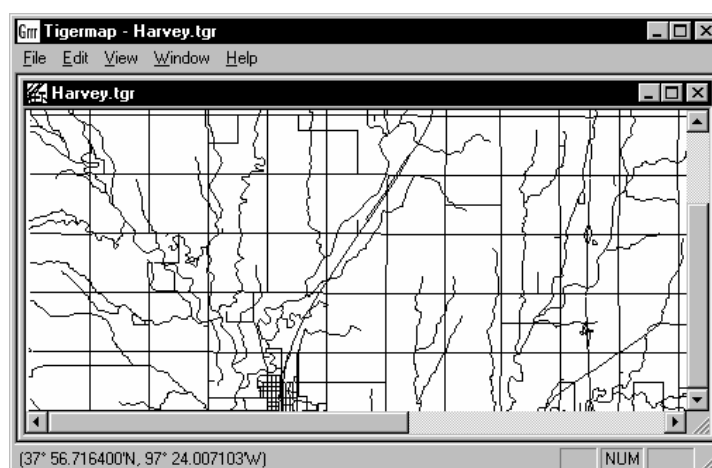
<b>New</b>	Creates a new map or polygon window.
<b>Open</b>	Opens an existing map or polygon file.
<b>Close</b>	Closes the active window.
<b>Save</b>	Saves an opened file using the same file name.
<b>Save As</b>	Save a file to a specified file name.
<b>Process Tiger Map</b>	Requests a state and county to process into a map.
<b>Merge Tigers To Clipboard</b>	Requests a number of map files to merge and send to the clipboard.
<b>Exit</b>	Exits TigerMap

## Process TigerMap Command

Use this command to create a map file in TigerMap. You will be asked to select the state and county or district to process.

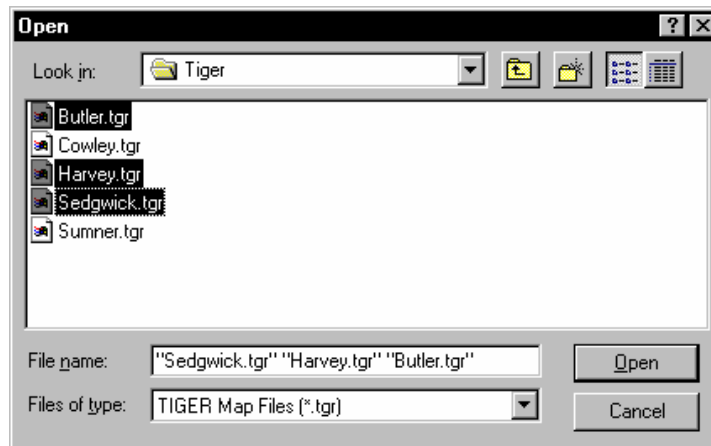


The Census data is on a county by county basis. Each county needed has to be processed separately. Later the maps of each county can be merged into one map with the use of the Merge Tigers To Clipboard command. The following figure illustrates output from processing the geographical information from Tiger/Line data.



## Merge Tigers to Clipboard Command

Use this command to merge a number of county maps into a single map. The following example dialog box displays pre-processed Tiger/Line map files for selection to be merged.



To select multiple files, hold down the <Ctrl> key while left mouse clicking on the desired .TGR files. Select Open and the resulting merged map will be sent to the clipboard where it can be accessed by the Map Definition Utility in CHARMED or a drawing program capable of accessing a Windows Metafile. You will be asked to select the files to process. When the merging is done the last county read is displayed. Each county map processing is done with the Process Tiger Map command.

## Edit Menu

The Edit menu offers the following commands:

<b>Zoom</b>	Displays an enlargement of a specified map area.
<b>Unzoom</b>	Returns a zoomed map display to its original size when the window was created/opened.
<b>Show Text</b>	Display text.
<b>Set Text Size</b>	If text is being displayed, set the size of text.
<b>Set Latitude/ Longitude Limits</b>	Use this command to define latitude and longitude limits to be used when creating a map file.
<b>Set Tiger Data Directory</b>	This dialog box allows you to define the location of the Census Bureau

CDROM data.

## Zoom/Unzoom Commands

Use this command to zoom a portion of the map display. Select the Zoom command from the Edit menu. The cursor changes from a pointer to a magnifying glass. Next, move the cursor to one corner of the area to be zoomed. If you are using a mouse, hold the left mouse button down, move the cursor to the opposite corner of the area to be zoomed, and release the button. During this process, notice that a rubberband box is drawn around the area that you intend to zoom until you release the left mouse button.

If you are not using a mouse, press <ENTER> to mark the first corner of the zoom box, expand the box with the arrow keys, and press < Enter> again to complete the zoom box. The zoom display may not have a one-to-one correlation to the marked area. To return to the initial map display, select the Unzoom command from the Edit menu.

## Show Text Command

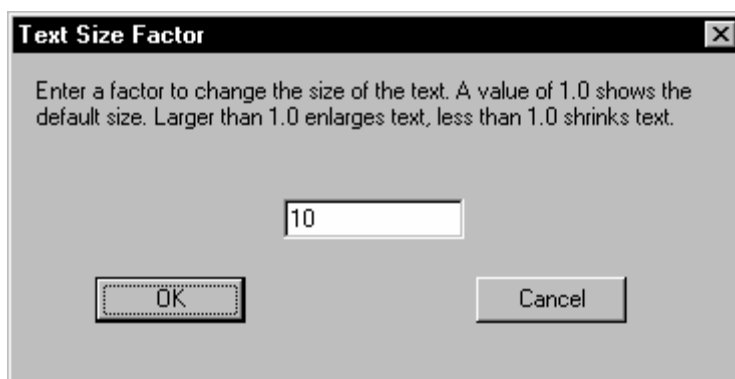
Use this command to have the text drawn with the map file. The text is the label for each object. The amount of text for a map can be quite large and take a long time for a redraw.

*Note: If this option is set, then text will be sent to the clipboard along with the rest of a map or polygon drawing. Sending text along with a map can make redrawing very slow.*

The text will not be drawn regardless if this option is selected or not if the drawn text would be too small to be seen legibly. The text size can be set by the Set Text Size command.

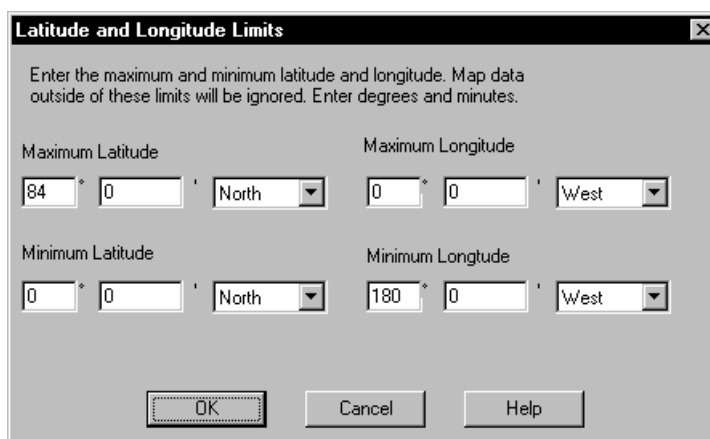
## Set Text Size Command

Use this command to set relative map text size. When a map file is first displayed a default text size is assumed. The default text size depends on the areal coverage of the map file. This option can be selected to change the size. The default size is 1.0. To double the text size use 2.0. To halve the text size use 0.5. Whether text is displayed at all can be controlled by the Show Text command.



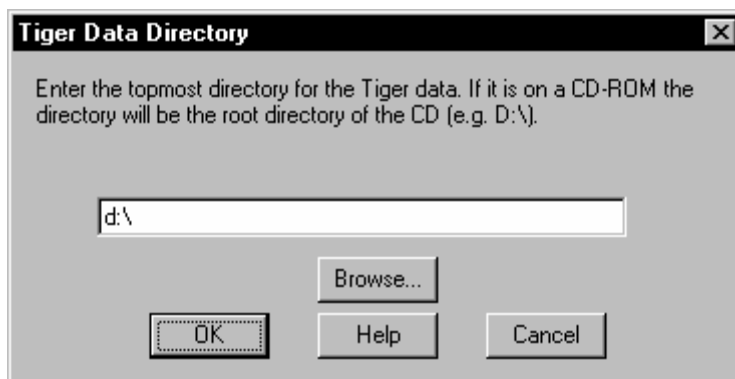
## Set Latitude/Longitude Limits Command

Use this command to define latitude and longitude limits to be used when creating a map file. If a feature lies completely outside of the limits it is not made part of the map. If part of a feature (e.g. street segment) is inside the limits it will be drawn.



## Set Tiger Directory Command

This dialog box allows you to define the location of the Census Bureau CDROM data. For example, if your CD is on drive D the directory would be D:\. Use the Browse button to search and set the drive and directory where the Tiger/Line data exists.



## Processing Tiger/Line Population Files

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### File Menu

Once the New command has been selected or a data file has been opened with the Open command on the File menu, the TIGERMAP MDI menu bar changes appropriately. The following menu commands become available from the File menu for Tiger Map File:

<b>New</b>	Creates a new map or polygon window.
<b>Open</b>	Opens an existing map or polygon file.
<b>Close</b>	Closes the active window.
<b>Save</b>	Saves an opened file using the same file name.
<b>Save As</b>	Save a file to a specified file name.
<b>Process Population File</b>	Requests a state and county to process into a population polygon file.
<b>Merge Pop Files To Clipboard</b>	Requests a number of population files to merge and send to the clipboard.
<b>Import Landview II Data</b>	Use this command to create a population polygon file in TigerMap. You will be asked to select the state and county or district to process. The Landview II data is on a county by county

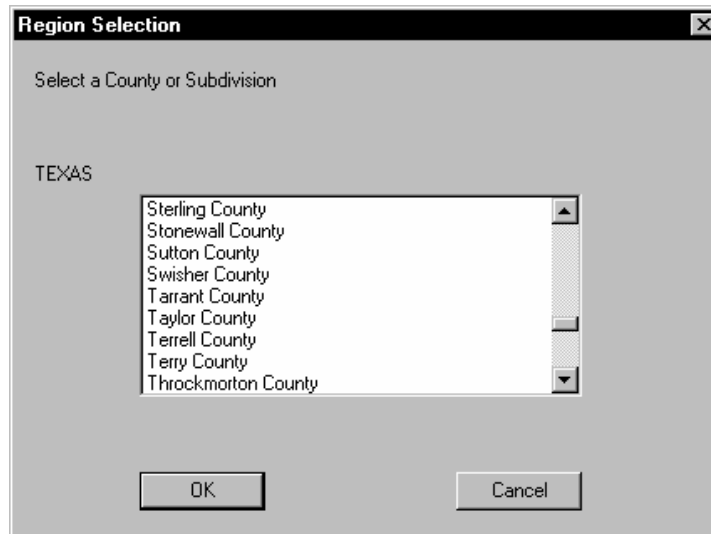
basis.

**Exit**

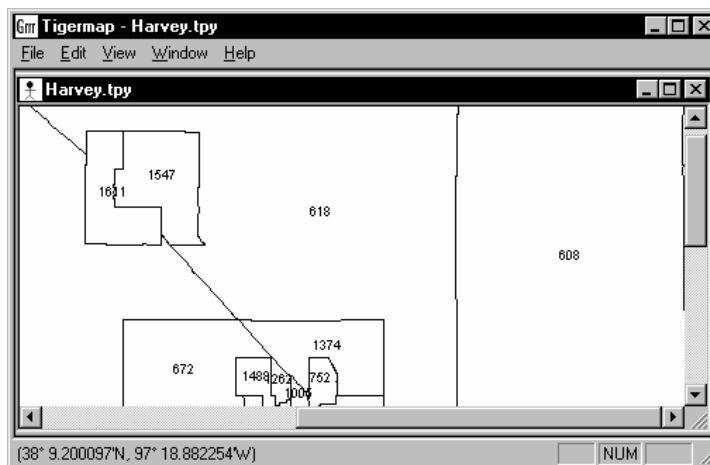
Exits TigerMap

## Process Population File Command

Use this command to create a population polygon file in TigerMap. You will be asked to select the state or county or district to process.



The Census data is on a county by county basis. Each county needed has to be processed separately. Later the polygon files of each county can be merged into a map with the use of the Merge Pop. Files To Clipboard command. More importantly these population files can be declared in CHARMED so that CHARM may use them to determine calculation impacts from a concentration, thermal radiation, or overpressure footprint. The following figure illustrates the results of processing the data.



The TigerMap Utility associates total number of people with each tract, along with some other data including age, race, home owners, and renters. Later in CHARM when determining population impacts, CHARM assumes that the total number of people in a tract is uniformly dispersed throughout the tract.

### **Merge Pop. Files To Clipboard Command**

Use this command to merge a number of county polygon population files into a map. The resulting map will be sent to the clipboard where it can be accessed by CHARMED or a drawing program capable of accessing a Windows Metafile. You will be asked to select the files to process. When the merging is done the last county read is displayed. Each county needs to be processed into a population file separately. County population processing is done with the Process Population File command.

### **Import Landview II Data Command**

Use this command to create a population polygon file in TigerMap. You will be asked to select the state and county or district to process. The Landview II data is on a county by county basis. Each county needed has to be processed separately. Later the polygon files of each county can be merged into a map with the use of the Merge Pop. Files To Clipboard command. More importantly these population files can be declared in CHARMED so that CHARM may use them to determine calculation impacts from a concentration, thermal radiation, or overpressure footprint.

The Landview II data can be put on your hard disk after purchasing a Landview CDROM by following the instructions provided. You can also download the data from the Internet. Simple instructions are:



1. Go to site <http://www.RTK.NET/landview>.
2. Select the desired County and State and press the Submit Query button.
3. If you want the complete Landview system download all the files and follow instructions.
4. If you only need the data for inclusion into CHARM you only need to download the Dbase files, the MARPLOT files, and the installation script.
5. Put the downloaded files into a directory for expansion.
6. Run the batch file lvinstal. Ignore any error messages.
7. Define the Data Directory in Tigermap as the directory where the files were expanded.

The batch file lvinstal will write over any files of the same names already in the directory.

For Tigermap to work the only files required are:

In the directory where the expansion occurred - states.dbf, counties.dbf, and cen\_blk.dbf.

Two subdirectories down (the county subdirectory) - censusb.sum and censusb.obj

## Edit Menu

The Edit menu offers the following commands:

<b>Zoom</b>	Displays an enlargement of a specified map area.
<b>Unzoom</b>	Returns a zoomed map display to its original size when the window was created/opened.
<b>Show Text</b>	Display text.
<b>Set Text Size</b>	If text is being displayed, set the size of text.
<b>Set Latitude/Longitude Point</b>	Defines a Latitude/Longitude point in the x/y Cartesian coordinate system to be used in CHARMED.
<b>Set Tiger Data Directory</b>	This dialog box allows you to define the location of the Census Bureau CDROM data.

## Zoom/Unzoom Commands

Use this command to zoom a portion of the map display. Select the Zoom command from the Edit menu. The cursor changes from a pointer to a magnifying glass. Next, move the cursor to one corner of the area to be zoomed. If you are using a mouse, hold the left mouse button down, move the cursor to the opposite corner of the area to be zoomed, and release the button. During this process, notice that a rubberband box is drawn around the area that you intend to zoom until you release the left mouse button.

If you are not using a mouse, press <ENTER> to mark the first corner of the zoom box, expand the box with the arrow keys, and press < Enter> again to complete the zoom box. The zoom display may not have a one-to-one correlation to the marked area. To return to the initial map display, select the Unzoom command from the Edit menu.

## Show Text Command

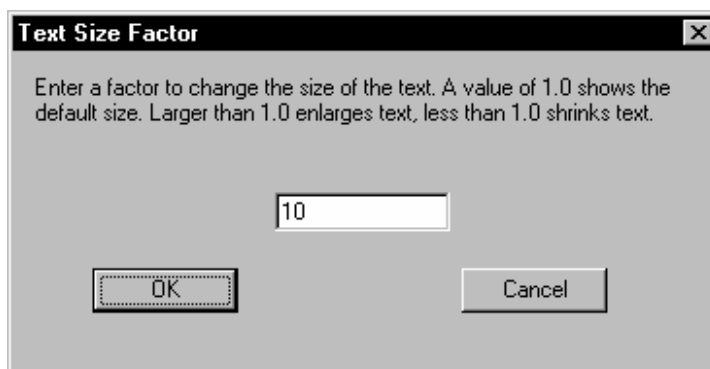
Use this command to have the text drawn with the tract data. The text is the population for each tract.

***Note: If this option is set, then text will be sent to the clipboard along with the rest of a map or polygon drawing.***

The text will not be drawn regardless if this option is selected or not if the drawn text would be too small to be seen legibly. The text size can be set by the Set Text Size command.

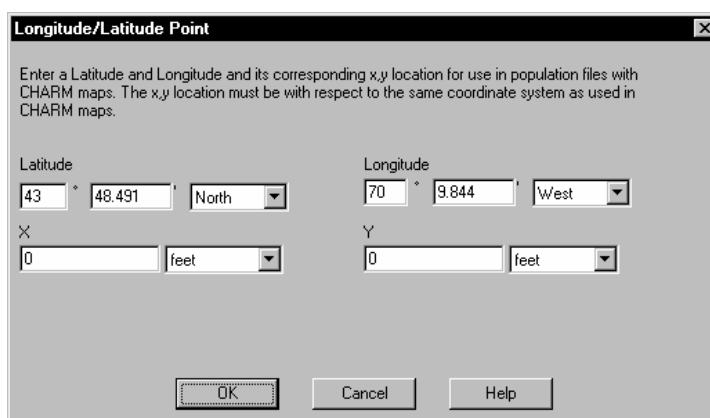
## Set Text Size Command

Use this command to set relative map text size. When a map file is first displayed a default text size is assumed. The default text size depends on the areal coverage of the map file. This option can be selected to change the size. The default size is 1.0. To double the text size use 2.0. To halve the text size use 0.5. Whether text is displayed at all can be controlled by the Show Text command.



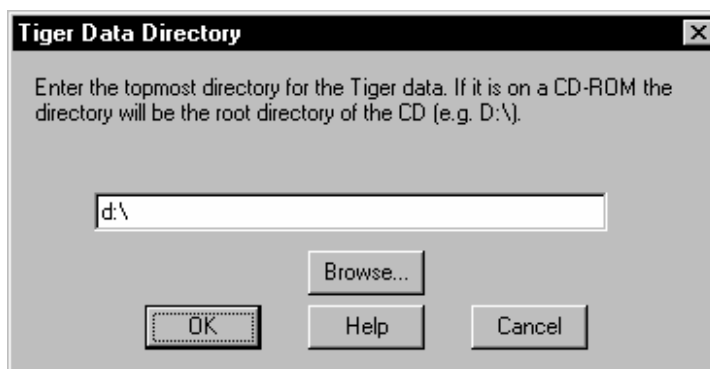
## Set Latitude/Longitude Point Command

Use this command to define latitude and longitude point which corresponds to a Cartesian coordinate in the reference frame used for defining the location of maps and release sites. This is required so that CHARM knows where the population polygons are with respect to a footprint.



## Set Tiger Directory Command

This dialog box allows you to define the location of the Census Bureau CDROM data. For example, if your CD is on drive D the directory would be D:\. Use the Browse button to search and set the drive and directory where the Tiger/Line data exists.

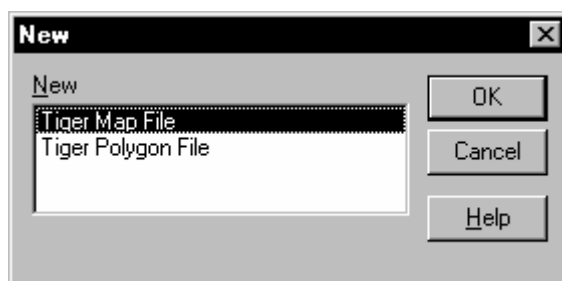


## Creating a Map File for Use With CHARM

---

To create a map for use with CHARM using U.S. Census Bureau Tiger/Line™ 1992 data, follow these steps:

1. Upon selecting New from the File menu, select TigerMap File from the New window.



2. Select the Process Tiger Map command in the File menu and press <OK>.
3. In the dialog boxes with follow, select the state and county to process. If only one state is available for selection, the state selection will be skipped.
4. Wait for the processing to be complete. This can take a very long time. Pressing cancel on the progress dialog box will stop the processing and all information will be lost.
5. Save the map file with the Save As command in the File menu.
6. Select the Merge Tigers To Clipboard command.
7. Run CHARMED®.

8. Select Map Definition in CHARMED.
9. Paste the map in the clipboard into CHARMED. See 'Defining Maps for Use with CHARM' in CHAPTER 4: Using the CHARM Editor for more information on defining the map.

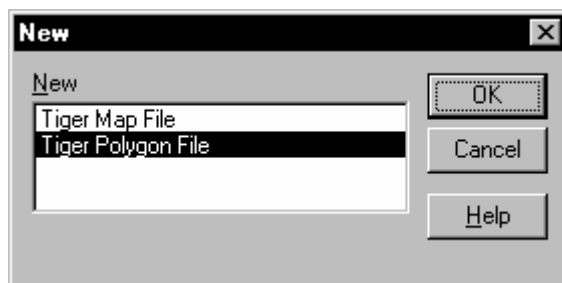
Once you have created and defined those files for use with CHARM using TIGERMAP and CHARMED, you can display the map two different ways in CHARM. For more information on displaying a map in CHARM, see CHAPTER 6 :CHARM Displays.

## Creating a Population File for Use With CHARM

---

To create a population file for use with CHARM using U.S. Census Bureau Tiger/Line™ 1992 data, follow these steps:

1. Upon selecting New from the File menu, select Tiger Polygon from the New window.



2. Select the Process Population command in the file menu.
3. In the dialog boxes which follow select the state and county to process. If only one state is available for selection, the state selection will be skipped.
4. Wait for the processing to be complete. This can take a very long time. Pressing cancel on the progress dialog box will stop the processing and all information will be lost.
5. Save the population file with the Save As command in the File menu.
6. Select the Merge Pop. Files To Clipboard command.
7. Run CHARMED®.
8. Define the population files(s) using the Select Population Files command in CHARMED.

Once you have created and defined those files for use with CHARM using TIGERMAP and CHARMED, you can calculate population impacts from a plan footprint display in CHARM.

For more information on calculating population impacts in CHARM, see CHAPTER 6 “CHARM Displays”.

## Chapter 9: Menu and Command Quick Reference

---

The purpose of this reference is to help you quickly find related information for CHARM menus and commands in this manual. The menus are listed in alphabetical order. The commands are listed as close as possible to their locations on the menus. Although this list provides a complete command listing, some commands appear only on the menus of specific CHARM displays, while other commands appear shaded on the menu and are not currently selectable. If a command is fully described in this reference, no page number is given. The menus will exist in CHARM, CHARMED, and/or the TIGERMAP Utility.

### Define Menu (Map Definition Window in CHARMED)

---

#### **Zoom**

**Page 73**

Displays an enlarged map of the specified area of the current map display.

#### **Unzoom**

**Page 73**

Returns a zoomed map area to its initial size when the window was opened.

#### **Change Default Size**

An unzoomed map size can be changed by entering a scale factor in a map window.

#### **Define Point**

**Page 74**

Define an x,y point of reference for a map you intend to display in CHARM.

#### **Define Scale**

**Page 75**

Display a scale for a map you intend to display in CHARM.

#### **Define Map Location**

**Page 77**

Place an icon on a map display that points to another map.

#### **Define Release Location**

**Page 78**

Place an icon on a map display that identifies the location of one or more defined release scenarios.

#### **Define Expand Map Name**

**Page 82**

Specify the name of a larger scaled map than the one being defined.

#### **Map Description**

**Page 79**

Allows the user to define pertinent information describing the currently displayed map.

## **Displays Menu (Main CHARM Input Window)**

---

When the Displays menu is selected, the cursor changes momentarily to an hour glass as CHARM calculates the source term.

### **Basemap**

**Page 160**

Displays a map which has been created with third party software and defined in the CHARM Editor CHARMED for use in emergency response mode.

### **Site Information**

**Page 161**

Displays a text file window containing site-specific information. This information may contain emergency phone numbers, evacuation routes, etc.

### **Chemical Data**

**Page 162**

Displays thermodynamic data and plot concentrations from the chemical database for the selected species.

### **Chemical Response**

**Page 163**

Displays a text window containing the emergency response information for the selected chemical species of interest.

### **Source/Puff Calculation**

**Page 164**

Displays the description resulting from the source term calculations using in the Main CHARM Input Window for data.

### **Emission Rate**

**Page 166**

Displays a plot of the emission rate as a function of time for the input data in the Main CHARM Input Window.

### **BLEVE Radiation**

**Page 166**

Displays a footprint of thermal radiation resulting from a fireball/BLEVE.

### **Pool Fire**

**Page 169**

Displays a submenu for selecting the footprint of the thermal radiation associated with the fire, or a plume of the unburned material of interest that makes it through the flames.

### **Jet Fire Radiation**

**Page 169**



Displays the footprint of thermal radiation resulting from a jet fire.

**Mechanical Overpressures** **Page 172**

Displays a footprint of potential overpressures from a bursting sphere.

**Plume** **Page 174**

Displays a snapshot view of the plume at the specified time after release.

## **Displays Menu (Plan Footprint View)**

---

**Maximum Distance** **Page 195**

Plots the maximum distance downwind of the specified concentration as a function of time.

**Maximum Width** **Page 197**

Plots maximum crosswind width of a user specified concentration as a function of time.

**Maximum Concentration** **Page 199**

Displays a table of maximum concentrations as a function of time.

**Vertical Xsection** **Page 200**

Plots a vertical cross-section through the middle of the plume. The line of sight runs from the release site through the middle of the initial puff.

**3D Plume** **Page 225**

Presents a three dimensional view of a concentration plume.

**Centerline Concentrations** **Page 201**

Plots the concentrations down the centerline of the plume as a function of distance.

**Plume Half-Widths** **Page 203**

Determines the crosswind half-width down the centerline of the plume as a function of concentration.

**Met Data** **Page 206**

Shows the meteorological data at the source location at the present receptor height and at the time specified for the Snapshot Plan Plume View display.

**Integrated Area** **Page 206**

Starts a minute by minute calculation of the plume display, showing all areas affected by the plume.

## **Time Averaged Footprint** **Page 208**

Displays a time averaged plume based on the user-defined averaging interval and the user-defined grid size. The user will be prompted for the averaging time and grid resolution. The user has the option of selecting an area of the footprint or the entire plume from a submenu.

## **Circular Population Impact** **Page 210**

Predicts population impacts using Census Bureau data. The impacted area is a circular region described by the user by specifying a radius out from the source location.

## **Population Impact** **Page 212**

Predicts population impacts using Census Bureau data. The number of people impacted depend on the Population Calculation type.

## **Population Calculation** **Page 213**

Select the type of calculation to use when predicting population impacts.

## **Explosion Overpressures** **Page 214**

Shows a footprint of potential overpressures if the displayed cloud ignited.

## **Input**

Shows the input data for the current CHARM run just as it appeared in the Main CHARM Input Window.

## **Source/Puff Calculation** **Page 164**

Shows the output of the source term calculation for the CHARM run that created the current plan plume view.

## **Emission Rate** **Page 166**

Shows a plot of the emission rate as a function of time throughout the release.

## **Site Information** **Page 161**

Displays a text file window containing site-specific information.

## **Chemical Data** **Page 162**

Displays thermodynamic data and plot concentrations from the chemical database for the selected species.

## **Chemical Response** **Page 163**

Displays a text window containing the emergency response information for the selected chemical species.

**Visual Verify****Page 211**

Displays the population tracts relative to the plume in order to visually verify that the plume indeed overlays the population tracts appropriately. The number of people affected within a tract will be displayed over the number representing the total population for that tract. If it is determined that the plume is not correctly overlayed on the population tracts, the user may adjust the inaccuracy by repositioning the plume or redefining the lat/long point within the TigerMap Utility.

## **Edit Menu (Plan Footprint Displays)**

---

**Copy**

Sends text and/or graphics in the current window to the Windows clipboard where it can be retrieved by other programs. If the window contains text only, all the text (visible or not) is sent to the clipboard. If the window contains graphics, a bitmap and a metafile representation of the visible contents of the window is sent to the clipboard.

**Change Run Title**

Changes the title of the CHARM run and all windows that are using the same data.

## **Edit Menu (TIGERMAP Utility)**

---

**Zoom****Page 242**

Displays an enlarged map of the specified area of the current map display.

**Unzoom****Page 242**

Returns a zoomed map area to its initial size when the window was opened.

**Show Text****Page 242**

Use this command to have the text drawn with the map or polygon file. If the drawing is a polygon file the text is the population for each polygon drawn at the geometric center of the polygon. If the drawing is a map file the text is the label for each object. The amount of text for a map can be quite large and take a long time for a redraw. The text will not be drawn regardless if this option is selected or not if the drawn text would be too small to be seen legibly. The text size can be set by the Set Text Size command.

**Set Text Size****Page 242**

Use this command to set relative map text size. When a map file is first displayed a default text size is assumed. The default text size depends on the areal coverage of the map file. This option can be selected to change the size. The default size is 1.0. To double the text size use 2.0. To halve the text size use 0.5. Whether text is displayed at all can be controlled by the Show Text command.

**Set Latitude/Longitude Limits****Page 243**

Use this command to define latitude and longitude limits to be used when creating a map file. If a feature lies completely outside of the limits it is not made part of the map. If part of a feature (e.g. street segment) is inside the limits it will be drawn.

**Set Latitude/Longitude Point****Page 249**

Use this command to define a latitude and longitude point which corresponds to a Cartesian coordinate in the reference frame used for defining the location of maps and release sites. This is required so that CHARM knows where the population polygons are with respect to a footprint.

**Set TIGER Data Directory****Page 249**

This dialog box allows you to define the location of the Census Bureau CDROM data. For example, if your CD is on drive D the directory would be D:\.

## **Edit Menu (CHARM Editor)**

---

**Chemical Database****Page 59**

Add, modify, or delete species data in the chemical database.

**Import Previous Database****Page 27**

Requests the path to the previous version of the CHARM database. Once the path is entered, CHARM will attempt to update the current database from those records in the previous database.

**Update Plot Concentrations****Page 27**

Requests the path to the previous version of the CHARM database. Once the path is entered, CHARM will attempt to update the default plot concentrations in the current database from those records in the previous database. The user will be prompted for verification.

**Pack Chemical Database** **Page 64**

Physically removes logically deleted records from the chemical database.

**Local Met Comm Parameters** **Page 66**

Sets the parameters for local communications with a meteorological tower.

**Network Met Server Location** **Page 28**

Requests the name/location of the server from which the meteorological interface will run.

**File Location** **Page 28**

Specifies where CHARM can find CHARM system required files.

**Site Information** **Page 64**

Allows site-specific information to be entered.

**Map Definition** **Page 72**

Reads maps to be defined for use in CHARM.

**Select Population Files** **Page 84**

Requests the names of the population files which were pre-processed using 1992 TigerLine Census Bureau data and the CHARM TIGERMAP Utility.

**Change Password** **Page 28**

Defines CHARM/System password to regulate CHARMED entry.

**Undo**

Undo the last text edit.

**Cut**

Remove the currently selected text from the active window and put it on the clipboard.

**Copy**

Copy the currently selected data from the active window and put it on the clipboard.

**Paste**

Insert a copy of the clipboard contents into the active window at the insertion point.

**Copy Data** **Page 37**

Copy the data in the Chemical Data Sheet to the clipboard in comma

delimited format in the order it is displayed in the Chemical Data Window.

### **Paste Data**

**Page 37**

Paste the comma delimited data from the clipboard into the Chemical Data Sheet in the order it is displayed in the Chemical Data Window.

### **Import From DIPPR**

**Page 37**

Displays a selection list of all the species in the DIPPR chemical database for import into the CHARM database.

### **Exit**

Exits CHARMED and closes the main CHARMED MDI window. If the Prompt at Exit command on the Options menu is selected, CHARMED will first prompt the user before exiting. If changes were made, the user is prompted as to whether or not the changes should be stored. The Exit command functions the same in CHARMED as it does in other Windows programs.

## **File Menu**

---

### **Emergency Response Text**

**Page 61**

Modifies emergency response text that is specific to the chemical of interest in the CHARM Editor.

### **Monochrome**

**Page 200**

Remove the color from the vertical cross-section, thereby displaying only the hatch marks.

### **Table**

View the current plot as records of numbers.

### **New**

**Page 94**

Restores all the values on the Main CHARM Input Window to their default values.

### **Open**

**Page 94**

Displays a dialog box requesting the name of an input file to open.

### **Copy**

Sends text and/or graphics in the current window to the Windows clipboard where it can be retrieved by other programs. If the window contains text only, all the text (visible or not) is sent to the clipboard. If the window contains graphics, a bitmap and a metafile representation of the visible contents of the window is sent to the clipboard.

### **Scenarios**

**Page 94**

Displays a selection list of the titles of release scenarios created and stored previously in CHARM.

### **Save**

**Page 96**

Saves the input data from the Main CHARM Input Window.

### **Save As**

**Page 96**

Displays a dialog box in which you can enter the name of the file being saved.

### **Save Input As**

Saves the release description input data for the current plan plume view under a different, user-specified file name.

### **Save Met As**

Saves the meteorological input data for the current plan plume view under a different, user-specified file name.

### **Print**

Prints all the text contained in the current window, whether the text is visible or not. This is a standard command for most text windows. For graphics windows, this command will print the display in the current window.

### **Print Preview**

**Page 97**

Prints all the text and graphics contained in the current window. This is a standard command for most text windows.

### **Printer Setup**

**Page 97**

Allows the user to change the current printer configuration.

### **Save As Default**

**Page 93**

Saves the current scenario described in the CHARM Input Window as the default scenario.

### **Close**

Closes the active CHARM window in the CHARM MDI. Select the Exit command (described below) to terminate CHARM.

### **Larger Scale Map**

**Page 189**

Displays a larger-scaled map that has been defined and assigned an expanded map name.

### **Process Population File**

**Page 245**

Use this command to create a population polygon file in TigerMap. You will be asked to select the state and county or district to process.

The Census data is on a county by county basis. Each county needed has to be processed separately.

### **Import Landview II Data** **Page 246**

Use this command to create a population polygon file in TigerMap. You will be asked to select the state and county or district to process. The Landview II data is on a county by county basis. Each county needed has to be processed separately.

### **Merge Pop Files to Clipboard** **Page 246**

Use this command to merge a number of county polygon population files into a map. The resulting map will be sent to the clipboard where it can be accessed by CHARMED or a drawing program capable of accessing a Windows Metafile. You will be asked to select the files to process. When the merging is done the last county read is displayed. Each county needs to be processed into a population file separately. County population processing is done with the Process Population File command.

### **Process Tiger Map** **Page 250**

Use this command to create a map file in TigerMap. You will be asked to select the state and county or district to process. The Census data is on a county by county basis. Each county needed has to be processed separately. This command has been removed.

### **Merge Tigers to Clipboard** **Page 250**

Use this command to merge a number of county maps into a single map. The resulting map will be sent to the clipboard where it can be accessed by CHARMED or a drawing program capable of accessing a Windows Metafile. You will be asked to select the files to process. When the merging is done the last county read is displayed. Each county needs to be processed into a map separately. County map processing is done with the Process Tiger Map command. This command has been removed.



**Exit**

Exits CHARM and closes the main CHARM MDI window. If the Prompt at Exit command on the Options menu is selected, CHARM will first prompt the user before exiting. If changes were made, the user is prompted as to whether or not the changes should be stored. The Exit command functions the same in CHARM as it does in other Windows programs.

## Help Menu

---

**Help**

Offers you help on the current task or command.

**Index**

Offers an index to topics on which you can get help.

**Using Help**

Provides general instructions on using help.

**Search for Help On**

Displays a list of keywords used in CHARM from which a list of related topics may be displayed.

**About**

Displays the version number and standard information required by Windows. This is a standard Windows command.

## MetFile Menu

---

**New****Page 99**

Restores all met data fields to their default values.

**Open****Page 100**

Displays a dialog box requesting the name of a met file to open.

**Save****Page 101**

Saves the current met data in a user-specified file.

**Save As****Page 101**

Saves the met data under a different, user-specified file name.

**Save As Default****Page 99**

Saves the current met data described in the CHARM Input Window as the default met data.

### **Solar Radiation Worksheet** **Page 101**

Use a worksheet to determine solar radiation value. Solar radiation is a function of latitude/longitude, cloud cover, time of day, and the day of the year.

### **Automatic Poll** **Page 101**

Initiates conversation between CHARM and the met interface (METINTER.EXE) to automatically read stored meteorological data.

### **Stop Poll** **Page 100**

Signals CHARM to stop real-time data acquisition.

### **Use Inverse Square** **Page 100**

Invokes inverse square weighting algorithm for use with multiple sites when using real-time data acquisition.

### **Calculate Solar Radiation** **Page 100**

Calculates the solar radiation as real-time met data is acquired.

## **Options Menu (Main CHARM Input Window)**

---

### **Prompt At Exit** **Page 103**

Switch to prompt the user before exiting CHARM.

### **Time is Minutes-Seconds** **Page 103**

Switch to run CHARM in Minutes/Seconds mode or Hours/Minutes mode.

## **Options Menu (Basemap Window)**

---

### **Zoom** **Page 224**

Displays an enlarged map of the specified area of the current map display.

### **Unzoom** **Page 224**

Returns a zoomed map area to its initial size when the window was opened.

### **Map Description** **Page 188**

Allows the user to view pertinent information describing the currently displayed map.

## Options Menu (Plan Footprint Displays)

---

### **Recalculate**

**Page 208**

Recalculated the impacted area from the beginning on an Integrated Area Display.

### **Continue**

**Page 207**

Continues simulation of the currently displayed plume integration on an Integrated Area Display.

### **Overpressures**

**Page 173**

Specifies up to three pressure values for the three distances shown on an Overpressure footprint display.

### **Distances**

**Page 174**

Specifies up to three distances from the source for the pressure and energy flux values shown on a BLEVE Thermal Radiation or Mechanical Overpressures footprint display.

### **Energy Fluxes**

**Page 167**

Specifies up to three energy flux values for the three distances shown on a BLEVE Thermal Radiation display.

### **Isopleths**

**Page 180**

Specifies the concentrations plotted on plume displays, graphs, and tables.

### **Averaging Time**

**Page 181**

Enter the averaging time in minutes from 1 to the present plot time for a time averaged plume. The average taken is the running average. The concentrations at a specific point are averaged over time to determine a time-weighted average.

### **Grid Size**

**Page 182**

Enter the number of points to be used in the grid when generating a Time-Averaged Plume. The grid is 2-dimensional and, therefore, the user must enter the number of points in the X direction (East/West) and the Y direction (North/South).

### **Time Averaged Footprint**

**Page 208**

Displays a time averaged plume based on the user-defined averaging interval and the user-defined grid size. The user has the option of selecting an area of the footprint or the entire plume from a submenu.

**Show Grid****Page 182**

This option removes/shows the user-defined grid for the Time-Averaged Plume. A check by the menu item displays the grid, whereas no check by the menu item indicates the option is not active and the grid is not visible.

**Grid Display****Page 182**

If the Show Grid option is on, this option displays the user-defined grid for the Time-Averaged Plume as a series of points or as a wire mesh. A check by either menu item indicates this option is turned on, whereas no check by the menu item indicates the option is not active and the grid points are not visible.

**Scale Radius****Page 183**

Changes the radius of the view port (solid circle) on the plume display according to a user-specified scale.

**Scale Ratio****Page 184**

Changes the radius of the view port according to a user-specified ratio.

**Distance Circles****Page 184**

To supplement the display of a plan view, additional circles can be drawn for a given radial increment within the large circle.

**Receptor Height****Page 185**

Specifies the height above ground of the display.

**Transparency****Page 185**

Changes the display from a colored, opaque plume to a "ghost" plume denoted only by concentration hatch marks, thereby allowing the map areas beneath the plume to be seen.

**No Hatch****Page 185**

A toggle indicating whether or not the hatch marks on a footprint display and in the legend are displayed. A check by the menu item indicates this option is turned on, whereas no check by the menu item indicates the option is not active and the hatch marks are visible.

**Use Auto Scale****Page 186**

A toggle switch indicating that CHARM will automatically scale the display to show the entire footprint whenever aspect changes are made to the display. A check by the menu item indicates this option is turned on, whereas no check by the menu item indicates the option is not active and that CHARM will automatically scale the display.

**Decay****Page 186**

Specifies the time (half-life) required for half of the emitted material to decay into neutral products.

**Map****Page 186**

Displays a dialog box in which you can select a map to display.

**No Map****Page 187**

Removes current map from display.

**Location****Page 187**

Relocates the source of the release on the current map display.

**Map Description****Page 187**

Displays pertinent information describing the currently displayed map.

**Reset Source****Page 188**

Resets the position of the source to the center of the view port.

**Auto Map Change****Page 188**

Enables CHARM to automatically display a larger-scaled map when the scale of the current map display is not large enough to cover a significant portion of the plot area. If checked, CHARM will attempt to select the map with best coverage.

**Auto Map Fraction****Page 188**

Defines the fraction of the footprint display area which must be covered by a map to preclude CHARM from trying to go to a larger scale map.

**Larger Scale Map****Page 189**

Displays the larger-scaled map associated with the current map.

**New Time****Page 189**

Specifies the time since release for the footprint display.

**Time Circles****Page 189**

Draws dashed circles around the source that indicate the location to which the current wind speed can move a parcel of air from the source in the number of minutes specified.

**Replay**

Once a Snapshot Plan Plume View display has been generated, the user may display the plume at every minute (or every second if Time mode is Minutes-Seconds) up to the current time since release. The user may cancel the automation at any time before the current time since release by hitting the <Cancel> button in the display window..

**Create ASCII File****Page 190**

Generates a file to hold a description of a footprint of impact (concentration, thermal radiation, or overpressure) which can be transferred to other programs.

**Create Shape File****Page 193**

This command enables the user to generate a file which describes a footprint of impact (concentration, thermal radiation, or overpressure) which can be transferred to ArcView for display.

**Observer Location****Page 227**

Change the location of the observer in a 3-dimensional display of a plume.

**Observed Point****Page 227**

Change the location of the observed point in a 3-dimensional display of a plume.

**Observer Step Distances****Page 228**

Change the incremental stepsizes of the observer when altering the location of the observer in a 3-dimensional display of a plume.

**Z Scale****Page 229**

Enter a dimensionless number to scale the plume z coordinates in the 3-dimensional plume display.

**Monochrome****Page 183**

Remove the color from the 3D Plume view, thereby displaying only the 3D frame.

## **View Menu**

---

**Status Bar**

The status bar is displayed at the bottom of the CHARM window. To display or hide the status bar, use the Status Bar command in the View menu.

The left area of the status bar describes actions of menu items as you use the arrow keys to navigate through menus. This area similarly shows messages that describe the actions of toolbar buttons as you depress them, before releasing them. If after viewing the description of the toolbar button command you wish not to execute the command, then release the mouse button while the pointer is off the toolbar button.

The right areas of the status bar indicate which of the following keys are latched down:

<b><u>Indicator</u></b>	<b><u>Description</u></b>
CAP	The Caps Lock key is latched down.
NUM	The Num Lock key is latched down.
SCRL	The Scroll Lock key is latched down.

## **Window Menu**

---

### **Cascade**

Arranges multiple opened windows in an overlapped fashion.

### **Tile**

Vertically arranges multiple opened windows in a non-overlapped fashion.

### **Arrange Icons**

Use this command to arrange the icons for minimized windows at the bottom of the main window. If there is an open window at the bottom of the main window, then some or all of the icons may not be visible because they will be underneath this window.

### **1, 2, ...**

CHARM displays a list of currently open windows at the bottom of the Window menu. A check mark appears in front of the name of the active window. Choose a window from this list to make it the active window.

## Appendix A: Enhancements in CHARM Ver. 9.1

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Functional software changes in CHARM Version 9.1 that are not found in CHARM Version 9.0 include the following:

- RMP distance is calculated for thermal radiation displays.
- For (x,y) plot displays, the user may toggle a mesh grid on or off.
- CHARM now supplies the user with container information as a species exits the container.
- CHARM displays a list of the five most recently opened scenario files in the File menu in the Main CHARM Input.
- CHARM displays a list of the five most recently opened meteorological files in the Met File menu in the Main CHARM Input Window.
- When using a Container/Surface Release Type, CHARM will calculate the pool diameter/area using a depth of 1 cm to comply with RMP specifications.
- Depending on the chemical, the solar radiation used for liquid evaporation may not be used completely for evaporation purposes.
- You may define a time schedule for user-defined stability classes under the meteorological parameters.
- You can execute the MS Windows Calculator program from within CHARM to do necessary calculations quickly and easily.
- CHARM version 9.1 comes with documentation inserts into the version 9.0 User's Manual, and updated on-line help, which includes information taken from quarterly training sessions.

### RMP Distance

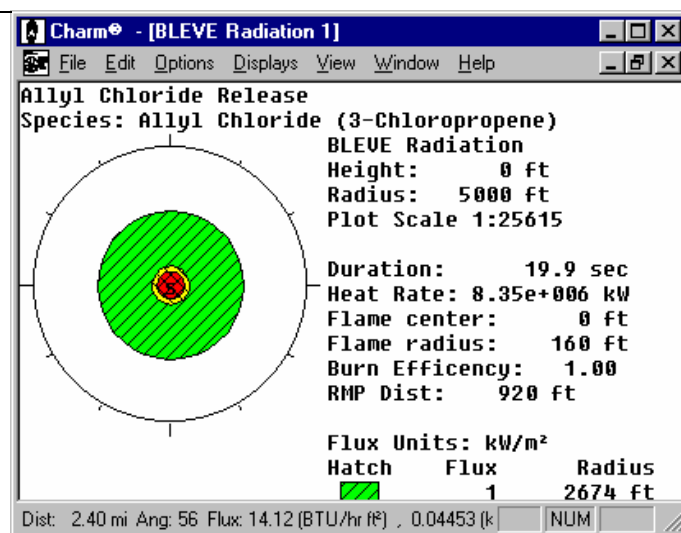
---

Risk Management Planning (RMP) dictates that flammables must be modeled and a distance determined at which 5 KW/m<sup>2</sup> is attained for 40 seconds. RMP distance is calculated in Fireball/BLEVE, Jet Fire, and Pool Fire Thermal Radiation displays. Figures A-1 - A-3 illustrate where the RMP distance is displayed in each output.



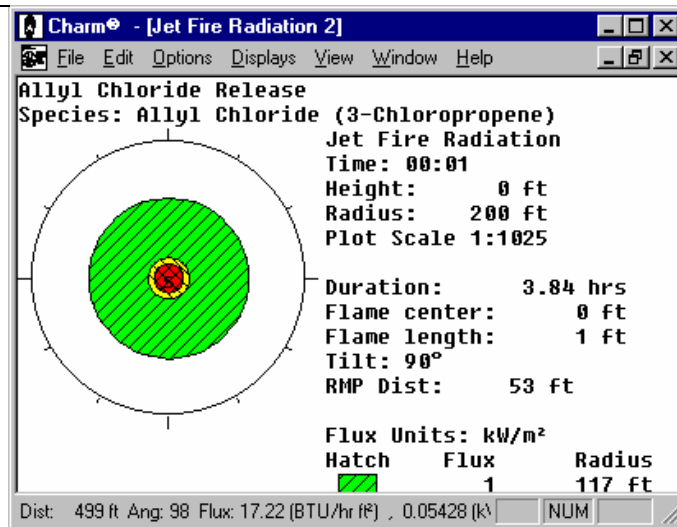
**Figure A-1**

BLEVE  
Display  
Illustrating  
RMP  
Distance

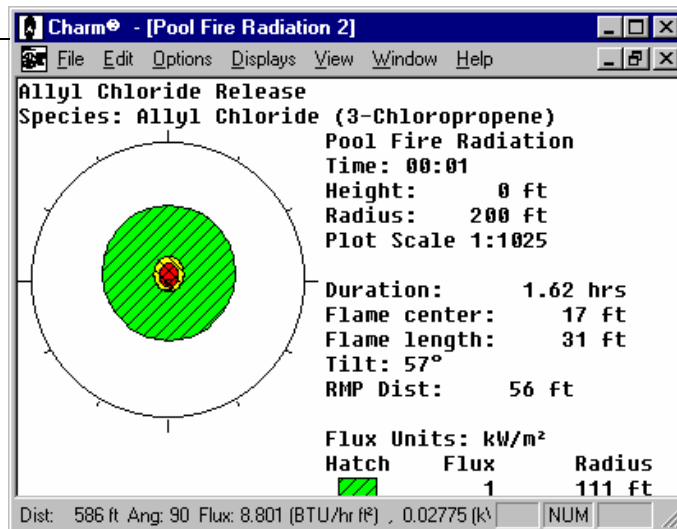


**Figure A-2**

Jet Fire  
Display  
Illustrating  
RMP  
Distance

**Figure A-3**

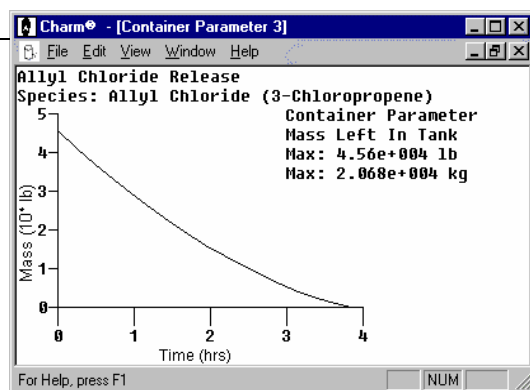
Pool Fire  
Display  
Illustrating  
RMP  
Distance



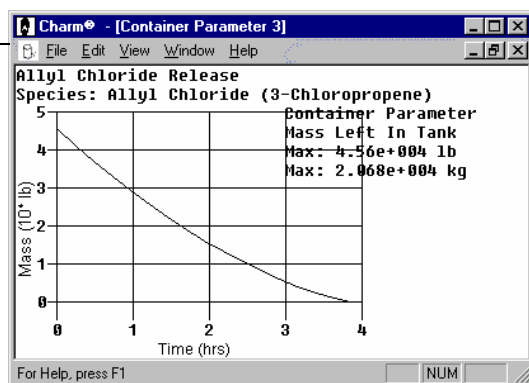
## Grid Plots

For all (x,y) plot displays, the user may toggle a mesh grid on or off by selecting/deselecting the 'Grid Plot' menu item under the 'File' menu. Figures A-4 and A-5 illustrate the mesh grid as it is (not) displayed on a plot.

**Figure A-4**  
Example of  
Plot with  
Grid OFF



**Figure A-2**  
Example of  
Plot with  
Grid ON

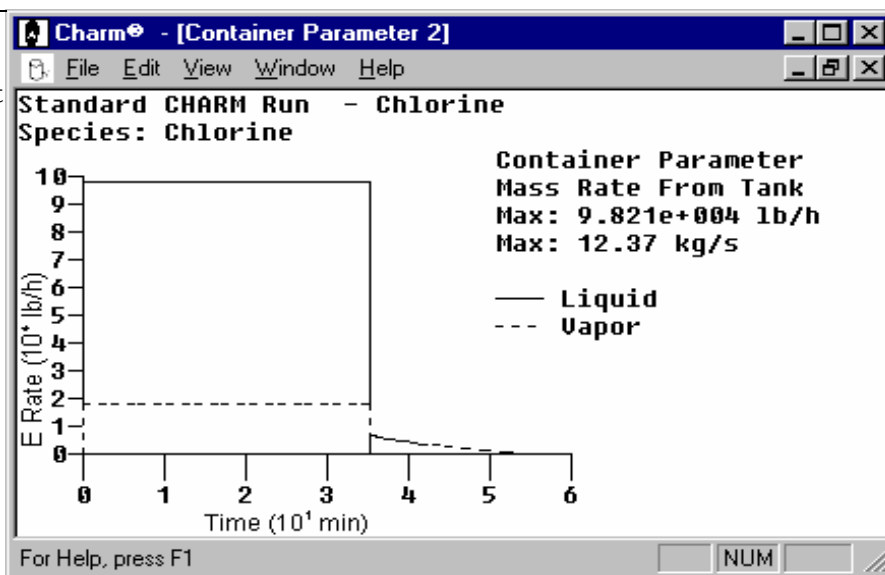


## Container Information

CHARM now supplies the user with container information as a species exits the container. The output may be displayed in graphical or tabular format.

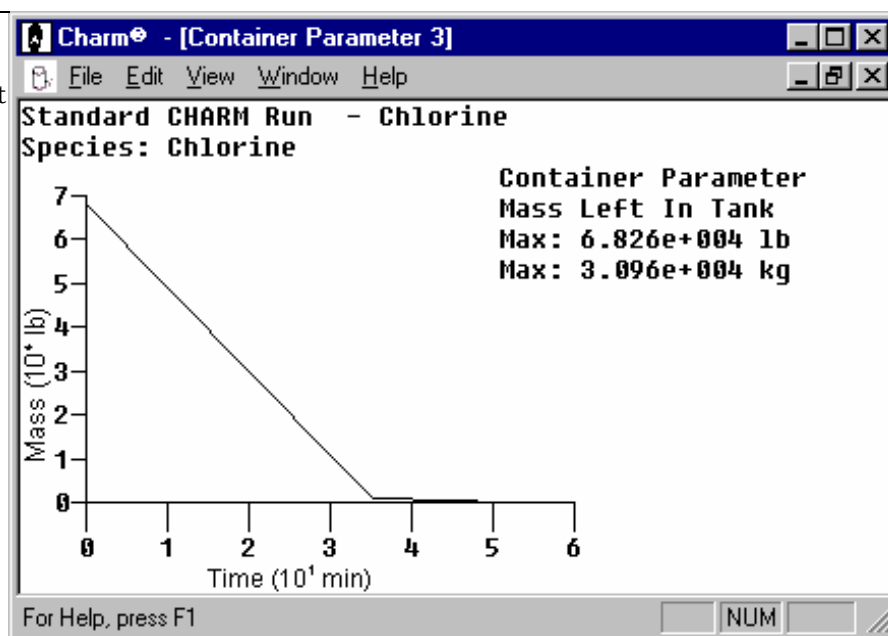
To generate a Mass Rate vs. Time Plot, select the 'Container Info' menu item from the 'Displays' menu located on the Main CHARM Input Window menu bar, or on any footprint display menu bar. Select the sub-menu item labeled 'Mass Rate'. Figure A-6 illustrates a plot of the mass rate exiting from a container as a function of time.

**Figure A-6**  
Mass Rate  
vs. Time Plot



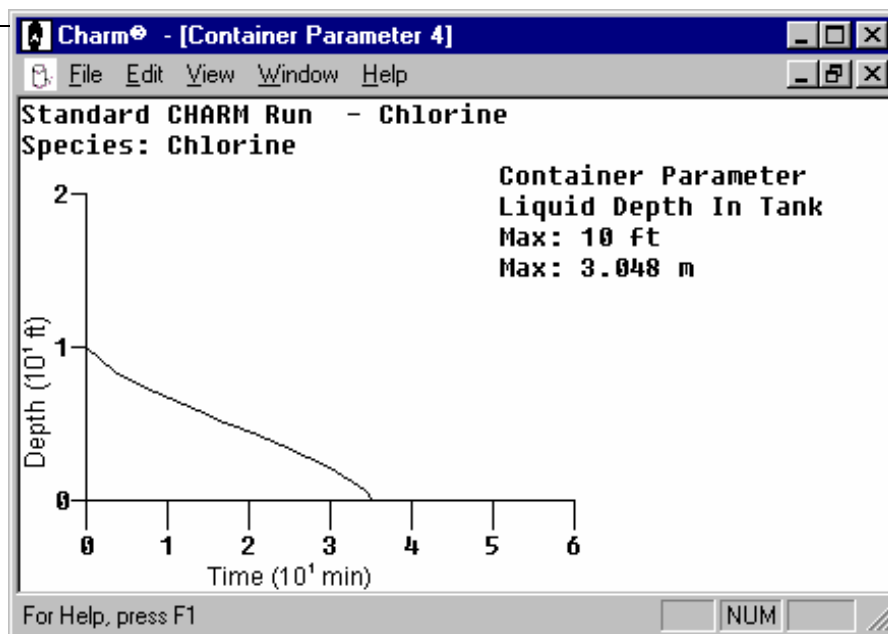
To generate a Mass Amount vs. Time Plot, select the 'Container Info' menu item from the 'Displays' menu located on the Main CHARM Input Window menu bar, or on any footprint display menu bar. Select the sub-menu item labeled 'Mass Amount'. Figure A-7 illustrates a plot of the mass amount exiting from a container as a function of time.

**Figure A-7**  
Mass Amt  
vs. Time Plot



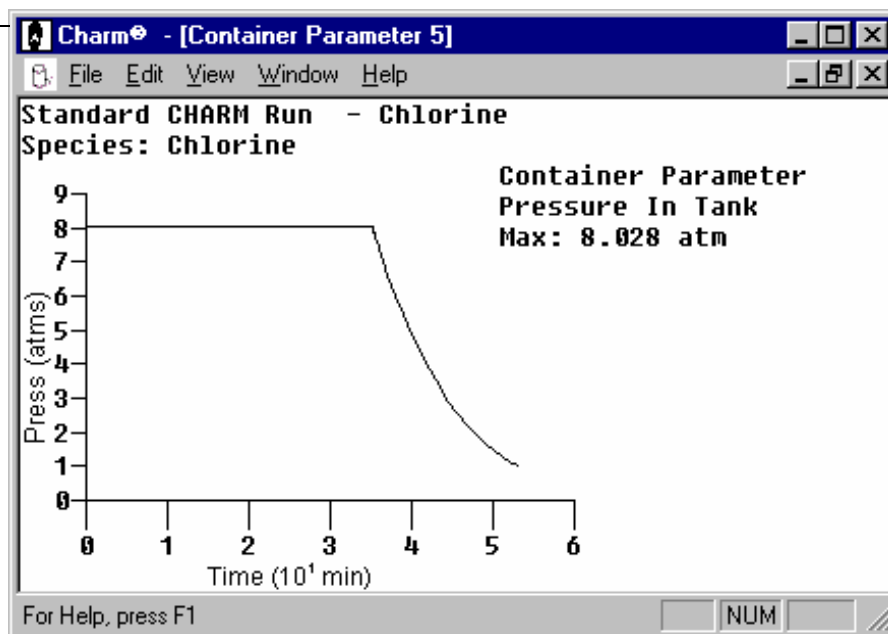
To generate a Liquid Depth vs. Time Plot, select the 'Container Info' menu item from the 'Displays' menu located on the Main CHARM Input Window menu bar, or on any footprint display menu bar. Select the sub-menu item labeled 'Liquid Depth'. Figure A-8 illustrates a plot of the liquid remaining in the container as a function of time.

**Figure A-8**  
Liquid  
Depth vs.  
Time Plot



To generate a Pressure vs. Time Plot, select the 'Container Info' menu item from the 'Displays' menu located on the Main CHARM Input Window menu bar, or on any footprint display menu bar. Select the sub-menu item labeled 'Pressure'. Figure A-9 illustrates a plot of the pressure in a container as a function of time.

**Figure A-9**  
Pressure vs.  
Time Plot



## Recent Scenario Files

---

CHARM displays a list of the five most recently opened scenario files in the 'File' menu in the Main CHARM Input Window. Choosing a file from this list makes it the current scenario in the Main CHARM Input Window.

## Recent Meteorological Files

---

CHARM displays a list of the five most recently opened meteorological files in the Met File menu in the Main CHARM Input Window. Choosing a met file from this list makes it the current met parameters in the Main CHARM Input Window.

## Estimating Pool Diameter In Accordance with RMP

---

When using a Container/Surface Release Type, CHARM will calculate the pool diameter/area using a depth of 1 cm to comply with RMP specifications.

To access this parameter in CHARM, select the 'Description Dialog Input' command from the 'Options' menu in the Main CHARM Input Window. With the 'Container/Surface Description' selected as the release type, select the 'Pool' tab and locate the radio button labeled 'Estimate with 1 cm depth'. Press the 'Apply' button at the bottom of the window and CHARM will calculate the pool diameter based on a 1 cm depth.



## Solar Radiation Pool Evaporation Efficiency

When using a Container/Surface or Pool/Lagoon release type, the solar radiation used for liquid evaporation may not be used completely for evaporation purposes. For instance, some of the solar radiation may not be incorporated into the evaporation, depending on the reflectivity of the species to light.

To access this parameter in CHARM, select the 'Description

Dialog Input' command from the 'Options' menu in the Main CHARM Input Window. With the 'Container/Surface Description' or the 'Pool/Lagoon' selected as the release type, select the 'Pool' tab and locate the single line edit box labeled 'Solar Radiation Pool Evaporation Efficiency'. You may enter a value 0.0 - 1.0.

Charm

Basic Location Building Container Storage Hole Pool Surface Pipe Fire/Droplets

Height of surface above ground:

1 feet

Maximum Diameter:

☐ Estimate with 1 cm depth

☒ 25 feet

Mitigation Time:

0 Minutes

Solar Radiation Pool Evaporation Efficiency:

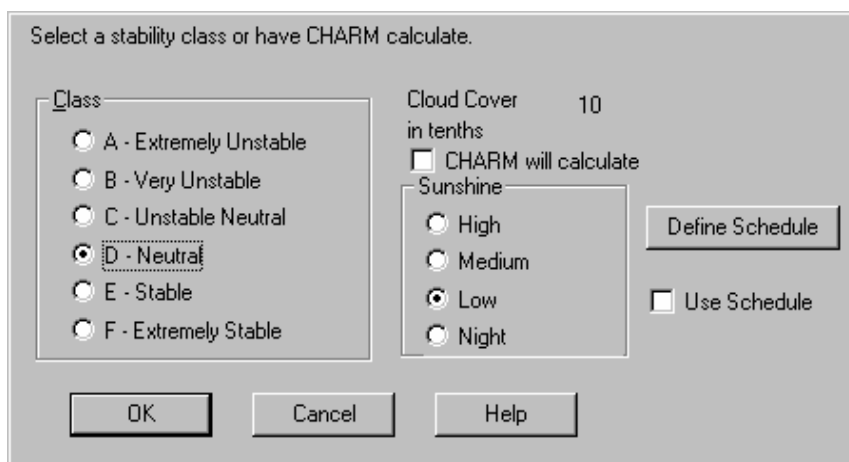
1

OK Cancel Apply Help

## Stability Class Schedule

You may define a time schedule for user-defined stability classes under the meteorological parameters. CHARM will use this schedule for dispersion calculations and calculation of wind profiles if a surface roughness is defined. Linear interpolation will be used to determine surface roughness at any given point.

To access this parameter in CHARM, double-click on Stability Class in the meteorological parameters in the Main CHARM Input Window. The following dialog box will appear:



Select a stability class or have CHARM calculate.

Class

- ☐ A - Extremely Unstable
- ☐ B - Very Unstable
- ☐ C - Unstable Neutral
- ☒ D - Neutral
- ☐ E - Stable
- ☐ F - Extremely Stable

Cloud Cover 10  
in tenths

☐ CHARM will calculate

Sunshine

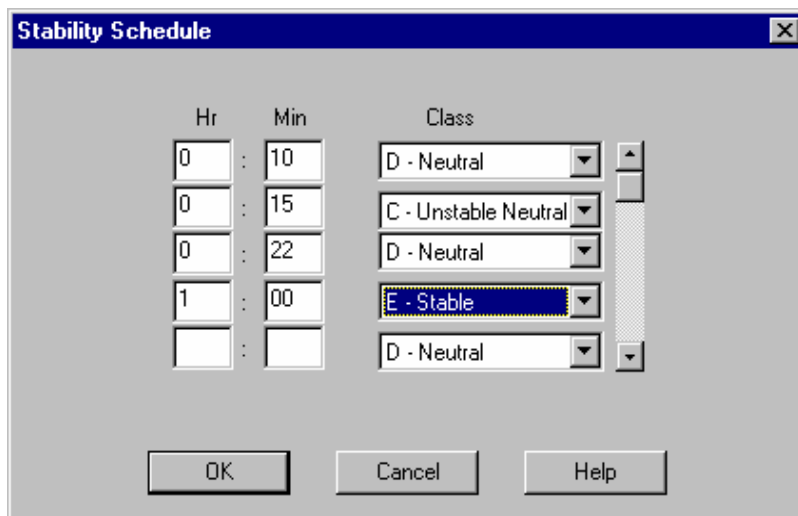
- ☐ High
- ☐ Medium
- ☒ Low
- ☐ Night

Define Schedule

☐ Use Schedule

OK Cancel Help

Click on the 'Use Schedule' checkbox and click on the 'Define Schedule' button. The following dialog box will appear:



Stability Schedule

Hr	Min	Class
0	10	D - Neutral
0	15	C - Unstable Neutral
0	22	D - Neutral
1	00	E - Stable
		D - Neutral

OK Cancel Help

Enter stability class values in chronological order since release. Use the scroll bar to input additional data.

Alternatively, the user may define the stability class schedule from the 'Met Dialog Input' command under the 'Options' menu in the

Main CHARM Input Window. Select the 'Stability Class' tab after the following dialog box is displayed.

The screenshot shows the 'Stability Class' tab of the CHARM input window. The window has a title bar 'Charm' and four tabs: 'Main', 'Stability Class', 'Solar', and 'Winds'. The 'Stability Class' tab is active. It contains a checkbox 'CHARM will calculate' which is unchecked. Below it is a 'Class' group box with six radio buttons: 'A - Extremely Unstable', 'B - Very Unstable', 'C - Unstable Neutral', 'D - Neutral' (selected), 'E - Stable', and 'F - Extremely Stable'. To the right of the 'Class' group is a 'Cloud Cover' input field with the value '10' and the unit 'Tenths'. Below the 'Cloud Cover' is a 'Sunshine' group box with four radio buttons: 'High', 'Medium', 'Low' (selected), and 'Night'. Below the 'Sunshine' group is a checkbox 'Use Solar Radiation' which is unchecked. To the right of the 'Sunshine' group is a 'Define Schedule' button and a 'Use Schedule' checkbox which is unchecked. At the bottom of the window are four buttons: 'OK', 'Cancel', 'Apply', and 'Help'.

Click on the 'Use Schedule' checkbox and click on the 'Define Schedule' button. Once again, the dialog box defining stability class schedule will appear.

The screenshot shows the 'Stability Schedule' dialog box. It has a title bar 'Stability Schedule'. The dialog contains a table with three columns: 'Hr', 'Min', and 'Class'. The table has five rows. The first four rows have data: (0, 10, D - Neutral), (0, 15, C - Unstable Neutral), (0, 22, D - Neutral), and (1, 00, E - Stable). The fifth row has empty fields for 'Hr' and 'Min', and 'D - Neutral' for 'Class'. To the right of the table is a vertical scroll bar. At the bottom of the dialog are three buttons: 'OK', 'Cancel', and 'Help'.

Hr	Min	Class
0	10	D - Neutral
0	15	C - Unstable Neutral
0	22	D - Neutral
1	00	E - Stable
		D - Neutral

Enter stability class values in chronological order since release. Use the scroll bar to input additional data.

## Appendix B: Enhancements in CHARM Ver. 9.3

---

***NOTE: CHARM Version 9.2 is exclusive to the Japanese version of CHARM and was not an update to the English version.***

Functional software changes in CHARM Version 9.3 that are not found in CHARM Version 9.1 include the following:

- From an Emission Rate plot within CHARM proper, the user has the ability to copy either the container rate, the pool rate, or the total combined rates of the pool and the container into the User Specified Emission Rate Schedule in the User-Specified release type. Once copied from the Edit menu of the Emission Rate plot, the selected rates may be pasted into the emission rate schedule with the push of a button.
- The 'Dose at Point' menu item under the Displays Menu for Plan concentration views in CHARM proper allows the user to input a specified point to generate a Dose Plot (or concentration history plot) rather than double-clicking on the display.
- CHARM version 9.3 comes with documentation inserts into the version 9 User's Manual, and updated on-line help.

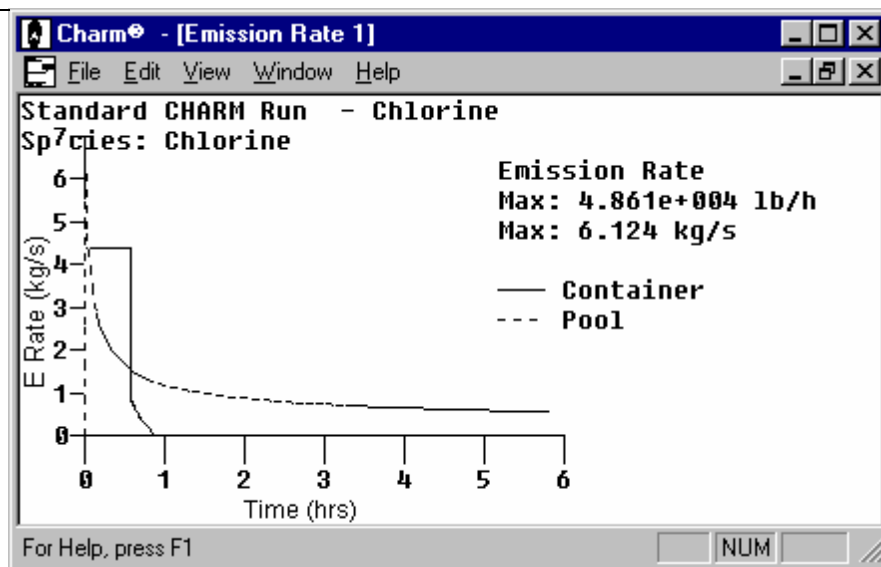
### Copy Container, Pool, Total Rate

---

Once a scenario has been modeled using any one or the three release types (i.e. Container/Surface, Pool/Lagoon, User-Specified After Release Conditions), the user may view the emission rate as a function of time.

**Figure B-1**

Example  
output of  
Emission  
Rate Plot



Select the Edit menu to view the section allowing the user to copy either the Container Rate, the Pool Rate, or the Total Rate consisting of both the Container Rate and the Pool Rate to the clipboard.

Once copied, the user may paste the data into the emission rate schedule of a User-Specified release. To do so, change the release type to User-Specified After Release Conditions and change the emission rate type to User-Specified Rate.

**Figure B-2**

Emission  
Rate  
Scheduler  
Input  
Window

**Emission Rate Scheduler**

Time units  
☒ hrs  
☐ min  
☐ sec

Emission rate units  
☐ lbs/hr   ☐ scfm   ☐ cfm  
☒ g/s   ☐ scms   ☐ cms

Time   Emission rate

Add     

Delete  

Clear  

Paste Data

Change   Save Change

OK   Cancel   Help

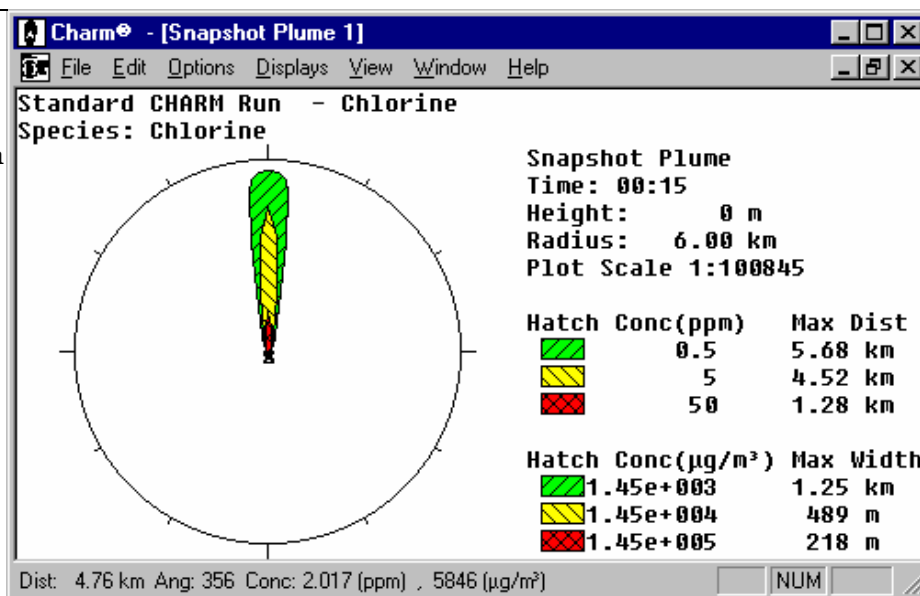
If the copied data exists in the clipboard, notice the Paste Data button is activated. Simply press the Paste Data button and the data, which

includes both time since release and emission rate, will be loaded into the emission rate schedule. This allows the user the flexibility to modify or tweak the data.

## Dose At Point

The Dose Plot (or concentration history) is normally displayed by generating a Plot Plan Snapshot view of the isopleths of interest, moving the cross-hair to the desired point, and either double-clicking the left mouse button or pressing <Enter>. The desired point is generally specified by locating the distance and direction (or angle) from the source in the status bar at the bottom of the window

**Figure B-3**  
Example of  
Snapshot  
Plan Plume  
Display from  
which the  
user may  
obtain a  
Dose Plot



The 'Dose at Point' menu item under the Displays Menu for Plan concentration views in CHARM proper allows the user to input a specified point to generate a Dose Plot (or concentration history plot) rather than double-clicking on the display. This method allows the user to input an exact location by specifying the distance and direction of the point of interest from the source.

**Figure B-4**  
Input  
window  
requesting  
direction  
and distance  
from source  
to generate  
Dose Plot

Enter the direction and distance from source to exposure point.

Distance

Direction



## Appendix C: Enhancements in CHARM Ver. 9.4

---

Functional software changes in CHARM Version 9.4 that are not found in CHARM Version 9.3 include the following:

- A glitch in the algorithm for estimating the “RMP Distance” for jet fire radiation effects has been corrected. The previous glitch only affected scenarios where the time step shown in the release profile of the “source puff” calculation is less than 40 seconds.
- The near-field dispersion algorithm has been changed to reduce enhanced dispersion at the source. The effects of this revision are to generally lower dispersion impacts as well as lower vapor cloud explosion overpressure impacts in the near field. This change is going back to the approach used prior to Version 9.3.
- The X-Y plot axes’ labels have been changed to eliminate exponential notation. Originally all tick marks were labeled between 1 and 10 and the axis label had the multiplier. Now the tick marks are labeled with their actual values with no multiplier notation.
- The “3D Plume” display shows multiple concentration isopleths corresponding to the isopleths shown on the 2D snapshot plume view. Previously, only one isopleth was shown in the 3D view, and the user was prompted to specify the concentration when selecting this option.
- A number of internal changes were made to the code that have no effect on the results but make maintenance and expandability of the code easier. Some changes make it easier to input data. For example, drag and drop input and output has been added to all tables (e.g. emission rates, winds, and stability class).
- CHARM Version 9.41 was released shortly after Version 9.4. An error in the calculation of the flame length for a jet fire was corrected.
- CHARM Version 9.4 comes with updated documentation, including on-line help and inserts into the CHARM User's Manual.

## **Appendix D: Enhancements in CHARM Ver. 9.5**

---

Functional software changes in CHARM Version 9.5 that are not found in CHARM Version 9.4 include the following:

- The color for each isopleth can be user defined. They no longer are restricted to just green, yellow, and red.
- A number of internal changes were made to the code such as some spelling corrections and text placement.

## Appendix E: Enhancements in CHARM Ver. 9.6

Functional software changes in CHARM Version 9.6 that are not found in CHARM Version 9.5 include the following:

- The number of isopleth values has been increased from 3 to 6. The code has been revamped to make further increases, if needed, more easily implemented. The isopleth values and colors can be altered in a single screen
- The 3D display has been enhanced to allow the use of the mouse for moving the observer and observed direction. The display has been made to move more smoothly.
- The CHARM version 9.6 help files have been reviewed to make them more useful and complete.

### Isopleth Value and Color

When a plan or 3-D view is in a window the isopleths (concentration, thermal radiation, or explosion overpressures) that are plotted can have their values and colors changed.

**Figure E-1**  
Example  
input screen  
for defining  
isopeth  
value and  
color.

	Value	Color
1	1	Green
2	3	Yellow
3	20	Red
4		Cyan
5		Purple
6		Magenta

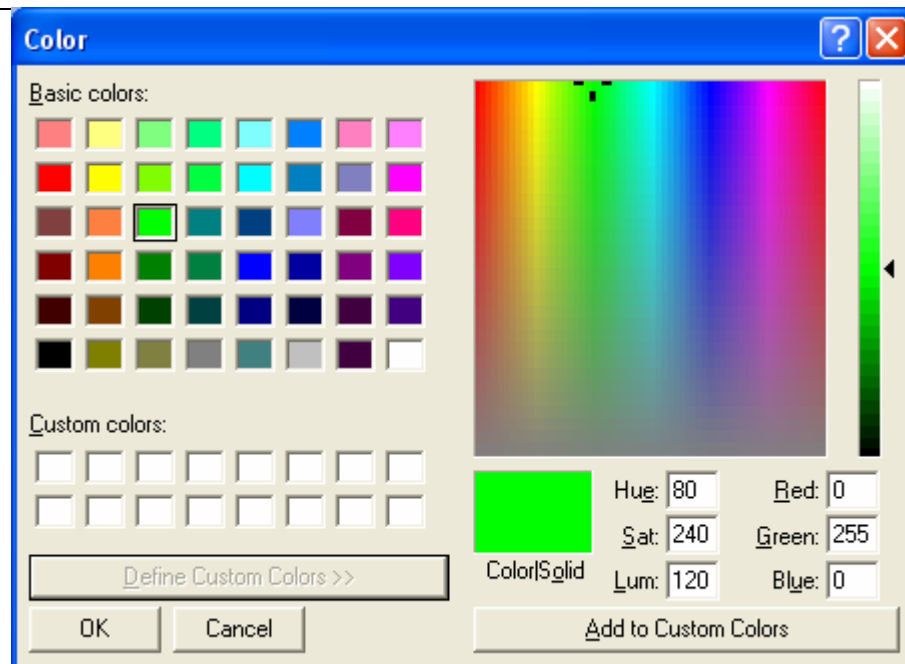
ppm

OK Cancel

Select the Isopleths... item in the Options menu to view a dialog box similar to the one in Figure E-1.

You can enter a value directly into column labelled Value. To change the color, double click on the color to change and the dialog box shown in Figure E-2 will be displayed. A new color can be selected directly from the boxes on the left or a custom color can be created by selecting a point in the area to the right.

**Figure E-2**  
Color  
Selection  
Dialog



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# Complex Hazardous Air Release Model (CHARM®)

## Technical Reference Manual

**By Mark W. Eltgroth, Ph.D.**

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## 1.0 INTRODUCTION

This document describes the algorithms used in URS's Complex Hazardous Air Release Model (CHARM®) software program. CHARM is a modeling program that calculates and predicts the dispersion and concentration of airborne vapor and particle plumes from released chemicals. CHARM also predicts the footprints of thermal radiation, overpressures, and particle deposition. CHARM is especially useful for evaluating the impact of accidental releases, designing emergency response plans, and implementing training programs.

The CHARM program provides a chemical database containing data on the physical, chemical, and toxic properties of over 100 chemical compounds. CHARM requires the user to select the chemical released, describe the release, select a terrain grid, and specify the meteorological conditions at the release site. A release can be described as instantaneous or continuous, contained or uncontained, liquid, gas, or particles. The release may be a liquid pool fire, Boiling Liquid Expanding Vapor Explosion (BLEVE), or jet fire. Overpressures for a flammable vapor cloud or mechanical failure of a pressurized vessel can also be predicted. Meteorological data for input to CHARM can be obtained from instruments brought to the site, from a nearby meteorological station, or from estimates prepared by a remote weather center. The user input combined with the chemical data enables CHARM to simulate the release.

CHARM is a 3D Eulerian grid model. The grid determines the region of computation. Beyond the grid all concentrations and impacts are assumed to be zero.

Section 2 of this document explains the formulations used in the source term calculations. CHARM's Source Term module calculates the state of the release (e.g emission rate, temperature, partitioning of liquid and vapor, densities, etc.). This information is then provided to the Transport/Dispersion module.

Section 3 of this document explains the transport and advection calculations. CHARM models releases that are heavier than air, neutrally buoyant, or positively buoyant. The model's calculations consider vapor and particle mass, particle number, energy, and momentum.

Section 4 describes the liquid pool fire module, which involves large spills of volatile organic chemicals that evaporate quickly and can form a combustible mixture with the air above the pool.

Section 5 provides the fireball/BLEVE (Boiling Liquid Expansion Vapor Explosion) calculations used in CHARM.

Section 6 describes CHARM's method for calculating jet fire radiation.

Section 7 explains the algorithms used by CHARM to calculate two types of explosion overpressures: sphere bursts and vapor cloud explosions.

This document provides all the major equations used in CHARM; however, it is not intended to repeat the detailed derivations of the equations when these derivations are given in cited references. This document deals with the physical models used in CHARM and does not discuss the computer code used to create graphics or to control the user interface. For information on how to operate the modeling software to produce useful output, refer to the *CHARM User's Manual*.

## 2.0 SOURCE TERM ALGORITHM

The user initially provides input describing the release and the meteorological conditions at the release site. The Source Term calculation takes the user input and determines the characteristics of the release (phases, emission rate, temperature, etc.).

The required calculations depend on the thermodynamic properties of the species released, the mechanism of the release, and the meteorological conditions. CHARM retrieves the thermodynamic properties of the release species from the CHARMED chemical database. CHARM comes with a number of chemicals in the database. Other chemicals can be added through use of CHARMED.

After the user selects a release type, CHARM prompts the user for the appropriate input. Depending on the species and release type, CHARM will allow the calculation of impacts of concentrations, thermal radiation from BLEVEs, jet fires, pool fires, or overpressures from mechanical failure or vapor cloud explosions.

The release description, which is calculated by the Source Term module, is prerequisite information for the Transport/Dispersion module. The calculated release description data includes the following:

- X, Y, Z position;
- Chemical mass rate (vapor and liquid phases);
- Temperature;
- Air mass rate;
- Water vapor mass rate;
- Direction and speed of exit velocity; and
- Dimensions.

The release type determines the calculations used in the Source Term module. CHARM models the following types of releases:

- Container/surface description;
- Evaporating pool/lagoon;
- User-specified; and
- User-defined grid of concentrations.

Sections 2.1 through 2.3 describe the calculations used in the Source Term module. The algorithms used in the calculation come from EPA (1993), Crawl and Louvar (1990), and Fauske and Epstein (1987). The user-defined grid of concentrations requires no source term calculation. The concentrations at the grid cells are held constant throughout the release.

## 2.1 *Container/Surface Description Release*

If a liquid is present during the release the emission into the atmosphere may be from two sources. Assuming that liquid is in the container, the emission directly from the container may consist of flashed vapor and droplets. The second source could be from a pool that would form from any liquid that did not flash or become droplets. The release is divided into these two major divisions. The pool evaporation calculation is given in Section 2.2.

The calculations given in this section are performed for a point in time. The changes in the source are then accounted for (e.g. some mass is gone or the pressure may fall) over an internally calculated time step. The calculation is then repeated with the new source characteristics. This is repeated until the end condition of a calculation is reached.

### 2.1.1 Release From Container

A release from a container can consist of up to four steps or phases. Figure 2-1 is a schematic of these four phases. The phases are:

- Liquid release;
- Depressurization to liquid/vapor equilibrium pressure;
- Boiling; and
- Depressurization to atmospheric pressure.

If there is no liquid in the container the first three phases do not occur. If a liquid is stored at a pressure in equilibrium with its storage temperature the second phase will not occur. This section describes the calculations performed to define the release from a container. The depressurization phases use the same calculation method. The two phases vary only by the pressure at which the depressurization is assumed to stop.

As the liquid is released some may form a pool that then evaporates. An example of what the emission rate versus time looks like for the four phases of the container release and the evaporating pool is given in Figure 2-2. The relationships between the container release rates and the emission from the pool will vary depending on chemical spilled, hole size, surface description, etc.

#### **Liquid Release**

Figure 2-3 is a blowup view of the liquid release phase in Figure 2-1. Depending on the storage conditions of a liquid there are three fates for the liquid:

- Flash to vapor in atmosphere;
- Become suspended droplets; or
- Form a pool and evaporate.

The liquid in the container in Figure 2-3 will continue to come out until the depth of the liquid in the container reaches the bottom of the hole in the container. The characteristics of the emission depend on the storage conditions, the species, and the meteorology. The amount of liquid mass that goes into suspended droplets is not well defined. In CHARM the model can be made to assume that the same amount of mass that flashes will also go into forming droplets. The user can also override this assumption and force the amount of mass going into droplets to be a fraction between 0 and 1 of the amount of liquid that does not flash.

The first calculation performed is for the fraction of species that flashes (F).

$$F = \frac{C_{pL}(T_c) - C_{pL}(T_b)}{H_v} \quad (2-1)$$

where  $C_{pL}(T)$  = heat capacity of liquid at constant pressure and temperature T;  
 $T_c$  = temperature in the container;  
 $T_b$  = boiling point of chemical at ambient pressure; and  
 $H_v$  = latent heat of evaporation at normal boiling point.

The flash fraction is restricted to be between zero and one, inclusive.

#### Flash Fraction is Zero

If the flash fraction is zero it is treated as a pure liquid release. The emission rate is determined by first calculating the exit velocity (u). From Crowl and Louvar (1990) the exit velocity is given by:

$$u = C_d \sqrt{\frac{\frac{P_c - P_a}{\rho_L} + g(z_L - z_H)}{\frac{1}{2} + \frac{2 f L}{d}}} \quad (2-2)$$

where  $C_d$  = discharge coefficient (0.65);  
 $P_c$  = pressure in container;  
 $P_a$  = ambient pressure;  
 $\rho_L$  = liquid density;  
 $g$  = gravitational acceleration;  
 $z_L$  = height of liquid;  
 $z_H$  = height of hole;  
 $f$  = Fanning friction factor;  
 $L$  = connecting pipe equivalent length (see Section 2.1.2); and  
 $d$  = connecting pipe diameter.



The value of  $f$  is calculated from:

$$\frac{1}{\sqrt{f}} = -4 \log \left( \frac{1}{3.7} \frac{\varepsilon}{d} + \frac{1.255}{Re \sqrt{f}} \right) \quad (2-3)$$

where  $\varepsilon$  = roughness length for clean pipes;  
 $Re$  = Reynolds number ( $= \frac{d u \rho_L}{\nu}$ ); and  
 $\nu$  = liquid viscosity at normal boiling point.

Once the exit velocity is calculated the emission rate ( $\dot{m}$ ) can be calculated from:

$$\dot{m} = \rho_L u A \quad (2-4)$$

where  $A$  = area of hole.

For the release of a pure liquid with no flashing the release temperature is assumed to be the storage temperature.

#### Flash Fraction is Not Zero

For this case the release temperature is assumed to be the atmospheric boiling point of the chemical.

If the storage pressure is greater than 1.05 times the vapor pressure in equilibrium with the storage temperature and the equilibrium vapor pressure is greater than the ambient pressure the release is treated as that of a sub-cooled liquid. In a sub-cooled liquid release it is assumed that the flashing that takes place occurs after the liquid has been released. In this case the release rate is calculated in the same manner as for the flash fraction being zero with one exception. The exception is that if a pipe exists the ambient pressure ( $P_a$ ) used in the zero flash case is replaced with the maximum of the ambient pressure and the vapor pressure of the chemical in equilibrium with the ambient temperature. If a pipe is present it is assumed that it is at ambient temperature.

If the release is not treated as that of a sub-cooled liquid it is assumed that the release is that of a pressurized liquid in thermal equilibrium. The release rate for this case consists of a basic formula that then gets modified depending on the existence of a connecting pipe. The basic formula for the emission rate ( $Q$ ) is from Fauske and Epstein (1987):

$$Q = \frac{H_v A}{v_{lg} \sqrt{T_c C_{pL}}} \quad (2-5)$$

where  $v_{lg}$  = specific volume ( $= 1/\rho_v + 1/\rho_L$ ) at container conditions; and  
 $\rho_v$  = vapor density.

The parameter to determine how to alter  $Q$  is  $L/L_e$  where  $L_e$  is the pipe length required to establish equilibrium flow conditions. The value of  $L_e$  is assumed to be 0.1 meters. If  $L/L_e < 1$  then the emission rate is given by:

$$\dot{m} = \frac{Q}{N} \quad (2-6)$$

where  $N$  = the correction factor given as:

$$N = \sqrt{\frac{H_v^2}{2(P_c - P_a)\rho_L C_D^2 v_{lg}^2 T_c C_{pL}}} + \frac{L}{L_e} \quad (2-7)$$

Otherwise the emission rate is given by:

$$\dot{m} = Q F \quad (2-8)$$

where  $F$  = the correction factor for friction in the pipe and is given as:

$$F = \sqrt{\frac{1}{1 + \frac{0.006L}{d}}} \quad (2-9)$$

### **Depressurization Release**

The depressurization release continues until the pressure in the container reaches a specific value. For the first depressurization phase this pressure is the one reached when the liquid and vapor are in equilibrium in the container. After this first depressurization it is assumed that boiling occurs and the container's pressure is held constant until all liquid is gone. Then the second depressurization occurs. The stopping pressure of the second depressurization is the atmospheric pressure.

The depressurization release calculation's first subdivision is if the release is occurring through a pipe or not. The calculation is then further subdivided into choked/unchoked flow and whether condensation occurs (two-phase release).

#### No Connecting Pipe

The first calculation is to determine whether the vapor flow is choked or not. This is done through:

$$P_* = P_c \left( \frac{2}{\gamma + 1} \right)^{\frac{\gamma}{\gamma - 1}} \quad (2-10)$$

where  $\gamma$  = ratio of heat capacities ( $C_{pv}/C_{vv}$ ) for the vapor phase  
 $C_{pv}$  = heat capacity of vapor at constant pressure  
 $C_{vv}$  = heat capacity of vapor at constant volume.

If  $P_*$  is greater than the ambient pressure, the flow is choked.

**Choked Flow** - If the flow is choked, the formation of liquid droplets at choked conditions needs to be investigated. The temperature at choked conditions ( $T_*$ ) can be estimated from:

$$T_* = T_c \left( \frac{2}{\gamma + 1} \right) \quad (2-11)$$

This temperature can be used to determine if condensation occurs. If condensation does occur the value of  $T_*$  is invalid. If  $T_*$  is greater than the critical temperature of the chemical, no condensation occurs. If  $T_*$  is less than the critical temperature, the vapor pressure at  $T_*$  needs to be compared to  $P_*$ . If the vapor pressure is greater than  $P_*$  then condensation does not occur.

Choked Flow (No Condensation) - The emission rate for choked flow with no condensation is given by:

$$\dot{m} = C_d A \sqrt{P_c \rho_c \gamma \left( \frac{2}{\gamma + 1} \right)^{\frac{\gamma + 1}{\gamma - 1}}} \quad (2-12)$$

where  $\rho_c$  = density of vapor in container.

The release temperature ( $T_{rel}$ ) is given by:

$$T_{rel} = T_c \left[ 1 - 0.85 \left( \frac{\gamma - 1}{\gamma + 1} \right) \right] \quad (2-13)$$

Choked Flow (Condensation) - For this case a more detailed calculation at the choked conditions is needed. First, the value of  $T_*$  is needed. In this case  $T_*$  is the equilibrium temperature at the pressure  $P_*$ . The vapor fraction at choked flow conditions ( $x_e$ ) is required. It is calculated from:

$$x_* = 1 + \frac{T_*}{MH_v} \left[ MC_{pv} \ln \left( \frac{T_c}{T_*} \right) - R \ln \left( \frac{P_c}{P_*} \right) \right] \quad (2-14)$$

where  $M$  = molecular weight of chemical; and  
 $R$  = gas constant.

Given  $T_*$  and  $x_*$  allows an estimate of enthalpy change ( $\Delta H$ ) and density ( $\rho_*$ ) to be made.

The estimates are given by:

$$\Delta H = C_{pv}(T_c - T_*) + H_v(1 - x_*) \quad (2-15)$$

and

$$\rho_* = \left[ \frac{x_*}{\rho_v} + \left( \frac{1 - x_*}{\rho_L} \right) \right]^{-1} \quad (2-16)$$

The emission rate is then given by:

$$\dot{m} = A \rho_* \sqrt{1.70 \Delta H} \quad (2-17)$$

The release temperature is assumed to be that in equilibrium with the ambient pressure (i.e. normal boiling point if the release is at sea level). With this assumption a vapor fraction at release ( $x_{rel}$ ) can be estimated by:

$$x_{rel} = x_* + \frac{C_{pv}(T_* - T_{rel})}{H_v} \quad (2-18)$$

If  $x_{rel}$  is between 0 and 1 the estimate of  $T_{rel}$  is valid. Otherwise the value of  $x_{rel}$  is set to one and the release temperature is calculated from:

$$T_{rel} = T_* + \frac{H_v(1 - x_*)}{C_{pv}} \quad (2-19)$$

**Unchoked Flow** - If the flow is not choked, the formation of liquid droplets still needs to be investigated. The method is to assume that the release has no condensation. The temperature at released conditions ( $T_{rel}$ ) can then be estimated. A check can be performed to determine if the release has condensation occurring.

Unchoked Flow (No Condensation) - The emission rate for unchoked flow with no condensation is given by:

$$\dot{m} = C_d A \sqrt{P_c \rho_c \left( \frac{2\gamma}{\gamma+1} \right) \left( \left( \frac{P_a}{P_c} \right)^{\frac{2}{\gamma}} - \left( \frac{P_a}{P_c} \right)^{\frac{\gamma+1}{\gamma}} \right)} \quad (2-20)$$

The release temperature ( $T_{rel}$ ) is given by:

$$T_{rel} = 2 \left[ \frac{T_c}{1 + \sqrt{1 + 4aT_c}} \right] \quad (2-21)$$

where

$$a = \frac{1}{2C_{pv}} \left( \frac{\dot{m}R}{P_a M A} \right)^2 \quad (2-22)$$

This temperature can be used to determine if condensation occurs. If condensation does occur the value of  $T_{rel}$  is invalid. If  $T_{rel}$  is greater than the critical temperature of the chemical, no condensation occurs. If  $T_{rel}$  is less than the critical temperature, the vapor pressure at  $T_{rel}$  needs to be compared to  $P_a$ . If the vapor pressure is greater than  $P_a$  then condensation does not occur. If condensation does occur the unchoked flow with condensation calculation needs to be done.

Unchoked Flow (Condensation) - First, the value of  $T_{rel}$  is needed. In this case  $T_{rel}$  is the equilibrium temperature at the pressure  $P_a$ . The vapor fraction at release ( $x_{rel}$ ) is required. It is calculated from:

$$x_{rel} = 1 + \frac{T_{rel}}{MH_v} \left[ MC_{pv} \ln \left( \frac{T_c}{T_{rel}} \right) - R \ln \left( \frac{P_c}{P_a} \right) \right] \quad (2-23)$$

Given  $T_{rel}$  and  $x_{rel}$  allows an estimate of enthalpy change ( $\Delta H$ ) and density  $\rho_{rel}$  to be made. The estimates are given by:

$$\Delta H = C_{pv} (T_c - T_{rel}) + H_v (1 - x_{rel}) \quad (2-24)$$

and

$$\rho_{rel} = \left[ \frac{x_{rel}}{\rho_v} + \left( \frac{1 - x_{rel}}{\rho_L} \right) \right]^{-1} \quad (2-25)$$

The emission rate is then given by:

$$\dot{m} = A \rho_{rel} \sqrt{1.70 \Delta H} \quad (2-26)$$

### Connecting Pipe

As in the No Connecting Pipe case the first determination is whether the flow is choked or not. This is done in the following manner.

By assuming that the Reynolds number is very large (i.e. the flow is turbulent) the Fanning friction factor can be estimated from:

$$\frac{1}{\sqrt{f}} = 4 \log \left( 3.7 \frac{d}{\varepsilon} \right) \quad (2-27)$$

The Mach velocity in the pipe ( $Ma_1$ ) can be calculated, with an iterative method, from:

$$\frac{\gamma+1}{2} \ln \left( \frac{2 Y_1}{(\lambda+1) Ma_1^2} \right) - \left( \frac{1}{Ma_1^2} - 1 \right) + \frac{4 \gamma f L}{d} = 0 \quad (2-28)$$

where

$$Y_1 = 1 + \frac{\gamma-1}{2} Ma_1^2 \quad (2-29)$$

The value of  $P_*$  can then be calculated from:

$$P_* = P_c Ma_1 \sqrt{\frac{2 Y_1}{\gamma+1}} \quad (2-30)$$

If  $P_*$  is less than  $P_a$  or if it is less than  $P_c$  the flow is unchoked. Otherwise the flow is choked.

**Choked Flow** - If the flow is choked, the formation of liquid droplets needs to be investigated. The temperature at choked conditions ( $T_*$ ) can be estimated from:

$$T_* = T_c \left( \frac{2 Y_1}{\gamma+1} \right) \quad (2-31)$$

This temperature can be used to determine if condensation occurs. If condensation does occur the value of  $T_*$  is invalid. If  $T_*$  is greater than the critical temperature of the chemical, no condensation occurs. If  $T_*$  is less than the critical temperature, the vapor pressure at  $T_*$  needs to be compared to  $P_*$ . If the vapor pressure is greater than  $P_*$  then condensation does not occur.

Choked Flow (No Condensation) - The emission rate for choked flow with no condensation is given by:

$$\dot{m} = P_* C_d A \sqrt{\frac{\gamma M}{R T_*}} \quad (2-32)$$

The release temperature ( $T_{rel}$ ) is equal to  $T_*$

Choked Flow (Condensation) - For this case the calculation is identical to the case for No Connecting Pipe except that the emission rate calculation formula is:

$$\dot{m} = A p_* \sqrt{1.70 \frac{\Delta H}{1 + \frac{4fL}{d}}} \quad (2-33)$$

**Unchoked Flow** - If the flow is not choked, the formation of liquid droplets still needs to be investigated. The method is to assume that the release has no condensation. The temperature at released conditions ( $T_{rel}$ ) can then be estimated. A check can be performed to determine if the release has condensation occurring.

Unchoked Flow (No Condensation) - The emission rate for unchoked flow with no condensation is solved for by first determining the emission temperature ( $T_{rel}$ ) from the formula (solved iteratively):

$$\frac{\gamma+1}{\gamma} \ln \left( \frac{P_c T_{rel}}{P_a T_c} \right) - \frac{\gamma-1}{2\gamma} \left( \frac{P_c^2 T_{rel}^2 - P_a^2 T_c^2}{T_{rel} - T_c} \right) \left( \frac{1}{P_c^2 T_{rel}} - \frac{1}{P_a^2 T_c} \right) + \frac{4fL}{d} = 0 \quad (2-34)$$

The emission rate is then given by:

$$\dot{m} = C_d A \sqrt{\frac{2M}{R} \frac{\gamma}{\gamma-1} \frac{T_{rel} - T_c}{\left( \frac{T_c}{P_c} \right)^2 - \left( \frac{T_{rel}}{P_a} \right)^2}} \quad (2-35)$$

The release temperature can be used to determine if condensation occurs. If condensation does occur the value of  $T_{rel}$  is invalid. If  $T_{rel}$  is greater than the critical temperature of the chemical, no condensation occurs. If  $T_{rel}$  is less than the critical temperature, the vapor pressure at  $T_{rel}$  needs to be compared to  $P_a$ . If the vapor pressure is greater than  $P_a$  then condensation does not occur. If condensation does occur the unchoked flow with condensation calculation needs to be done.

Unchoked Flow (Condensation) - For this case the calculation is identical to the case for No Connecting Pipe except that the emission rate calculation formula is:

$$\dot{m} = A \rho_* \sqrt{1.70 \frac{\Delta H}{1 + \frac{4fL}{d}}} \quad (2-36)$$

### Boiling Release

The emission rate from this portion of the release is calculated the same as for the depressurization portion of the release except that the emission rate is held constant until all liquid remaining in the container below the hole level has been emitted. The temperature assumed is the given storage temperature and the pressure assumed is that in equilibrium with the storage temperature. Whether the emission is choked/unchoked with or without condensation is the same as described for the depressurization.

### 2.1.2 Connecting Pipe Description

The connecting pipe specified by the user is allowed to have characteristics such as valves, elbows, tees, and connections. The number and types of these characteristics are used to calculate an equivalent pipe length. These valves etc. have the effect of lengthening the pipe. In all calculations where the pipe length  $L$  is used it is assumed that the equivalent pipe length is actually being used. Each valve, elbow, etc. increases the apparent length of the pipe by some factor that is to be multiplied by the diameter of the pipe and added to the actual pipe length. Table 2-1 lists these factors for the pipe characteristics used in CHARM. Another input to describe the connecting pipe that affects the frictional losses of flow is the Relative Roughness Factor. Some representative roughness lengths are given in Table 2-2.

### 2.1.3 Pool Evaporation Release

The evaporation emission from the pool is described in Section 2.2. The pool is allowed to grow in size with time as the liquid emission continues or the chemical spreads.

## 2.2 *Pool Dynamics for Container/Surface and Pool/Lagoon Release Descriptions*

This section describes the algorithms used to simulate the source term from an evaporating pool. In CHARM a pool may form in a Container/Surface Description release or a pool may be defined with the Pool/Lagoon Description release. In the Container/Surface Description release the pool is allowed to grow in diameter and depth as mass is added to it. In a Pool/Lagoon Description release CHARM assumes that the pool is of a constant diameter with no mass being added as the evaporation occurs. In other words, the Pool/Lagoon Description release assumes that there is no container or mass source for the pool. This also means that no flash calculation (Eq. 2-1) or droplet



suspension is assumed in the Pool/Lagoon Description release. Since the Pool/Lagoon Description assumes there is no flash, it should only be used for releases where no flash occurs, such as for low volatility liquids. Use the Pool/Lagoon Description release with care for high volatility liquids since flashing may actually occur.

### 2.2.1 Pool Growth

A constraint on the pool spreading is a minimum depth that the pool is allowed to be. The theoretical minimum that a pool should form at is the capillary depth ( $h_{cap}$ ). The capillary depth is given by:

$$h_{cap} = \sqrt{\frac{\sigma_L}{g \rho_L}} \quad (2-37)$$

where  $\sigma_L$  = surface tension of the liquid.

For a spreading pool that is being fed by a mass rate ( $\dot{m}_L$ ), the minimum depth ( $h_{fed}$ ) is given by (Webber, 1990, 1991):

$$h_{fed} = \left( \frac{6 v_L \dot{m}_L}{\pi g} \right)^{\frac{1}{4}} \quad (2-38)$$

CHARM uses the maximum of  $h_{cap}$  and  $h_{fed}$  to determine a minimum depth ( $h_{min}$ ). If the pool becomes lower than  $h_{min}$  no pool diameter growth occurs. The rate of pool radius (R) growth is given by:

$$\frac{dR}{dt} = \sqrt{2g \max(0, h - h_{min})} \quad (2-39)$$

where  $h$  = present depth of pool.

For any time step ( $\Delta t$ ) the value of  $h$  is given by:

$$h = h_{old} + \frac{dh}{dt} \Delta t \quad (2-40)$$

where

$$\frac{dh}{dt} = \frac{\dot{m}_L}{A_{pool}} \quad (2-41)$$

where  $A_{pool}$  = pool area.

If the pool gets to the maximum diameter allowed then the rate of change of the pool radius is forced to be zero. This maximum diameter is explicitly defined by the user in the Container/Surface Description release option. In the Pool/Lagoon Description release the maximum diameter is assumed to be the initial diameter and  $\dot{m}_L$  is zero. Therefore in the Pool/Lagoon Description release no pool growth is assumed.

## 2.2.2 Pool Evaporation

There are three processes allowed for adding energy to the pool to allow it to evaporate. These are heat transfer ( $Q_{HT}$ ), mass transfer ( $Q_{MT}$ ), and solar radiation ( $Q_S$ ). The heat transfer is subdivided into heat transfer from conduction with the surface and from convection in the air. As suggested in the SPILLS model (Fleischer, 1980) only the maximum of heat transfer and mass transfer is used to determine the evaporation rate ( $Q_{EVAP}$ ). So  $Q_{EVAP}$  is given by:

$$Q_{EVAP} = \max(Q_{HT}, Q_{MT}) + Q_S \quad (2-42)$$

In the case of the Container/Surface Description release all flash and droplet suspension calculations are carried out in the Container release portion of the code. For the Pool/Lagoon Description release no flash or droplets are assumed.

### Heat Transfer

The equation for the heat transfer emission rate ( $Q_{HT}$ ) is:

$$Q_{HT} = \frac{D_F k_s A (T_a - T_b)}{p \Delta H_v \sqrt{\pi \alpha_s t}} + \frac{k_a Nu_L A}{\Delta H_v L} (T_a - T_b) \quad (2-43)$$

where  $D_F$  = freezing factor (see below);  
 $k_s$  = thermal conductivity of the soil;  
 $A$  = area of spill;  
 $T_b$  = normal boiling point;  
 $p$  = percolation factor (see below);  
 $\alpha_s$  = thermal diffusivity of the soil;  
 $t$  = time;  
 $k_a$  = thermal conductivity of air; and  
 $Nu_L$  = Nusselt number =  $h L / k_a$   
 where  $h$  = convective heat transfer coefficient

The first term in the heat transfer equation is the conduction term. The second term is that due to convection.

The expression for the freezing factor ( $D_F$ ) is

$$D_F = \frac{T_b}{T_b - T_a} \frac{1}{\text{erf}(\lambda)} \quad (2-44)$$

where  $\lambda$  is solved from the following equation:

$$\frac{1}{\lambda \exp(\lambda^2) - \lambda \exp(\lambda^2) \text{erfc}(\lambda)} + \frac{E_1}{\lambda \chi \exp^2(\lambda \chi) \text{erfc}(\lambda \chi)} - E_2 = 0 \quad (2-45)$$

where

$$\chi = \sqrt{\frac{\alpha_F}{\alpha_{UF}}}$$

$$E_1 = \frac{T_a (\rho c)_{UF}}{T_b (\rho c)_F}$$

$$E_2 = \frac{F \sqrt{p}}{c_F T_b}$$

$\alpha$  = thermal diffusivity;

$\rho$  = density;

$c$  = specific heat;

$F$  = latent heat of freezing water; and subscripts F and UF refer to frozen and unfrozen, respectively.

The expression for the percolation factor ( $p$ ), is:

$$p = \exp\left(\frac{K^2}{4\alpha_D}\right) \text{erfc}\left(\frac{K}{2\sqrt{\alpha_D}}\right) \quad (2-46)$$

$K$  is solved from the following equation:

$$\left(\frac{C_1}{\eta^2} - C_2\right) \eta \exp(\eta^2) (1 - \text{erf}(\eta)) - 1 = 0 \quad (2-47)$$

where

$$\eta = \frac{K}{2\sqrt{\alpha_D}}$$

$$C_1 = \frac{\sqrt{\pi} \rho_L \Delta H_v K' \gamma_L}{2(\rho c)_D (T_a - T_b) \mu_L \alpha_D}$$

$$C_2 = \frac{\sqrt{\pi} \Delta H_v \varepsilon}{(\rho c)_D (T_a - T_b)}$$

$K'$  = modified Darcy's constant;  
 $\gamma_L$  = liquid surface tension;  
 $\mu_L$  = dynamic liquid viscosity;  
 $\varepsilon$  = porosity; and  
 subscripts L and D refer to liquid and dry, respectively.

For laminar flow, the Nusselt number ( $Nu_L$ ) is:

$$Nu_L = 0.664 Pr^{\frac{1}{3}} \sqrt{Re} \quad (2-48)$$

where  $Pr$  = Prandtl number =  $\nu_{air}/D_{air}$

For turbulent flow, the Nusselt number is

$$Nu_L = 0.037 Pr^{\frac{1}{3}} (Re^{0.8} - 15,200) \quad (2-49)$$

### Mass Transfer

The equation used to calculate the mass transfer emission rate ( $Q_{MT}$ ) is:

$$Q_{MT} = D_{c-a} Sh_L \rho_G \left( \frac{A}{L} \right) \quad (2-50)$$

where  $D_{c-a}$  = molecular diffusion coefficient between the chemical and air;  
and

$Sh_L$  = Sherwood number =  $k_c L / D_{air}$

The SPILLS model has the following assumptions:

$$Nu_L \cong Sh_L \text{ and } Pr \cong Sc = \frac{\nu_{air}}{D_{air}}$$

This assumption allows the use of equations of the same form as those used for the Nusselt Number. For laminar flow, the Sherwood Number is calculated as follows:

$$Sh_L = 0.664 Sc^{\frac{1}{3}} \sqrt{Re} \quad (2-51)$$

For turbulent flow, the equation for the Sherwood number is:

$$Sh_L = 0.037 Sc^{\frac{1}{3}} (Re^{0.8} - 15,200) \quad (2-52)$$

## Solar Radiation

The equation for the solar radiation transfer emission rate ( $Q_s$ ) is:

$$Q_s = f_s S_{\text{rad}} A \quad (2-53)$$

where  $S_{\text{rad}}$  = solar radiation (from user); and  
 $f_s$  = efficiency that the solar radiation is used in evaporation (from user).

## 2.3 User-Specified Release

The module for a user-specified release requires the user to supply most of the parameters needed for the Transport/Dispersion model. The required user input for this module includes:

- Exit temperature;
- Source diameter;
- Release direction of movement;
- Horizontal release speed;
- Vertical release speed;
- Droplet mass fraction;
- Molar water vapor fraction; and
- Molar air fraction.

The user must also specify whether the release is continuous or instantaneous. Continuous releases have emission rates that can be described as constant, linearly decreasing, exponentially decreasing, or some user-defined schedule. The module does not modify the input but performs the calculations described in the following paragraphs.

CHARM can calculate one of three other variables for the user: emission rate, molar air fraction, or exit velocity.

The volume of material being emitted per unit time ( $V_T$ ) is calculated by the following equation, which is a restatement of the Perfect Gas Law.

$$V_T = \frac{E}{M} \frac{R T_e}{P_a} \quad (2-54)$$

where  $E$  = emission rate (mass/time);  
 $M$  = molecular weight of the vapor;  
 $R$  = universal gas constant;  
 $P_a$  = atmospheric pressure; and

$T_e$  = exit temperature.

The value of  $V_T$  can also be stated as

$$V_T = \frac{\pi}{4} D_h^2 v_e FG \quad (2-55)$$

where  $D_h$  = diameter of hole;  
 $v_e$  = exit velocity; and  
 $FG$  = molar fraction of emitted material.

The sum of the fractional compounds in a release must be equal to one; the calculation for the molar fraction of emitted material (FG) is expressed as follows.

$$FG = 1 - FW - FA \quad (2-56)$$

where  $FW$  = molar fraction of water vapo; and  
 $FA$  = molar fraction of air.

Equating the two formulas for  $V_T$  and using the relationships between FG, FW, and FA leads to an equation where, one of  $v_e$ , E, or FA can be calculated, if two of the three variables are known and all other input (such as the hole diameter) is provided. CHARM considers only turbulent mixing as a source of FA. Therefore, if the user enters an exit velocity of zero, FA is assumed to be zero.

The user-specified release can be defined as continuous or instantaneous. If the release is defined as continuous, the user must enter the length of time in which the emission took place and whether the emission rate is constant, decreasing linearly, decreasing exponentially, or user-defined. CHARM estimates the emissions as a function of time (t).

For constant emissions, CHARM uses the specified rate throughout the release. For linearly decreasing emissions, CHARM calculates the emission rate as follows:

$$E = E_0 \left( 1 - \frac{t}{t_e} \right) \quad (2-57)$$

where  $E$  = emission rate (mass/time);  
 $E_0$  = initial emission rate; and  
 $t_e$  = total time of emission.

The amount of mass emitted (GM) between times  $t_1$  and  $t_2$  (where  $t_2 = t_1 + \Delta t$ ) is calculated as follows:

$$GM = E_0 \Delta t \left( 1 - \frac{(t_1 + t_2)}{2t_e} \right) \quad (2-58)$$

For exponentially decreasing emissions, the total emission time is assumed to be the time it takes for the emission rate to reach one percent of its original value. The time it takes for the emission rate to become one-half of its original value ( $t_{1/2}$ ) is calculated as follows:

$$t_{1/2} = \frac{\ln(1/2)}{\ln(0.01)} t_e \quad (2-59)$$

Therefore, the rate for an exponentially decreasing emission has the following form:

$$E = E_0 \exp\left(-\frac{t}{\tau}\right) \quad (2-60)$$

where

$$\tau = \frac{t_{1/2}}{\ln(2)}$$

The amount of mass emitted between times  $t_1$  and  $t_2$  is then calculated with the following equation:

$$GM = E_0 \tau \left( 1 - \exp\left(-\frac{\Delta t}{\tau}\right) \right) \exp\left(-\frac{t_1}{\tau}\right) \quad (2-61)$$

For a user-defined schedule, the emission rate between any two times is assumed to be linear.

**Table 2-1. Equivalent Pipe Length Factors (Turbulent Flow, Multiply By Pipe Diameter For Equivalent Length)**

Globe Valves (100% open)	300
Gate Valves (100% open)	7
Gate Valves (75% open)	40
Gate Valves (50% open)	200
Gate Valves (25% open)	900
90° Elbows	30
45° Elbows	15
Tee Elbows-Entering Stem	90
Tee Elbows-Entering Side	60
Tee Straight Throughs	20
Flush Pipe-Vessel Connections	16
Borda Pipe-Vessel Connections	30
Round Pipe-Vessel Connections	0



**Table 2-2. Example Roughness Lengths (mm) For Clean Pipes**

Riveted Steel	0.9-9.1
Concrete	0.3-3
Cast iron	0.26
Galvanized iron	0.15
Commercial steel	0.046
Wrought iron	0.046
Drawn tubing	0.0015
Glass	0
Plastic	0

Source: Perry's Chemical Engineer's Handbook, 7<sup>th</sup> Edition, 1997

# Container/Surface Description Release

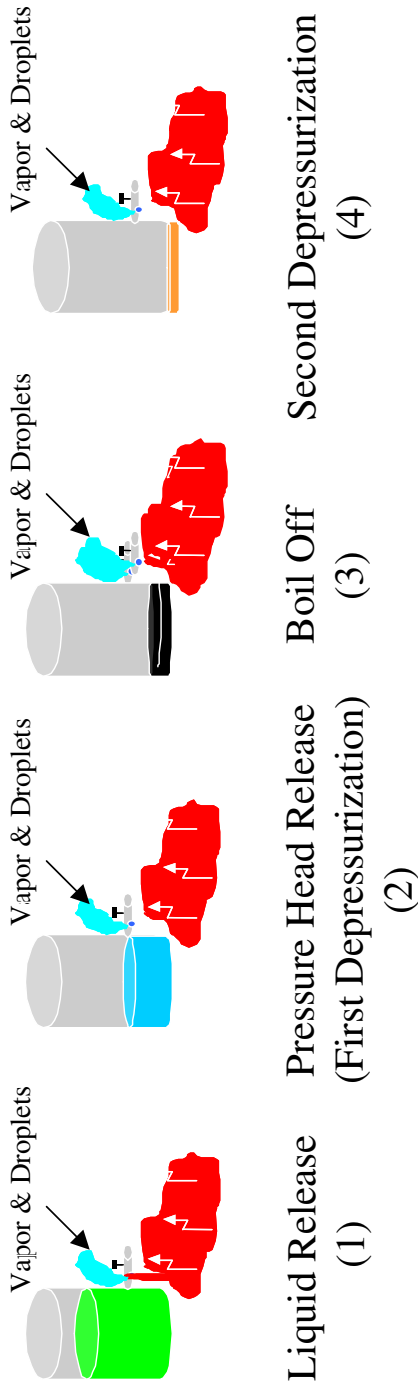


Figure 2-1. Schematic of Release Phases for Container/Release Description.

# Phases of Emission

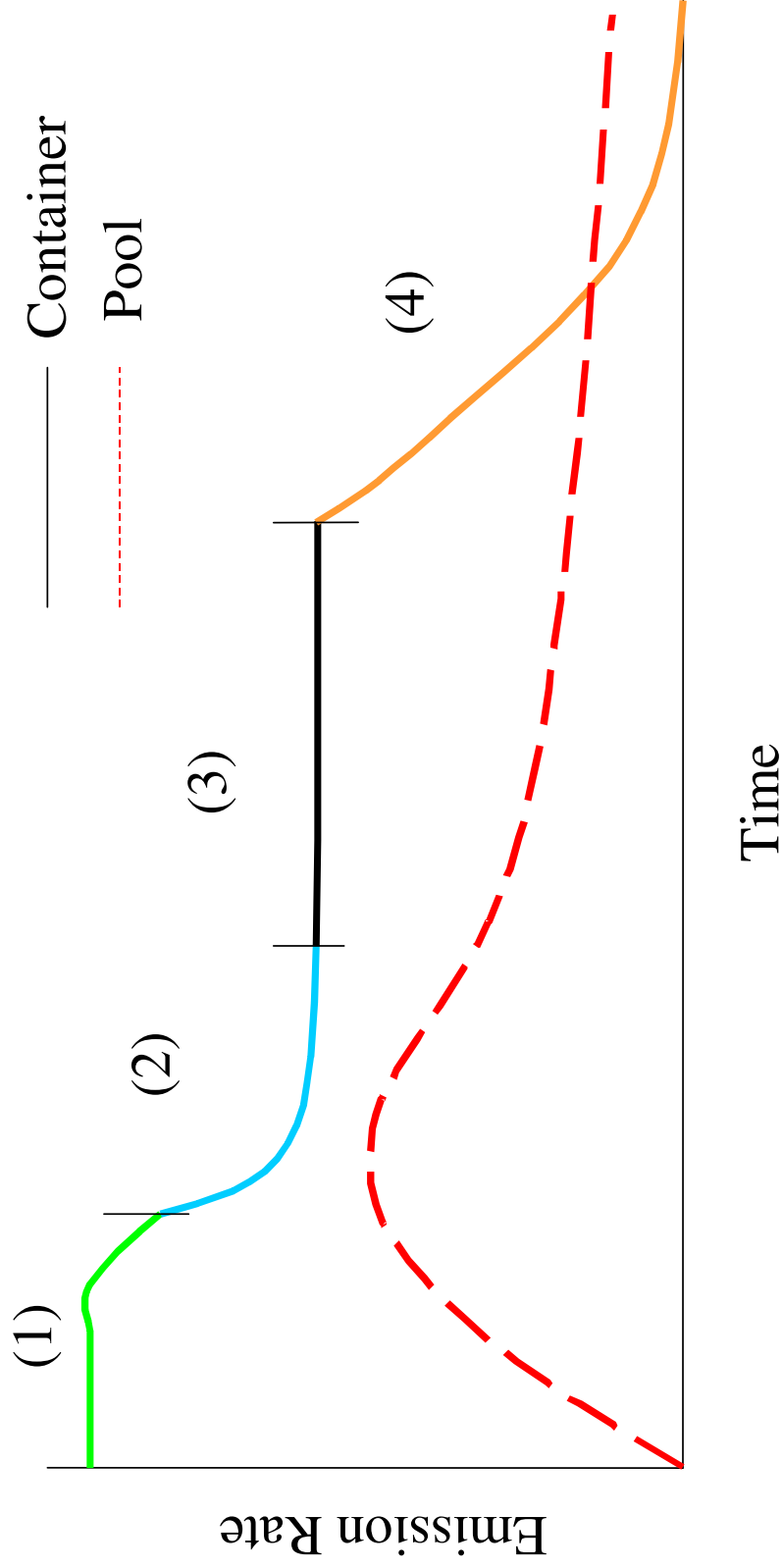
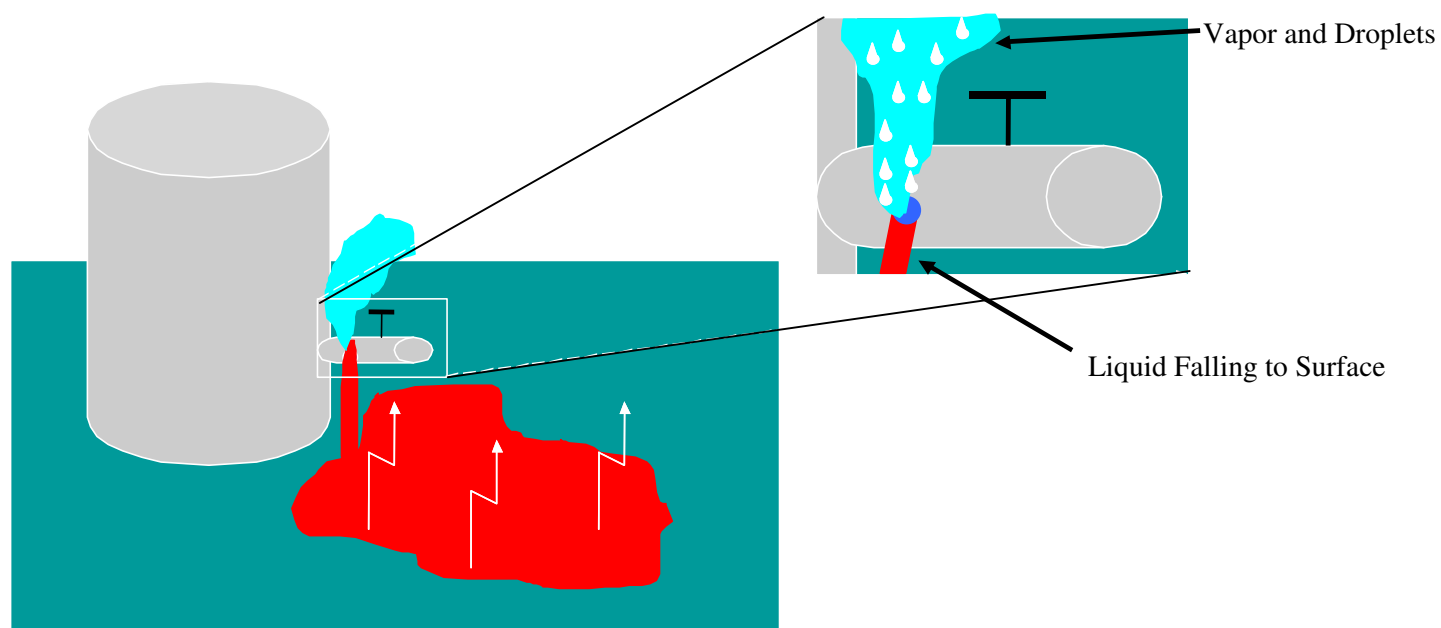


Figure 2-2. Example Emission Rate Over Time For Container Release With Pool Formation.

# Liquid Release Fates



**Figure 2-3. Closeup of Liquid Release Phase.**

### 3.0 CHARM FORMULATION

There are a number of parameters calculated in CHARM as they move throughout the atmosphere. These parameters include, momentum, energy, gas concentration, particle concentration, and particle number. The advection and dispersion calculation for each of these parameters are essentially identical. Some of the parameters have extra terms to calculate processes that are particular to a parameter. The basic equations are given here. More detail on the particular terms for some of the parameters follows.

Conserved parameters (p – momentum and energy) governing equation:

$$\begin{aligned} & -\frac{\partial up_i}{\partial x} - \frac{\partial vp_i}{\partial y} - \frac{\partial wp_i}{\partial z} && \text{advection} \\ \frac{\partial p_i}{\partial t} = & + \frac{\partial}{\partial x} K_x \frac{\partial p_i}{\partial x} + \frac{\partial}{\partial y} K_y \frac{\partial p_i}{\partial y} + \frac{\partial}{\partial z} K_z \frac{\partial p_i}{\partial z} && \text{diffusion} \\ & + S_i && \text{source} \end{aligned} \quad (3-1)$$

Gas concentration equation

$$\begin{aligned} & -\frac{\partial uc_i}{\partial x} - \frac{\partial vc_i}{\partial y} - \frac{\partial wc_i}{\partial z} && \text{advection} \\ \frac{\partial c_i}{\partial t} = & + \frac{\partial}{\partial x} K_x \frac{\partial c_i}{\partial x} + \frac{\partial}{\partial y} K_y \frac{\partial c_i}{\partial y} + \frac{\partial}{\partial z} K_z \frac{\partial c_i}{\partial z} && \text{diffusion} \\ & + S_i && \text{source} \\ & - P_{\text{cond}_i} && \text{condensation onto particles} \\ & + P_{\text{evap}_i} && \text{evaporation of particles} \end{aligned} \quad (3-2)$$

Particle concentration equation

$$\begin{aligned} & -\frac{\partial un_i}{\partial x} - \frac{\partial vn_i}{\partial y} - \frac{\partial wn_i}{\partial z} && \text{advection} \\ \frac{\partial n_i}{\partial t} = & + \frac{\partial}{\partial x} K_x \frac{\partial n_i}{\partial x} + \frac{\partial}{\partial y} K_y \frac{\partial n_i}{\partial y} + \frac{\partial}{\partial z} K_z \frac{\partial n_i}{\partial z} && \text{diffusion} \\ & + S_i && \text{source} \\ & + \frac{\partial V_s n_i}{\partial z} && \text{sedimentation} \\ & \pm C_i && \text{coagulation} \end{aligned} \quad (3-3)$$

where  $V_s$  = the sedimentation velocity of particle of radius  $r_i$ :

$$V_s = \frac{2\rho_{\text{part}} r_i^2 g}{9\eta} \left\{ 1 + \text{Kn}_i \left[ A + B \exp\left(\frac{-C}{\text{Kn}_i}\right) \right] \right\} \quad (3-4)$$

where

$$\text{Kn}_i = \text{Knudsen number} = \frac{\lambda_g}{r_i}$$

$\rho_{\text{part}}$  = particle density

$g$  = gravitational acceleration

$\eta$  = dynamic viscosity of air

A, B, C = corrections for particle resistance to motion (Millikan, 1923)

A, B, C = 1.246, 0.42, 0.87 (Kasten, 1968)

The mean free path of a gas molecule ( $\lambda_g$ ) is given in terms of viscosity and air density ( $\rho_g$ ) as:

$$\lambda_g = \frac{2\eta}{\rho_g \bar{v}_g} \quad (3-5)$$

The value of  $\bar{v}_g$  is given by:

$$\bar{v}_g = \sqrt{\frac{8k_B T}{\pi m_{\text{air}}}} \quad (3-6)$$

where  $k_B$  = Boltzmann's constant

$T$  = temperature

$m_{\text{air}}$  = mass of an air molecule

Particle mass equation

$$\begin{aligned} \frac{\partial m_i}{\partial t} = & -\frac{\partial u m_i}{\partial x} - \frac{\partial v m_i}{\partial y} - \frac{\partial w m_i}{\partial z} && \text{advection} \\ & + \frac{\partial}{\partial x} K_x \frac{\partial m_i}{\partial x} + \frac{\partial}{\partial y} K_y \frac{\partial m_i}{\partial y} + \frac{\partial}{\partial z} K_z \frac{\partial m_i}{\partial z} && \text{diffusion} \\ & + S_i && \text{source} \\ & + P_{\text{cond}_i} && \text{condensation} \\ & - P_{\text{evap}_i} && \text{evaporation} \end{aligned} \quad (3-7)$$

### 3.1 Grid Definition

A 3D grid is required for the calculation. For each grid column (at an x, y location) two parameters are required. One is the elevation of the terrain in that column, the second is the surface roughness.

The CHARM Editor (CharmEd) has the capability of reading in DEM files and Globe data files to determine the terrain elevations over a grid once the position and size of the grid has been set. CharmEd also has the capability of reading in USGS land use files. The land use classifications are set to various surface roughnesses. The user can modify the relationship between land use and surface roughness. Of course, surface roughness and elevation can be set by the user for each grid cell.

It is suggested that the number of cells in the vertical should be sufficient so that the highest terrain is within the grid. That is, it is best if there are no grid columns that are completely within the terrain.

### 3.2 West Wind Field Model

CHARM is designed to be used with as little or much meteorological data as are available, since possible applications range from unmonitored wilderness to intensively instrumented research areas. Thus, the wind field uses any and all available data, with its accuracy improving with increased, usable data.

Atmospheric stability data are interpolated via a  $1/r^2$  weighting to produce a stability field over the computational domain (1.0 = A stability, 7.0 = G stability). Wind observations are projected upwards from the measurement point through the portion of the grid without any measurement. Such projected data are weighted as 0.001 compared with user-specified weighting of from 0.0 to 1.0.

The projections are based on a power law extrapolation of the form

$$S = S_0 \left( \frac{z}{z_0} \right)^P \quad (3-8)$$

for speeds  $S$  and  $S_0$  at vertical coordinates  $z$  and  $z_0$ , respectively, with  $P$  determined by linear interpolation from the following table:

Stability	A	B	C	D	E	F	G
Category	1	2	3	4	5	6	7
P	0.15	0.17	0.20	0.26	0.39	0.48	0.54

The maximum wind speed allowed is 20 m/sec and the initial  $z_0$  is assumed equal to  $\Delta z/2$ . After the wind speeds are projected upwards, the wind speed and direction are resolved into  $u$  and  $v$  vector components at every wind data site. Next, the entire wind field is developed via a weighted  $1/r^2$  interpolation of the vertical profiles for each horizontal plane. Up to this point, terrain has not been considered. Terrain first enters by shifting the interpolated winds upward to clear the terrain. Thus, a complete wind field is calculated. However, this wind field is not satisfactory since it is not divergence-free (and it has no vertical components). Before the winds are made divergence-free, the velocity fluxes in and out of the boundaries of the computational domain are adjusted such that the flux in equals the flux out. If the wind field were to be made divergence-free at this point, the effects of atmospheric stability would be lost. Atmospheric stability has the effect of varying the relative response to terrain of horizontal and vertical motion. This is accomplished by varying the relative transparencies of the horizontal and vertical cell faces. The assignment of transparency was developed on the basis of simulations of idealized problems and appears to be qualitatively correct. The assignment of transparency is as follows:

Stability Category		1	2	3	4	5	6	7
Horizontal Transparency	$T_x, T_y$	1.0	1.0	1.0	1.0	200.	500.	1000.
Vertical Transparency	$T_z$	1.6	1.4	1.2	1.0	0.8	0.6	0.4

Terrain cells are assigned zero transparency.

The non-divergence of the wind field is imposed by an interactive solution based on calculating the divergence such that:

$$\nabla U = \frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = \mathcal{D} \quad (3-9)$$

and readjusting the velocity to minimize the divergence.

$$\begin{aligned} u &= u + \alpha \mathcal{D} \\ v &= v + \alpha \mathcal{D} \\ w &= w + \alpha \mathcal{D} \end{aligned} \quad (3-10)$$

In finite difference, these expressions are written as:

$$\frac{u_{ijk} - u_{i-1,j,k}}{\Delta x} + \frac{v_{ijk} - v_{i,j-1,k}}{\Delta y} + \frac{w_{ijk} - w_{i,j,k-1}}{\Delta z} = \mathcal{D}_{ijk} \quad (3-11)$$

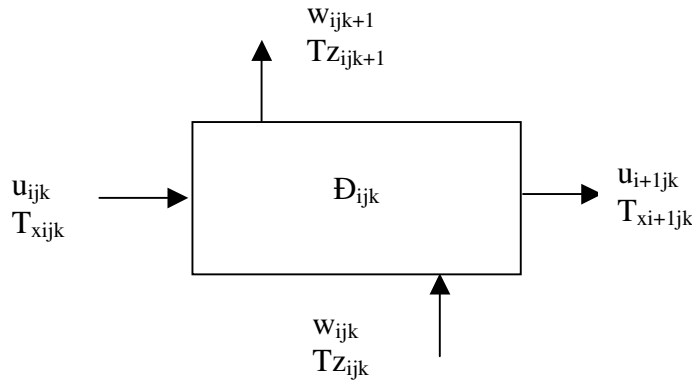


$$\begin{aligned}
u_{ijk} &= u_{ijk} - \frac{\alpha}{\Delta x} D_{ijk} T_{xijk} \\
v_{ijk} &= v_{ijk} - \frac{\alpha}{\Delta y} D_{ijk} T_{yijk} \\
w_{ijk} &= w_{ijk} - \frac{\alpha}{\Delta z} D_{ijk} T_{zijk}
\end{aligned} \tag{3-12}$$

where

$$\alpha = \frac{\beta}{\left\{ \frac{(T_{xijk} + T_{xi+1jk})}{\Delta x^2} + \frac{(T_{yijk} + T_{yij+1k})}{\Delta y^2} + \frac{(T_{zijk} + T_{zij+1k})}{\Delta z^2} \right\}} \tag{3-13}$$

where  $\beta$  is an over-relaxation factor ( $1.0 \leq \beta < 2.0$ ) and is set to 1.25. The positioning of the variables is illustrated below:



The subroutine sweeps through the grid from each of the eight corners for fifteen cycles. After each cycle, the wind data profiles are incorporated in the wind field by a weighted averaging of the iterative solution. At the completion of the iterative cycles, all residual divergences are swept out the top of the grid. This completes the wind field development.

### 3.3 Myrup-Ranzieri Diffusivity Model

CHARM uses the Myrup/Ranzieri (M/R) (Myrup and Ranzieri, 1976) model for calculating the diffusivity of the atmosphere. The model calculates the surface wind speed and the Monin-Obukhov length ( $L$ ) based on the surface stability and surface roughness parameter ( $Z_0$ ). The determination of the Monin/ Obukhov length is based on a three-part linear fit to the curves presented in the original M/R paper. The fitted curves are shown in Figure 3-1. A linear interpolation between integerized stability classifications is performed. The top and bottom of the inversion (if any) is determined as follows. The inversion base height relative to the terrain ( $ZI_{base}$ ) is calculated from:

$$ZI_{\text{base}} = \begin{cases} (k_2 - k_1 + 0.5)\Delta z & k_1 \neq k_2 \\ 0 & k_1 = k_2 \end{cases} \quad (3-14)$$

where  $k_1$  is the  $k$ -coordinate of the first cell lying above the terrain and  $k_2$  is the  $k$ -coordinate of the first cell that has a stability number greater than 4.5. If there are no cells with a stability category number greater than 4.5,  $ZI_{\text{base}}$  is set equal to -99.00.

The top of the inversion relative to the terrain ( $ZI_{\text{top}}$ ) is calculated from:

$$ZI_{\text{top}} = (k_4 - k_1 + 0.5)\Delta z \quad (3-15)$$

where  $k_4$  is the  $k$ -coordinate of the first cell above the inversion base with a stability category number less than 4.5. If no such cell is found,  $ZI_{\text{top}}$  is set equal to  $10^6$ . The vertical diffusivities are calculated by looping over the vertical cells and determining if the cell is:

1. below the inversion base or inside a surface inversion,
2. inside the elevated inversion, or
3. above the top of the inversion.

For the first case,

$$D = \begin{cases} 0.35 U_* z \left( 1 + 4.7 \frac{z}{L} \right) & L \geq 0 \\ 0.35 U_* z \left( 1 - 15 \frac{z}{L} \right)^{\frac{1}{4}} & L < 0 \text{ and } \frac{z}{L} < 27.6 \\ 0.5 U_* z \left( -\frac{0.4}{0.35} \frac{z}{L} \right)^{\frac{1}{3}} & L < 0 \text{ and } \frac{z}{L} \geq 27.6 \end{cases} \quad (3-16)$$

where  $z$  = the height above the ground  
 $L$  = the Monin-Obukhov length, and  
 $U_*$  = the friction velocity

$$U_* = \begin{cases} \frac{0.35 U_0}{\ln\left(\frac{z}{z_w}\right) + 4.7\left(\frac{z_w - z_0}{L}\right)} & L \geq 0 \\ \frac{0.35 U_0}{\ln\left(\frac{z'_w - 1}{z'_w + 1}\right) + 2 \tan^{-1}(z'_w) - \ln\left(\frac{z'_0 - 1}{z'_0 + 1}\right) - 2 \tan^{-1}(z'_0)} & L < 0 \end{cases} \quad (3-17)$$

$$z'_w = \left(1 - 15 \frac{z_w}{L}\right)^{\frac{1}{4}} \quad (3-18)$$

$$z'_0 = \left(1 - 15 \frac{z_0}{L}\right)^{\frac{1}{4}} \quad (3-19)$$

$U_0$  is wind speed at a height  $z_w$  above the surface and

$$z_w = \frac{\Delta z}{2} \quad (3-20)$$

The parameter  $z_0$  is the surface roughness.

The vertical diffusivity  $D$  is further modified by the function

$$D = D \left(1.1 - \frac{z}{ZI_{base}}\right)^{\frac{1}{4}} \quad (3-21)$$

when

$$0.1ZI_{base} < z < 1.1ZI_{base} \quad (3-22)$$

For the second case (inside an elevated inversion), the surface wind speed is set to 3.0 m/sec, the Monin-Obukhov length is set to 20.0, and  $z$  (the height above the surface) is measured from  $ZI_{base}$ .

Above the elevated inversion, the third case, neutral stability is assumed and  $z$  is measured from the top of the inversion  $ZI_{top}$ . The vertical diffusion is then limited by

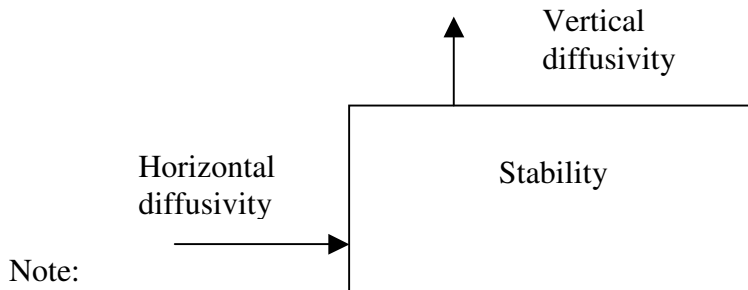
$$0.001 \frac{m^2}{sec} < D < 1000 \frac{m^2}{sec} \quad (3-23)$$

and assigned to the top face of the cell.

The horizontal diffusivities are calculated using the relation  $D_H = \alpha D_V$  where  $\alpha$  depends on stability as follows:

Stability	A	B	C	D	E	F
$\alpha$	0.5	0.75	1.05	1.35	1.7	2.0

The location of the related stability vertical diffusivity and horizontal diffusivity parameters are indicated below:



Because the diffusivities are face-centered, the vertical stability is offset one-half cell above the cell center; the horizontal diffusivity is offset one-half cell to the left of the cell center.

### 3.4 Advection and Diffusion

The advection and diffusion formulation is the same for all constituents simulated: gases, aerosols, momentum, and energy. The advection/diffusion time step is calculated such that the maximum normalized flux across any cell is less than alpha, i.e.:

$$\Delta t = \frac{\alpha}{F_{\max}} \quad (3-24)$$

where

$$F_{\max} = \text{Maximum} \left( \frac{U_i}{\Delta x_i} + 2 \frac{K_{x_i}}{\Delta x_i^2} \right) \quad i = 1, 2, 3 \quad (3-25)$$

The time step is limited to no less than the default time of 0.01 seconds. Adding a statement in the initialization file can change this value.

The model solves the differential equation describing advection and diffusion of a parameter (C), i. e.:

$$\frac{\partial C}{\partial t} = -\nabla u C + \nabla^2 K C \quad (3-26)$$

The solution is performed separately in each direction with the form

$$\frac{\partial C}{\partial t} = -\frac{\partial u C}{\partial x} + \frac{\partial}{\partial x} K_x \frac{\partial C}{\partial x} \quad (3-27)$$

The value of  $u$  to be used is determined from the ambient wind velocity and modifications to that velocity due to the presence of mass that has been emitted into the grid. The first modification is due to the emitted momentum in each direction:

$$u' = \frac{m_a u + p_e}{m_t} \quad (3-28)$$

where  $u'$  = the new wind speed  
 $u$  = the atmospheric wind speed  
 $m_a$  = the mass of air in a cell  
 $m_t$  = the total mass in a cell  
 $p_e$  = the momentum in a cell from an emission

The mass from an emission is tracked for each cell as well as the fraction that may be in droplet form. The volume occupied by the mass from an emission can then be calculated. Whatever volume remains in a cell is assumed to be air.

The next modification is only to the vertical component of the velocity and is due to buoyancy. If the difference of the cell's density ( $\rho$ ) with the ambient density ( $\rho_a$ ) is greater than one percent of  $\rho_a$  then the vertical velocity may be modified. If the cell's bottom is not in contact with terrain the vertical velocity is assumed to be changing by:

$$\frac{dw}{dt} = g \left( \frac{\rho_a}{\rho} - 1 \right) \quad (3-29)$$

where  $g$  = gravitational acceleration =  $9.8 \text{ m/sec}^2$

If the bottom of the cell is in contact with the ground and the density difference is less than  $-0.01$ , the vertical motion due to slump is assumed to be transferred to horizontal motion. The horizontal velocity due to the downward motion is given by:

$$u' = \sqrt{-2g \left( \frac{\rho_a}{\rho} - 1 \right) \Delta z} \quad (3-30)$$

The finite difference solution is based on a flux-corrected version of Crowley's (1968) second-order advection scheme (Sklarew and Wilson, 1976). For the  $n^{\text{th}}$  time step of the concentration ( $C$ ) of the  $i^{\text{th}}$  species in the  $x$  direction:

$$C_i^{n+1} = C_i^n + \left( F_{i-\frac{1}{2}}^n - F_{i+\frac{1}{2}}^n \right) \frac{\Delta t}{\Delta x} \quad (3-31)$$

where

$$F_{i+\frac{1}{2}}^n = \frac{\Delta x}{2\Delta t} \left\{ (C_i^n + C_{i+1}^n) \alpha_{i+\frac{1}{2}} + (C_i^n - C_{i+1}^n) \alpha_{i+\frac{1}{2}}^2 \right\} + K_{xi+\frac{1}{2}} \left( \frac{C_i^n - C_{i+1}^n}{\Delta x} \right) \quad (3-32)$$

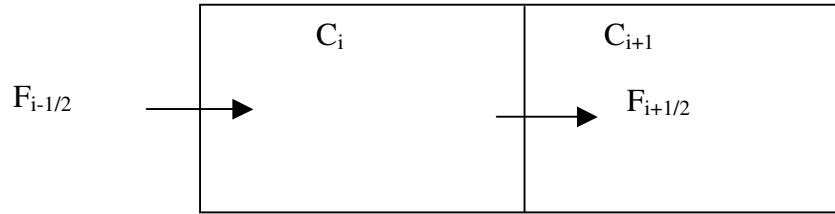
and

$$\alpha_{i+\frac{1}{2}} = u_{i+\frac{1}{2}} \frac{\Delta t}{\Delta x} \quad (3-33)$$

The flux corrector prohibits the calculation of negative concentrations and by an adjustment of the flux, as follows:

$$F_{i+\frac{1}{2}} = \begin{cases} \min \left( F_{i+\frac{1}{2}}, \frac{\Delta x}{\Delta t} C_i, \frac{\Delta x}{\Delta t} C_i + F_{i-\frac{1}{2}} \right) & F_{i+\frac{1}{2}} \geq 0 \\ \min \left( -F_{i+\frac{1}{2}}, \frac{\Delta x}{\Delta t} C_{i+1} \right) & F_{i+\frac{1}{2}} < 0 \end{cases} \quad (3-34)$$

The location of the related concentrations and fluxes are indicated below:



### 3.5 Cell Temperature

The temperature in each cell is calculated for each time step. The calculation is given by:

$$T_c = \frac{E_e + m_{air} C_{pair}(T_{amb}) T_{amb}}{m_{air} C_{pair}(T_c) + \sum_{i=1}^{i=n_c} m_i ((f_{di} C_{pli}(T_c) + (1-f_{di}) C_{pvi}(T_c)))} \quad (3-35)$$

where  $T_c$  = cell temperature;  
 $E_e$  = energy in the cell from the emissions;  
 $m_{air}$  = mass of air in the cell;  
 $n_c$  = number of emitted species;  
 $C_{pair}(T)$  = heat capacity of air at temperature  $T$ ;  
 $C_{pli}(T)$  = heat capacity of the liquid  $i^{th}$  species at temperature  $T$ ;  
 $C_{pvi}(T)$  = heat capacity of the vapor  $i^{th}$  species at temperature  $T$ ;  
 $f_{di}$  = mass fraction of the  $i^{th}$  species in droplet form;

$T_{amb}$  = ambient temperature;  
 $m_i$  = mass of the  $i^{th}$  species in cell.

The equation needs to be solved iteratively since the term  $T_c$  cannot be totally isolated.

For each time step energy is added to the source's grid cells. The energy is then allowed to advect and disperse according to Equation 3-1. The amount of energy added to a source's grid cell ( $\Delta E_e$ ) in a time step ( $dt$ ) is defined as:

$$\Delta E_e = \sum_{i=1}^{i=n_c} R_i \left( (f_{di} C_{pli}(T_e) + (1 - f_{di}) C_{pvi}(T_e)) \right) dt \quad (3-36)$$

where  $T_e$  = emission temperature  
 $R_i$  = emission rate of the  $i^{th}$  species

### 3.5 Convective Heat Transfer

Heat can be transferred between the plume just above the terrain and the terrain itself. The heat transfer is allowed only when that portion of the plume that is not at the source location and is in contact with the ground.

The rate that energy ( $q$ ) is transferred between the plume and the ground is given by:

$$\frac{dq}{dt} = h A (T_g - T_c) \quad (3-37)$$

where  $h$  = convective heat transfer coefficient (assumed to be  $100 \text{ W/m}^2 \text{ K}$ )  
 $A$  = surface area shared by the cell and ground  
 $T_g$  = surface or ground temperature (assumed to be ambient)  
 $T_c$  = cell temperature

The addition or loss of energy can raise or lower the cell temperature to a new value. After the heat is added or depleted from the cell a new cell temperature is calculated.

### 3.6 Source Terms

The grid cells that have sources in them have mass, momentum, and energy added to them at the beginning of each time step. Complete mixing is assumed to occur in the grid cell in which the emission occurs.

### 3.7 Particles

Particles or aerosols are modeled as existing in a number of size bins. The size bins are geometric in nature. That is, the particle volume in a size bin ( $v_i$ ) is equal to the next smaller volume bin ( $v_{i-1}$ ) times a constant value ( $V_{rat}$ ). In terms of the bin with the smallest volume ( $v_0$ ), the volume of the  $i^{th}$  bin is given as:

$$v_i = v_0 V_{rat}^i \quad (3-38)$$

The particle radius for the  $i^{th}$  bin is then given as:

$$r_i = r_0 V_{rat}^{\frac{i}{3}} \quad (3-39)$$

If there is more than one definition of the size bins from the input (each release can have its own size distribution), the model uses the smallest value of  $V_{rat}$ , the smallest value of  $v_0$  and the largest bin volume to determine a new size bin distribution.

When two particles of volumes  $v_i$  and  $v_j$  collide and stick the volume ( $V_{i,j}$ ) of the resulting particle is:

$$V_{i,j} = v_i + v_j \quad (3-40)$$

The volume of the resulting particle is partitioned between the two size bins  $k$  and  $k+1$ . The partitioning is performed in the manner described by Jacobson, et al., 1994.

$$f_{i,j,k} = \begin{cases} \left( \frac{v_{k+1} - V_{i,j}}{v_{k+1} - v_k} \right) \frac{v_k}{V_{i,j}} & v_k \leq V_{i,j} < v_{k+1} & k < (N_B - 1) \\ 1 - f_{i,j,k-1} & v_{k-1} < V_{i,j} < v_k & k > 0 \\ 1 & V_{i,j} \geq v_k & k = (N_B - 1) \\ 0 & \text{all other cases} \end{cases} \quad (3-41)$$

where  $N_B$  = the number of size bins

Following Jacobsen and Turco, 1995, the general formula for calculating the number concentration change of particles due to coagulation is given by:

$$\frac{dC_k}{dt} = \frac{1}{2} \sum_{j=0}^k \left( \sum_{i=0}^{k-1} f_{i,j,k} \beta_{i,j} C_i C_j \right) - C_k \sum_{j=0}^{N_B} (1 - f_{k,j,k}) \beta_{k,j} C_j \quad (3-42)$$

Jacobsen, et al., 1994 provides the formula for the volume-conserving calculation of the coagulation of particles of uniform composition as:



$$\frac{d(C_k v_k)}{dt} = \sum_{j=0}^k \left( \sum_{i=0}^{k-1} f_{i,j,k} \beta_{i,j} C_i V_{i,j} C_j \right) - C_k \sum_{j=0}^{N_B} (1 - f_{k,j,k}) V_{k,j} \beta_{k,j} C_j \quad (3-43)$$

The Brownian diffusion kernel ( $\beta_{i,j}$ ) used in the calculation is from Fuchs (1964):

$$\beta_{i,j} = \frac{4\pi(r_i + r_j)(D_i + D_j)}{\frac{r_i + r_j}{r_i + r_j + \sqrt{\delta_i^2 + \delta_j^2}} + \frac{4(D_i + D_j)}{(r_i + r_j)\sqrt{\bar{v}_{pi}^2 + \bar{v}_{pj}^2}}} \quad (3-44)$$

where the particle diffusion coefficient ( $D_i$ ) is defined by:

$$D_i = \frac{k_B T}{6\pi r_i \eta} \left\{ 1 + Kn_i \left[ A + B \exp\left(\frac{-C}{Kn_i}\right) \right] \right\} \quad (3-45)$$

The value of  $\bar{v}_p$  is given by the general formula:

$$\bar{v}_p = \sqrt{\frac{8k_B T}{\pi m_{part}}} \quad (3-46)$$

where  $m_{part}$  = the mass of a particle

The mean distance ( $\delta$ ) traveled by a particle leaving a sphere's surface and going the particles mean free path distance ( $\lambda_{pi}$ ) is given by Fuchs (1964) as:

$$\delta_i = \frac{\left\{ (2r_i + \lambda_{pi})^3 - (4r_i^2 + \lambda_{pi}^2)^{\frac{3}{2}} \right\}}{6r_i \lambda_{pi}} - 2r_i \quad (3-47)$$

where

$$\lambda_{pi} = \frac{8D_i}{\pi \bar{v}_{pi}} \quad (3-48)$$

Condensation and evaporation is calculated using the expression given by Fleagle and Businger (1963) for droplets in the atmosphere:

$$\frac{dm_d}{dt} = 4\pi \frac{r D MW}{R T} (e_\infty - e_{sc}) \quad (3-49)$$

where  $m_d$  = mass of a drop in a size bin;  
 $r$  = drop radius;

- $D$  = the diffusion coefficient;  
 $MW$  = molecular weight of the material in the drop;  
 $R$  = universal gas constant;  
 $T$  = temperature of air surrounding the drop;  
 $e_{\infty}$  = vapor pressure of the material in the drop surrounding the drop;  
 $e_{sc}$  = saturation vapor pressure of the material in the drop.

The value of  $e_{sc}$  is the value of the saturation vapor pressure of the material in the drop over a flat surface ( $e_s$ ), corrected for the curvature of the drop. It is given as:

$$e_{sc} = e_s \exp\left(\frac{2 \sigma MW}{\rho R T r}\right) \quad (3-50)$$

- where  $\sigma$  = surface tension of the material in the drop;  
 $\rho$  = density of the drop.

Once mass has been evaporated or condensed the particles in the  $i^{\text{th}}$  size bin move to another size bin because the volume has changed. Since the number of droplets have not changed the new volume of the droplets ( $V_{di}$ ) is given by:

$$V_{di} = \frac{M_i^{t+\Delta t}}{C_i^{t+\Delta t} \rho_{\text{drop}}} \quad (3-51)$$

- where  $\rho_{\text{drop}}$  = the density of a particle.

The particles with a new volume can be allocated as above using the fraction  $f_{i,j,k}$  with  $V_{i,j}$  replaced by  $V_{di}$ .

When condensation or evaporation occurs latent heat and sensible heat can be exchanged. The exchanged energy ( $dE$ ) can be given as:

$$\frac{dE}{dt} = L_v \frac{dm_d}{dt} \quad (3-52)$$

- where  $L_v$  = latent heat of drop component.

### 3.8 Chemical Reactions

Chemical reactions can be taken into account for each grid cell of the calculation region. The chemical reactions are assumed to be of the form:



where A = mole concentration of reactant species A (moles/m<sup>3</sup>);  
 B = mole concentration of reactant species B (moles/m<sup>3</sup>);  
 C = mole concentration of product species C (moles/m<sup>3</sup>);  
 D = mole concentration of product species D (moles/m<sup>3</sup>);  
 a = the amount of species A consumed in the reaction;  
 b = the amount of species B consumed in the reaction;  
 c = the amount of species C produced in the reaction;  
 d = the amount of species D produced in the reaction;  
 K = the reaction rate (moles/m<sup>3</sup> second).

There can be unlimited reactants and products; however, each reactant and product must exist in the chemical database. The reactions can be entered for use in the Charmed program. The reactions can be grouped into sets for use in the calculation.

The value for K is calculated using the expression:

$$K = k [A]^m [B]^n \quad (3-54)$$

where k = the rate constant;  
 m = the order of the reaction for species A;  
 n = the order of the reaction for species B.

The values for m and n are normally determined experimentally. A number of dependencies are allowed for k. These are:

$$k = \left\{ \begin{array}{l} A \\ A e^{\frac{b}{T}} \\ A (UV)^b \\ A (TSR)^b \\ A (Air)^b \\ A (Water)^b \\ A (AerosolNumber)^b \\ A (AersolArea)^b \\ A (AerosolVolume)^b \end{array} \right. \quad (3-55)$$

where A = a user supplied constant;  
 b = a user supplied constant;  
 T = temperature in Kelvin;  
 UV = ultraviolet radiation in kW/m<sup>2</sup>;  
 TSR = total solar radiation in kW/m<sup>2</sup>;  
 Air = concentration of air in moles/m<sup>3</sup>;

Water = concentration of water vapor in moles/m<sup>3</sup>;  
 AerosolArea = surface area concentration of particles in m<sup>2</sup>/m<sup>3</sup>;

There is a special case usage for the value of k. Rather than being treated as a rate constant it is used as a mole concentration of a species. The special case is indicated to the model by having no reactants. One or more products can be defined, each of which will be assigned a constant concentration equal to the value of k. For example, if a constant supply of O<sub>2</sub> is wanted in a set of reactions, the following reaction could be defined:



The O<sub>2</sub> concentration can then be defined to be 20 percent of the air available to the reaction by using the expression  $k = A (\text{Air})$  and assigning the value of A to be 0.2.

### 3.9 Liquid Flow Over Terrain

The flow of liquid over terrain is built around a modified Manning Equation for open channel flow:

$$U = \frac{D_{\text{liq}}^{\frac{2}{3}} \sqrt{s}}{n} \frac{\rho_{\text{liq}}}{\eta_{\text{liq}}} \frac{\eta_{\text{water}}}{\rho_{\text{water}}} \quad (3-57)$$

where U = the average speed of the liquid flow;  
 D<sub>liq</sub> = the liquid depth;  
 s = the slope of the terrain;  
 n = the Manning Roughness Coefficient (set to 0.025);  
 ρ<sub>liq</sub> = the flowing liquid density;  
 η<sub>liq</sub> = the viscosity of the flowing liquid;  
 ρ<sub>water</sub> = water density; and  
 η<sub>water</sub> = the viscosity of water.

The flow speed from the Manning Equation is compared to the speed that would be expected if the liquid were spreading due to gravitational spread. The gravitational spread speed (U<sub>g</sub>) is given by:

$$U_g = \sqrt{2D_{\text{liq}} g} \quad (3-58)$$

If the gravitational spread speed is greater than the Manning speed it is used. The gravitational spread speed is normally only greater on a flat surface.

Much of the liquid flow calculation is taken up in determining boundary conditions such as the liquid is not allowed to flow uphill. For any one grid cell the liquid is allowed to flow in eight directions (each corner and the center of each side).

As the flow continues the heat and mass transfer and porosity terms for an evaporating pool as described in Chapter 2 are used to determine mass loss terms. These loss terms become the source terms into the atmosphere.

### 3.10 Hydrogen Fluoride

Hydrogen Fluoride exhibits non-ideal dynamics. At high concentrations, the individual molecules can form oligomers (polymers which contain two, three, or four monomers). The dynamic effect is to increase the molecular weight of the release. It may be desirable to have different data sets for a compound such as hydrogen fluoride. One set of parameters could be used for low concentration releases, the other for pure releases. From Bekerdt et al (1983), there is sufficient data to create a table relating the apparent molecular weight of hydrogen fluoride to the temperature and concentration of the hydrogen fluoride gas. Such a table is presented in Table 3-1. As that table shows, in pure concentration (1,000,000 ppm) hydrogen fluoride at 20°C has an apparent molecular weight of 51.6. Above 70°C, however, hydrogen fluoride is present as a monomer at all concentrations giving a molecular weight of 20.

The dispersion of hydrogen fluoride is handled by the algorithms in this section with the molecular weight of the hydrogen fluoride varying according to Table 3-1. CHARM uses the name of the chemical to determine if the table should be used. The chemical name in the database must match exactly "Hydrogen Fluoride" for the table to be invoked.

Table 3-1. Hydrogen Fluoride Apparent Molecular Weight As A Function Of Temperature And MolarFraction Concentration.

Temp(°C)/fj	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
20	51.59	48.58	43.78	39.53	35.47	31.56	27.03	23.78	21.53	20.32
30	36.22	33.45	30.51	27.20	24.65	22.91	21.65	20.68	20.37	20.03
40	25.26	23.66	22.50	21.51	20.88	20.53	20.36	20.15	20.02	20.01
50	21.06	20.65	20.53	20.32	20.18	20.09	20.02	20.01	20.01	20.01
60	20.17	20.10	20.05	20.01	20.01	20.01	20.01	20.01	20.01	20.01
70	20.01	20.01	20.01	20.01	20.01	20.01	20.01	20.01	20.01	20.01

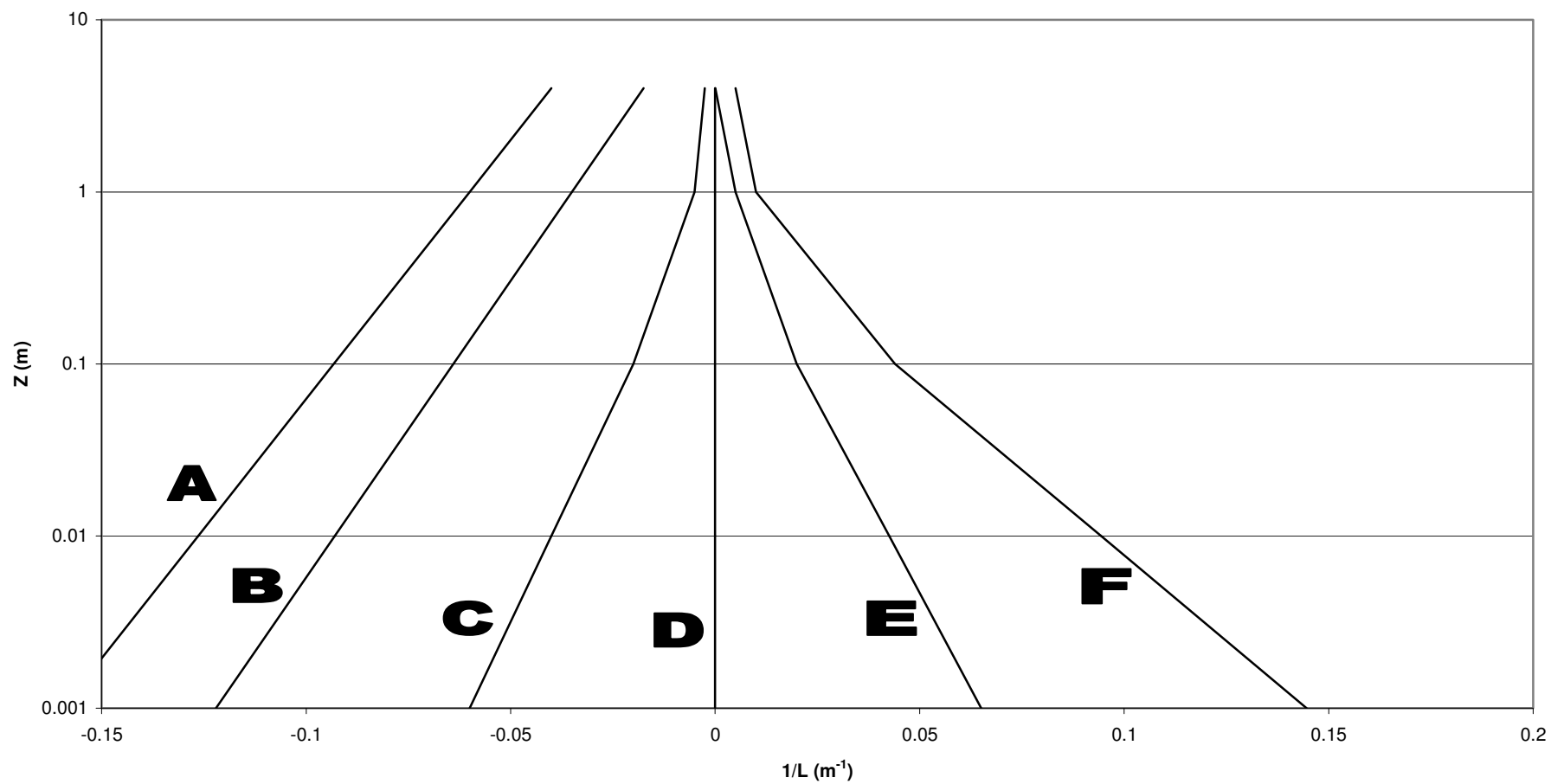
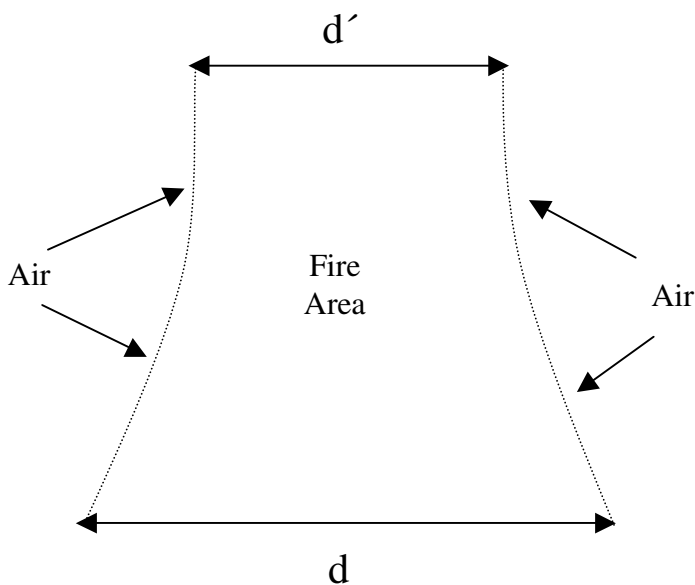


Figure 3-1.  $1/L$  as a Function of Pasquill Stability Class.

## 4.0 LIQUID POOL FIRE ALGORITHM

Large spills of volatile organic chemicals evaporate readily and can form a combustible mixture with air above the pool. When ignited, a major fire can result. Experience has shown that flames initially appear at several locations over the pool and spreading begins. In a typical fire, the intensity grows and combustion products reach 1500°F after several minutes. The intensity and speed of growth depend largely on the material involved and its heat of combustion. The algorithms shown in this section were prepared by Shirley (1982).

After a stable flame involving the entire pool has been established, the overall shape of the fire appears to be a truncated cone whose sides are slightly concave (Blackshear, 1974). Figure 4-1 shows the general appearance and configuration.



**Figure 4-1. General Appearance of a Liquid Pool Fire**

The base of the flame area is only slightly smaller than the pool itself. The diameter of the cone top is about 2/3 that of the base at a height roughly equal to the diameter of the base. Fuel evaporates from the pool surface, and air is drawn into the cone sides to mix with the fuel. Since air enters from the outside of the cone surface, fuel vapors in the center move up the axis of the cone with flames surrounding them. Near the upper end of the cone, these fuel vapors mix with the combustion products and react with them, as well as with the air being drawn further toward the cone center. As the unburned material is heated, cracking reactions form soot causing the pool fires to be generally very smokey. Mixing conditions at the lower levels of the cone are very poor, but a considerable amount of turbulence appears in the upper levels.

The air supply in such fires is not enough to burn all the vapors of combustible material evaporated. These unburned vapors are entrained in the plume and carried up with it. When the fire occurs in a diked area containing tanks, heating of the tank walls occurs, with rapid evaporation of material in the tanks. This material joins the plume (if the tank vent is not remotely located). The plume is then very rich in the organic chemicals involved. The fire reactions are a complex mixture of oxidation, cracking, reduction, and recombinations. In this technique, gross estimates were used to predict likely quantities of heat released and the reaction products obtained. A kinetic model that accounts for reaction rates and residence times at various temperatures is needed to improve the predictions.

#### **4.1 Heat Release and Product Composition**

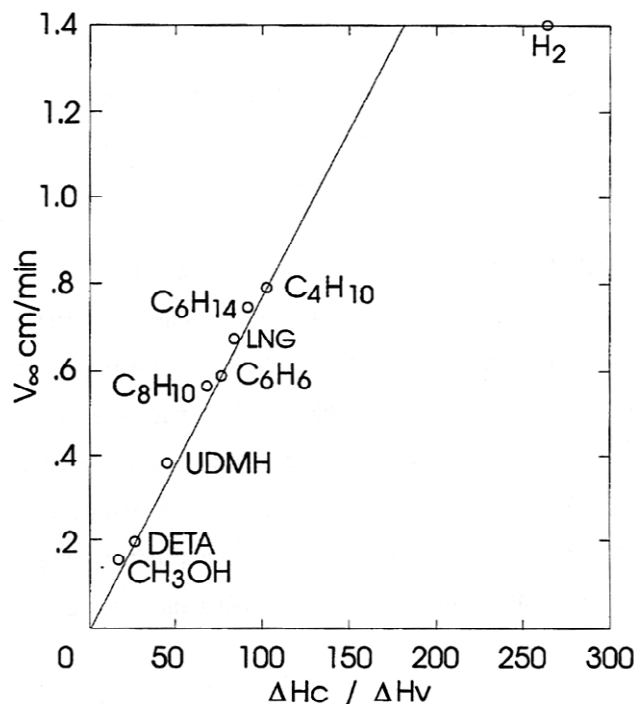
Fuel supply to the fire comes from evaporation at the surface of the pool in response to heat from the fire. A study (Zabetakis, 1964) of pool fires using various combustible materials produced an equation for predicting the drop in liquid level during burning. The equation is:

$$V_{\infty} = 0.0076 \frac{H_c}{H_v} \quad (4-1)$$

where  $V_{\infty}$  = maximum decrease in pool level (cm / min);  
 $H_c$  = heat of combustion; and  
 $H_v$  = heat of evaporation.

The study included butane, hexane, benzene, xylene, unsymmetrical dimethyl hydrazine, methanol, and diethylene triamine. Figure 4-2 plots these data.

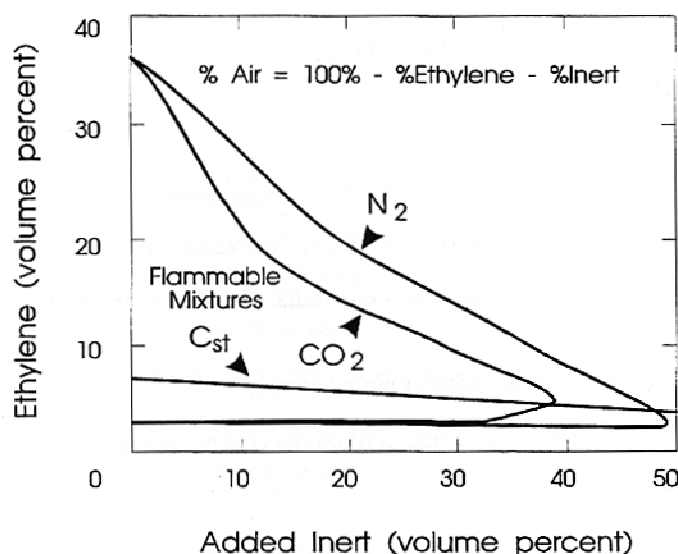




**Figure 4-2. Relationship between liquid-burning rate (large pool diameter) and ratio of net heat of combustion to sensible heat of vaporization.**

This equation for the decrease in pool level is valid for pools in still air that are larger than two meters diameter and for all sizes of pools in windy conditions. No increase in rate is indicated at reasonable wind conditions. Small pools less than one meter in diameter had lower rates of surface level decreases.

Air supply enters the fire area by diffusion and by reduced pressure in the cone caused by the rising of hot gases. Data on the quantity of air that entered were not available. The assumption was made that the burning took place at the upper flammability limit for the organic compound involved. Using the evaporation rate for the pool area ( $V$ ) produced a value for the fuel rate, which was divided by the upper flammability limit value to get the air rate. In the formaldehyde and phenol cases evaluated, both water vapor and the chemical evaporated. The upper flammability limit is affected (Zabetakis, 1964) by an inert diluent, as shown in Figure 4-3.



**Figure 4-3. Limits of flammability of ethylene-carbon dioxide-air and ethylene-nitrogen-air mixtures at atmospheric pressure and 26° C.**

This figure shows the effect of  $N_2$  diluent and  $CO_2$  diluent for ethylene. The upper flammability limits for formaldehyde and phenol were adjusted using the nitrogen example, because the molar heat capacities of nitrogen and water are similar.

The stoichiometric amount of combustible in air is related to its molecular constituents. Given the compound  $C_N H_M O_L F_K$ , where C is carbon, H is hydrogen, O is oxygen and F is a halogen, the equation (Zabetakis, 1964) is:

$$C_{ST} = \frac{100}{1 + 4.733 \left( N + \frac{M - K - 2L}{4} \right)} \quad (4-2)$$

where  $C_{ST}$  = concentration (volume percent) of combustible in air at stoichiometric ratio.

An estimate for the percent burned is required. The percent burned can be estimated by assuming the burning plume is axially symmetric. The value of  $C_{ST}$  should lie between the lower and the upper flammable limits. Above the lower flammable limit and below  $C_{ST}$  all is burned. Above  $C_{ST}$ , too much organic is present to burn entirely. One hundred percent is assumed to be burned at  $C_{ST}$ , and zero percent is assumed burned at the upper flammable limit. Between  $C_{ST}$  and the upper flammable limit, the relationship between the concentration and the percent burned is assumed to be linear. The amount of material burned ( $m_B$ ) is:

$$m_B = \int_{r(F_L)}^{r(C_{ST})} c dV + \int_{r(C_{ST})}^{r(F_U)} \left( \frac{F_U - c}{F_U - C_{ST}} \right) c dV \quad (4-3)$$

where  $F_L$  = concentration, vol. %, of combustible in air at lower flammable limit;

$F_U$  = concentration, vol. %, of combustible in air at upper flammable limit;

$c$  = concentration at some radial distance,  $r$ , from plume center;  
 $= c_0 \exp(-a^2 r^2)$ ;

$c_0$  = concentration at plume center;

$a$  = inverse of standard deviation of plume concentration; and

$dV$  =  $2 \pi r dr dz$ .

The total mass,  $m_T$ , in the plume is given as:

$$m_T = \int_0^\infty c dV \quad (4-4)$$

The percent burned,  $B_{\%}$ , is then given as:

$$B_{\%} = \frac{100 m_B}{m_T} \quad (4-5)$$

Integrating and using the mass per vertical length  $dz$ , leads to:

$$B_{\%} = \frac{100}{c_0} \left[ \left( \frac{F_U + C_{ST}}{2} \right) - F_L \right] \quad (4-6)$$

The value of  $c_0$  is assumed to be identical to  $F_U$  since that is the first concentration at which a burn will occur.

In a review of the literature on carbon black manufacture, Schwartz et al (1974), Hustvedt et al. (1976), Shreve and Brink (1977), and U.S. EPA (1979)) provide an estimate of heat release and product composition for a combustion reaction involving cracking. The data indicates that at 1500 to 1800°F, an approximate 10 percent yield of carbon could be obtained from heavy aromatic compounds. The ratio of CO to CO<sub>2</sub> in the gas stream would be about 1:1, and 1/2 mole of H<sub>2</sub> would be present for each mole of CO and CO<sub>2</sub> present. Under these conditions, the endothermic reactions reduce the heat of reaction to about 80 percent of the standard net heat of combustion. These conditions were chosen for evaluating liquid pool fires. The heat evolved in these fires is calculated as evaporation rate times the fraction burned times 80 percent of the heat of reaction. If chlorine is present in the material being burned, the model assumes that 10 percent of the CO is being converted to phosgene.

The one-to-one ratio for CO:CO<sub>2</sub> is accurate to  $\pm 30\%$  and the 0.5-to-one ratio for H<sub>2</sub> to (CO + CO<sub>2</sub>) is accurate to about  $\pm 50\%$ . There will be some CO and some H<sub>2</sub> remaining in the plume after it cools to a temperature that is below the activation temperature. The amount depends on the equilibrium approach in the CO<sub>2</sub>-H<sub>2</sub>O-soot system, which exists at high temperatures for relatively long residence times (two or three seconds) in the fire area. The carbon black production data used for these assumptions were at slightly higher temperatures for very short residence times ( $< 1/2$  second). Lower values for these ratios result in higher temperature plumes with less potential for hazards, while higher values yield lower temperature plumes.

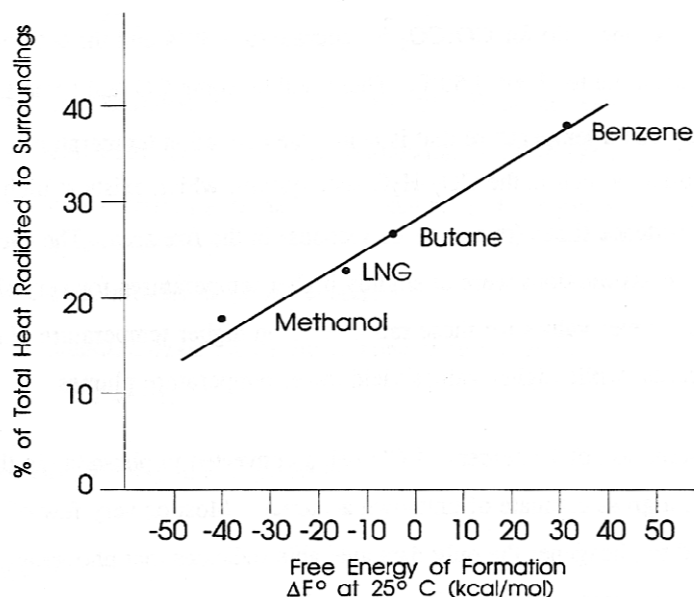
The assumption of 10 percent of CO being converted to phosgene in the presence of chlorine atoms is a gross estimate of unknown accuracy. Most or very few of the chlorine atoms may be converted to phosgene; the only data available indicates that phosgene has been observed in fires with chlorine present. As a case in point, carbon tetrachloride is no longer recommended for fire extinguisher use, with phosgene evolution being the primary cause.

## 4.2 Heat Sumps

Heat from the fire evaporates the materials from the pool, heats the evaporated material and air to auto-ignition temperature, radiates to the surroundings, and heats the combustion/reaction products in the plume. The considerations for heat include:

- Heat of evaporation, which is the product of quantity of material evaporated times the latent heat of evaporation;
- Quantity of vapor generated multiplied by its heat capacity;
- Temperature difference between boiling point and auto-ignition temperature;
- Quantity of air times its heat capacity; and
- Temperature difference between ambient temperature and auto-ignition temperature.

In the original study (Burgess et al, 1961), which developed the evaporation rate equation, infrared sensors were located around the pool to measure radiation and determine the percent of total heat that radiated to the surroundings from various fires. These data were found to correlate with free energy of formation ( $\Delta F$  at 25°C) for the chemicals burned. This relationship does not apply for hydrogen, but appears usable for hydrocarbons and alcohols. Figure 4-4 shows a plot of the data in this form.



**Figure 4-4. Relationship between percent of total heat radiated to the surroundings and free energy of formation.**

The developed equation is:

$$R = 0.26\Delta F + 27 \quad (4-7)$$

where  $R$  = percent of total heat release radiated to surroundings; and  
 $\Delta F$  = free energy of formation (kcal/mole).

The radiant heat is the product of total heat evolved in the fire times  $R/100$ .

To obtain a heat available for raising the combustion product temperature, the total heat release is reduced by the latent heat of evaporation, by sensible heats of the air and organic vapors up to auto-ignition temperature, and by the radiant heat to surroundings. To determine this temperature rise, the composition of the combustion products and the quantity of each component is determined by a material balance. Then each component is multiplied by its heat capacity. The summation of these multiplications is the heat capacity of the plume in units of BTU per unit time per °F temperature difference. Dividing the heat available by the heat capacity of the plume gives the increase in temperature of the products above the auto-ignition temperature. The sum of these is the plume temperature. The equations are:

$$E_{\text{plume}} = \sum_{i=1}^n W_i C_{pi} \quad (4-8)$$

where  $E_{\text{plume}}$  = energy addition to plume (BTU °F / second);  
 $n$  = number of components  
 $W_i$  = rate each component is added to plume (pounds / second); and

$C_{pn}$  = heat capacity of each component (BTU °F / pound).

$$\Delta T_{\text{plume}} = \frac{Q}{E_{\text{plume}}} \quad (4-9)$$

where  $\Delta T_{\text{plume}}$  = temperature rise of plume; and  
 $Q$  = heat available from combustion.

$$T_{\text{plume}} = T_i + \Delta T_{\text{plume}} \quad (4-10)$$

where  $T_{\text{plume}}$  = final plume temperature; and  
 $T_i$  = auto-ignition temperature.

The material balance provides information on hazardous chemicals remaining in the plume and the total quantities of components in the plume. The total volume at the final temperature is computed to obtain a plume velocity at the top of the cone-shaped fire area.

### 4.3 Tank Involvement in Fire

When a fire surrounds a tank, materials in the tank are heated and vented. National Fire Codes (National Fire Protection Association, 1973-74) specify the size of vents required in terms of the volume rate of release for tanks with fire surrounding them. Table 4-1 shows the required venting rates as free airflow. The table shows the wetted area versus cubic feet free air per hour at 14.7 psia and 60° F.

**Table 4-1. Wetted Area Versus Cubic Feet Free Air\***

Square Feet	Cubic Feet/Hour
20	21,100
30	31,600
40	42,100
50	52,700
60	63,200
70	73,700
80	84,200
90	94,800
100	105,000
120	126,000
140	147,000
160	168,000
180	190,000
200	211,000
250	239,000
300	265,000
350	288,000

400	312,000
500	354,000
600	392,000
700	428,000
800	462,000
900	493,000
1,000	524,000
1,200	557,000
1,400	587,000
1,600	614,000
1,800	639,000
2,000	662,000
2,400	704,000
2,800 and over	742,000

\* Interpolate for intermediate values.

The wetted surface area is the area inside the tank in contact with the liquid. This table was used to determine airflow rate, and a conversion to the equivalent flow of organic chemical was made by using the density of the chemical vapor at its boiling point. This procedure gave a slightly higher venting rate than an alternate procedure that estimates the heat transfer rate shown in the appendix of the National Fire Codes.

The effect of the blending vapors into the plume is the reduction of the plume temperature and the increase of the total component weight of the plume due to the added chemical. The heat capacity of the added chemical vapor times its weight included in the plume heat capacity provided a smaller  $T_{\text{plume}}$  for the mixed system. The heat used to vaporize the material in the tank was assumed to be included in the heat radiated to surroundings.

## 5.0 FIREBALL/BLEVE ALGORITHM

The Fireball/BLEVE (Boiling Liquid Expanding Vapor Explosion) algorithm is one of the simplest in CHARM; only a few equations must be solved. The method comes from Moorhouse and Pritchard (1982) and Roberts (1982). Instead of being derived from fundamental principles, the BLEVE equations are parametric.

### 5.1 *Calculation of the Efficiency of Explosion*

An efficiency of explosion is either entered by the user or calculated by CHARM. If calculated, the explosion efficiency ( $v$ ) is a function of the vapor pressure of the material and is:

$$v = 0.27P_s^{0.32} \quad (5-1)$$

where  $P_s$  = vapor pressure in Pascals of the chemical at the storage pressure.

The radius ( $R_f$ ) of the ensuing fireball (in meters) is calculated as follows:

$$R_f = 2.665 m_{kg}^{0.327} \quad (5-2)$$

where  $m_{kg}$  = mass of material in kilograms involved in the explosion.

The duration ( $T_f$ ) of the fireball in seconds is given as:

$$T_f = 1.089 m_{kg}^{0.327} \quad (5-3)$$

Finally, the amount of radiation ( $W$ ) being emitted is given as:

$$W = \frac{H_c m_{kg} v 1000}{T_f} \quad (5-4)$$

where  $W$  = energy emission rate in watts; and  
 $H_c$  = heat of combustion of the material in Joules per gram.



## **5.2 Calculation of Fluxes**

Once the energy emission rate (W) is calculated, the fluxes can be determined at any distance from the source. The fireball is assumed to be a point source. As such, the flux (F) at some distance (r) from the fireball can be calculated using the inverse square property of radiation:

$$F = \frac{W}{4\pi r^2} \quad (5-5)$$

Because the fireball is assumed to be a point source, either F or r can be specified and the other parameter calculated.

## 6.0 JET FIRES

The jet fire algorithm used is designed around the Multiple Point Source Model (MPSM) described by Crocker and Napier (1988). In this method, the radiation from a jet fire is divided into three components: that which falls on a vertical target perpendicular to the X-axis, that which falls on a vertical target parallel to the X-axis, and that which falls on a horizontal target.

### 6.1 Calculation of the Flame Length

Crocker and Napier present an expression relating the flame length to jet fluid mole fraction in an unreacted stoichiometric mixture, flame temperature, and ratio of reactants to products in the unreacted stoichiometric mixture. These values would change for different releases and may be difficult to discern for any single release. Because of this, CHARM uses another expression for the flame length, which is also given by Crocker and Napier. The flame length calculation is actually for a vertical flame, but it has simpler parameters for its computation, which should result in longer flames.

The length of flame (L) expression is:

$$L = 1.32 \times 10^{-3} Q^{0.52} - a \quad (6-1)$$

where Q = total heat released by combustion (W); and  
a = distance of the base of the flame from the exit (m).

Q is the emission rate times the heat of combustion. The emission rate is calculated from one of the source term algorithms described in Section 2.0. Only those sources with an exit velocity greater than zero are allowed to also have a jet fire analysis performed.

### 6.2 Calculation of the Lift-Off Distance of the Flame

The lift-off distance (a) of the flame from the exit, is:

$$a = 1.6 \pi d_j \frac{U_j}{U_1} \quad (6-2)$$

where  $d_j$  = diameter of the jet;  
 $U_j$  = exit velocity of jet; and  
 $U_1$  = velocity of jet at distance a from the exit, given as 0.2 Mach.

If  $U_j$  is less than  $U_1$ , the value of a is set equal to zero.

### 6.3 Calculation of the Radiation Fields of the Flame

The values of  $a$  and  $L$  are used in placement of the flame. In CHARM, the radiation fields are calculated as if the flame is at the origin of the coordinate system and the centerline is in the direction of the X-axis. The flame may be at an upward angle but the projection of the flame axis into the X-Y plane is assumed to fall on the X-axis. After the calculation is completed, the radiation field is rotated and translated to reflect the actual location of the flame base. This action makes the calculation somewhat simpler by eliminating cross terms in the formulae presented by Crocker and Napier.

#### 6.3.1 Calculation of Radiation Falling on a Horizontal Target

The equation used for the intensity of radiation falling on a horizontal target ( $q_h$ ) is:

$$q_h = \frac{f Q \sqrt{1+m^2}}{2\pi L(b^2 - 4dc)} \left( \frac{B x_L + C}{P_L} - \frac{C}{P_O} \right) \quad (6-3)$$

where  $f$  = fraction of total heat released as radiation

$$= 2.2 \times 10^{-4} \sqrt{H_c M_j}$$

where  $H_c$  = heat of combustion (J/g); and

$M_j$  = molecular weight of jet fluid at exit;

$m$  = slope of flame;

$b$  =  $-2(x - m z)$

$c$  =  $x^2 + y^2 + z^2$ ;

$d$  =  $1 + m^2$ ;

$B$  =  $m b + 2dz$ ;

$C$  =  $2 m c + b z$ ;

$$P_L = \sqrt{d x_L^2 + b x_L + c}$$

$$P_O = \sqrt{c}$$

$$x_L = L \cos\left(\frac{\pi}{2} - \Theta\right)$$

$\Theta$  = flame tilt from vertical; and

$x, y, z$  = location of the center of the target relative to the source.

### 6.3.2 Calculation of Radiation Falling on a Vertical Target

The equation for the radiation falling on a vertical target perpendicular to the X-axis ( $q_{v\perp}$ ), outside of the flame and where  $x > x_L$ , is given by:

$$q_{v\perp} = \frac{f Q \sqrt{1+m^2}}{2\pi L(4dc-b^2)} \left( \frac{D x_L + E}{P_L} - \frac{E}{P_O} \right) \quad (6-4)$$

$$\begin{aligned} \text{where } D &= 2 x d + b; \text{ and} \\ E &= x b + 2 c \end{aligned}$$

Finally, the equation for the radiation falling on a vertical target parallel to the X-axis ( $q_{v=}$ ) is:

$$q_{v=} = \frac{f Q y \sqrt{1+m^2}}{2\pi L(4dc-b^2)} \left( \frac{2d x_L + b}{P_L} - \frac{b}{P_O} \right) \quad (6-5)$$

### 6.3.3 Calculation of the Total Radiation

The intensity of radiation falling on horizontal and vertical targets contributes to the entire radiation being received at the target. The total radiation ( $q$ ) received is calculated as follows:

$$q = \sqrt{q_h^2 + q_{v\perp}^2 + q_{v=}^2} \quad (6-6)$$

The isopleths of radiation flux for the jet fire are determined by performing a binary search in both directions pointed at by the flame. For example, if the flame is pointing from the origin down the X-axis, CHARM first searches down the positive X-axis until the desired radiation flux value is passed, and then it searches down the negative X-axis.

Once the two extremes are found, CHARM arbitrarily divides the distance into twenty segments. For each segment, CHARM performs a binary search left and right of the line on which the flame lays to find the extremes of the desired radiation.

## 7.0 EXPLOSION OVERPRESSURES

CHARM calculates overpressures or shockwave pressures for two scenarios: a sphere bursting due to failure of the vessel and an unconfined vapor cloud explosion. Both of these phenomena are modeled using methods from Baker et al. (1983).

### 7.1 Sphere Burst Overpressure

Although the equations described here are strictly for the mechanical failure of a pressurized sphere, they are used for all cases of pressurized failure. A mechanical failure, such as in an instantaneous gas release, is always assumed to be from a spherical vessel.

Two important factors in a pressurized vessel failure shockwave calculation are the storage pressure and the amount of material stored. Pressure has the units of energy density and describes the amount of energy available for shockwave formation.

The equation for calculating the maximum overpressure of a sphere burst is provided by Liepman and Roshko (1967):

$$\frac{p_1}{p_0} = \frac{p_{s0}}{p_0} \left\{ 1 - \frac{(\gamma_1 - 1) \left( \frac{a_0}{a_1} \right) \left( \frac{p_{s0}}{p_0} - 1 \right)}{\sqrt{2\gamma_0 \left[ 2\gamma_0 + (\gamma_0 + 1) \left( \frac{p_{s0}}{p_0} - 1 \right) \right]}} \right\}^{\left( \frac{-2\gamma_1}{\gamma_1 - 1} \right)} \quad (7-1)$$

- where
- $p_1$  = pressure inside the sphere;
  - $p_0$  = atmospheric pressure;
  - $p_{s0}$  = air shock pressure at the instant of burst;
  - $\gamma_1$  =  $C_p/C_v$  for gas in sphere;
  - $\gamma_0$  =  $C_p/C_v$  for air;
  - $C_p$  = specific heat at constant pressure;
  - $C_v$  = specific heat at constant volume;
  - $a_0$  = speed of sound in air; and
  - $a_1$  = speed of sound in sphere;

The parameter that must be solved for by iteration, is  $p_{s0}/p_0$ .

The value used in CHARM is the overpressure ( $\bar{P}_s$ ), which is defined as follows:

$$\bar{P}_s = \frac{P_s}{P_0} - 1 \quad (7-2)$$

At the sphere surface, the overpressure equation is:

$$\bar{P}_{s0} = \frac{P_{s0}}{P_0} - 1 \quad (7-3)$$

The other parameter required for predicting the overpressure at distances downwind is an energy-scaled radius ( $\bar{R}$ ). At the surface of the sphere, the energy-scaled radius ( $\bar{R}_1$ ) given by Baker is:

$$\bar{R}_1 = \left[ \frac{3(\gamma_1 - 1)}{4\pi \left( \frac{P_1}{P_0} - 1 \right)} \right]^{\frac{1}{3}} = \frac{r_1}{R_0} \quad (7-4)$$

where  $r_1$  = radius of the sphere;

$R_0$  = energy radius

$$= \left( \frac{E}{P_0} \right)^{\frac{1}{3}}$$

$$E = \left( \frac{P_1 - P_0}{\gamma_1 - 1} \right) V_1; \text{ and}$$

$V_1$  = volume of sphere.

Once the values of  $\bar{P}_s$  and  $\bar{R}$  are known at the sphere surface, a curve that agrees with these values can be selected from Figure 7-1. Once a curve is selected, if either value,  $\bar{R}$  or  $\bar{P}_s$ , is known, the other can be calculated. The curves shown in Figure 7-1 have been digitized, and CHARM interpolates the actual curve to use once the conditions at the sphere surface are known. The dimensional pressure and radius can be found by multiplying the dimensionless overpressures and radii by  $P_0$  and  $R_0$ , respectively.

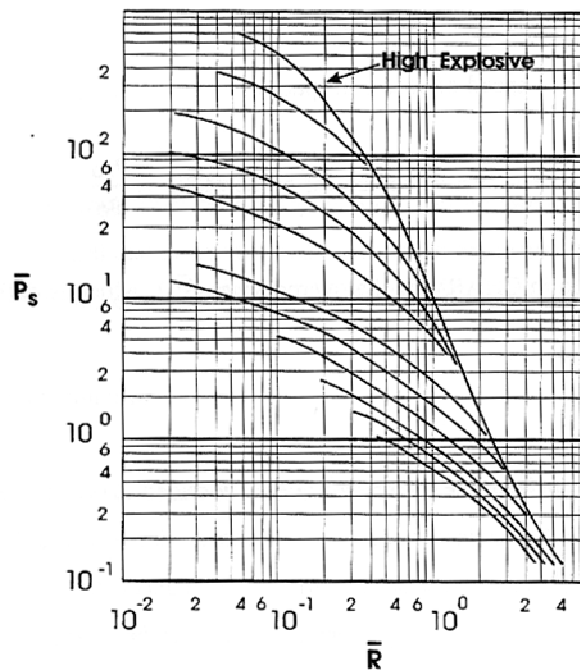


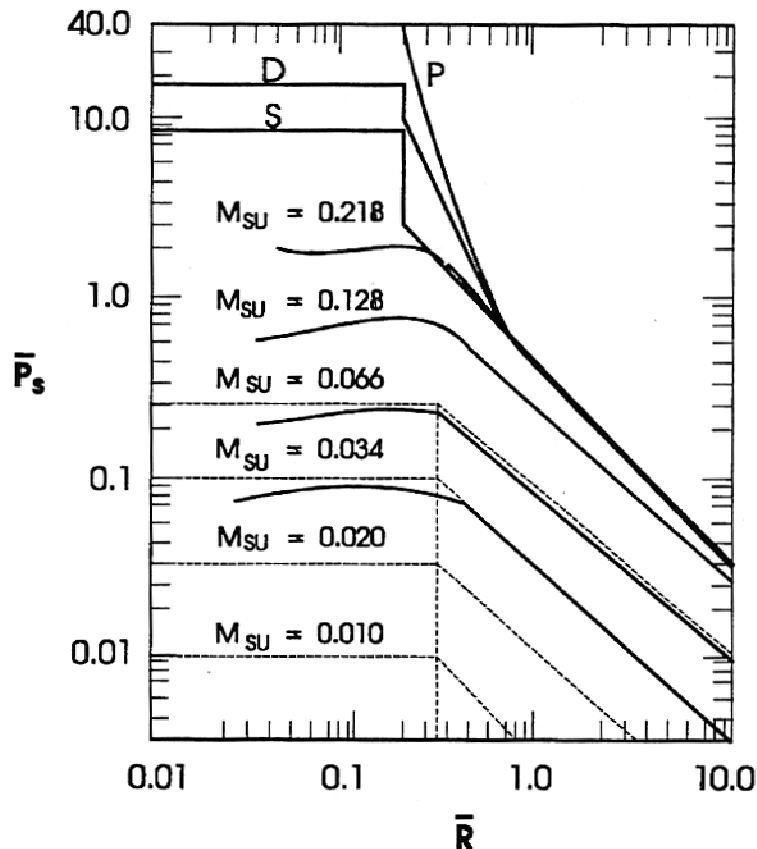
Figure 7-1.  $\bar{P}_s$  Versus  $\bar{R}$  for Sphere Burst Overpressure Calculations.

## 7.2 Unconfined Vapor Cloud Explosion

Vapor cloud explosions are modeled also by determining the  $\bar{P}_s$  and  $\bar{R}$  at some location in the vapor cloud and then using Figure 7-1 to predict the overpressures at any distance. The vapor cloud is subdivided into user-definable cells. These cells are not the ones that CHARM uses to calculate the advection and dispersion of the release. Each cell is exploded individually, and its contribution at a point is individually determined. The maximum overpressure at a point is selected as the maximum overpressure from any of the exploding cells.

The creation of isopleths of overpressure is handled similarly to the jet fire case. The maximum extents of the selected overpressure values upwind and downwind are determined. Once the two extremes are found, CHARM creates a grid containing the impact region.

The amount of mass within an exploding cell is only the amount that is in concentrations greater than the lower explosive limit (LEL). A cloud can either detonate or deflagrate. Detonation is treated as the case limit of deflagration as the flame speed increases. If the flame speed is greater than Mach 1, CHARM treats it as a detonation. Otherwise, CHARM treats it as a deflagration. Figure 7-2 illustrates the hierarchy of mechanisms used. The chosen mechanism is determined by flame speed.



**Figure 7-2. Maximum Wave Overpressure Versus Energy-Scaled Distance for Explosions With an Energy Density  $q = 8$  and Various Normal Burn Velocities.**

Figure 7-2 illustrates the different overpressures that can be expected in the case of a cloud with energy density of 8. The curve labeled P represents Pentolite. All other solid curves were calculated using the CLOUD program. The curve labeled D is for Detonation and S is for a Sphere Burst of the same energy density. The horizontal dashed lines represent the predicted flame overpressures for very low-velocity flames calculated using the theory of Taylor (1946) for piston motion where the piston motion has been transformed to an equivalent normal burning velocity for a flame system. The vertical dashed line in the figure represents the final radius of the cloud based on energy-scaled radius for an energy density of 8 when the energy is added so slowly that there is no pressure rise.

The dashed lines outside this vertical line are predicted overpressures based on the following equation:

$$\bar{P}_s = \frac{1}{\bar{R}} \quad (7-5)$$

The dashed vertical line in the figure represents the final radius of a deflagrating cloud based on an energy-scaled radius when the energy is added so slowly that there is no



pressure rise. This scaled radius is equivalent to the  $\bar{R}_1$  in the sphere burst calculation.  $\bar{R}_1$  is different for a deflagration than a detonation. The value of  $\bar{R}_1$  is:

$$\bar{R}_1 = \begin{cases} \left[ \frac{3 (\gamma_1 - 1)}{4 \pi q} \right]^{\frac{1}{3}} & \text{detonation} \\ \left[ \left( \frac{q}{\gamma_1} + 1 \right) \frac{3 (\gamma_1 - 1)}{4 \pi q} \right]^{\frac{1}{3}} & \text{deflagration} \end{cases} \quad (7-6)$$

where  $q$  = energy density  
 $= \frac{H_{\text{ceff}}}{C_{va} T_a}$   
 $H_{\text{ceff}}$  = effective heat of combustion; and  
 $C_{va}$  = specific heat at constant volume of air.

$H_{\text{ceff}}$  is the molar weighted average of the heats of combustion of the released material ( $M_g$ ) and air ( $M_a$ ). Normally, the heat of combustion of air is ignored, so that it can be calculated from:

$$H_{\text{ceff}} = \frac{FG H_c M_g}{FG M_g + (1 - FG) M_a} \quad (7-7)$$

where  $FG$  = molar fraction of the emitted material in the cell

In either deflagration or detonation the value of  $R_0$  is the same:

$$R_0 = \left( \frac{E}{p_0} \right)^{\frac{1}{3}} \quad (7-8)$$

where  $E$  = energy expended from the burn  
 $= m_{\text{lel}} \epsilon H_c$ ;  
 $m_{\text{lel}}$  = mass above LEL; and  
 $\epsilon$  = efficiency of explosion.

Given values for  $\bar{R}_1$  and  $R_0$ , a value for  $r_1$  can be calculated. This leaves the computation of the value of  $\bar{P}_s$ . Consider the case of a flame speed of less than Mach 1, which is considered by CHARM to be a deflagration. The value of  $\bar{P}_s$  at  $\bar{R}_1$  is given by Taylor (1946) as:

$$\bar{P}_s = \frac{2\gamma_0 \left(1 - \frac{\rho_2}{\rho_1}\right) \left(\frac{\rho_1}{\rho_2}\right)^2 M_{SU}^2}{1 - \left(1 - \frac{\rho_2}{\rho_1}\right)^{\frac{2}{3}} \left(\frac{\rho_1}{\rho_2}\right)^2 M_{SU}^2} \left(1 - M_{SU} \frac{\rho_1}{\rho_2}\right) \quad (7-9)$$

where  $\rho_1$  = density ahead of the flame;  
 $\rho_2$  = density behind the flame; and  
 $M_{SU}$  = flame speed in Mach.

The ratio of  $\rho_2/\rho_1$  can be taken as the zero pressure rise density change across the flame if the overpressure is assumed to be low, which is valid for many deflagration cases. Using this assumption leads to:

$$\frac{\rho_2}{\rho_1} = \frac{q}{\gamma_1} + 1 \quad (7-10)$$

The Taylor equation breaks down as  $M_{SU}$  gets large. If  $M_{SU}$  gets larger than  $(\rho_2/2) \rho_1$  an extrapolation is made from lower  $M_{SU}$  values. In such a case, the value of  $\bar{P}_s$  is assumed to go as the logarithm of  $M_{SU}$ .

In the detonation case, the sphere burst technique of solution is used after determining an equivalent storage pressure. As shown in Figure 7-2, the detonation and sphere burst curves are similar. In a detonation, there is a choking limit velocity called the Chapman-Jouguet velocity ( $M_{CJ}$ ) that cannot be exceeded.  $M_{CJ}$  is given by:

$$M_{CJ} = \sqrt{\left[\frac{(\gamma_1 + 1)q}{\gamma_1} + 1\right]} + \sqrt{\left[\frac{(\gamma_1 + 1)q}{\gamma_1} + 1\right]^2 - 1} \quad (7-11)$$

The  $\bar{P}_s$  at the speed  $M_{CJ}$  is treated as equivalent to the storage pressure in a bursting sphere and is calculated as:

$$\bar{P}_{CJ} = \frac{1 + \gamma_1 M_{CJ}^2}{\gamma_1 + 1} \quad (7-12)$$

If  $M_{SU}$  is greater than or equal to  $M_{CJ}$ , the problem is treated as a bursting sphere with the internal storage pressure given as  $\bar{P}_{CJ}$ . If  $M_{SU}$  is less than  $M_{CJ}$ , a second  $\bar{P}_s$  is calculated for a bursting sphere at the same value of  $q$  as in the vapor cloud explosion calculation.

The shockwave speed for the bursting sphere ( $M_{bs}$ ) from Liepmann and Roshko (1967) is:

$$M_{bs} = \sqrt{1 + \frac{(\gamma_1 + 1)q}{2\gamma_1}} \quad (7-13)$$

Once again,  $\bar{P}_s$  is assumed to go as the logarithm of  $M_{SU}$ . With the two values of  $\bar{P}_s$  and the two values of  $M$ , an equation can be formulated to estimate the value of  $\bar{P}_s$  for the given flame speed,  $M_{SU}$ .

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## **Appendix F**

### **Input Data Used for Site 3 Emission Estimate Modeling**

### Input Data Used for Site 3 Emission Estimate Modeling

Date: 20-Sep-06																
Name	Duration	StabilityClass	Spd_Res_mph	Dir_Res_deg	Temp_F	PathLoad	LoadSigma	BkgPathLoad	PathLength	SourceN	SourceE	SourceZ	TransceiverN	TransceiverE	TransceiverZ	RetrN
Site3_Path1_0	1	1	1.515	75.8	51.55	29.7692308	0.11357556	28.9158669	14.4579335	5299880	11622415	1	5299893	11622382	4.5	5299866
Site3_Path1_1	1	1	1.205	112.3	51.39	29.5314286	0.16522094	28.9158669	14.4579335	5299880	11622415	1	5299893	11622382	4.5	5299866
Site3_Path1_2	1	1	1.524	79.4	51.36	30.1382353	0.19099539	28.9158669	14.4579335	5299880	11622415	1	5299893	11622382	4.5	5299866
Site3_Path1_3	1	2	1.642	84.7	51.23	95.3029412	356.612967	28.9158669	14.4579335	5299880	11622415	1	5299893	11622382	4.5	5299866
Site3_Path1_4	1	4	2.562	121.6	50.96	377.925	323.477726	28.9158669	14.4579335	5299880	11622415	1	5299893	11622382	4.5	5299866
Site3_Path1_5	1	3	1.692	93	50.91	29.94	0.19595918	28.9158669	14.4579335	5299880	11622415	1	5299893	11622382	4.5	5299866
Site3_Path1_6	1	1	1.536	113	50.89	31.0176471	1.89107355	28.9158669	14.4579335	5299880	11622415	1	5299893	11622382	4.5	5299866
Site3_Path1_7	1	1	2.352	112.2	50.66	29.3294118	0.23076524	28.9158669	14.4579335	5299880	11622415	1	5299893	11622382	4.5	5299866
Site3_Path1_8	1	1	1.92	58.06	50.6	29.1352941	0.18610932	28.9158669	14.4579335	5299880	11622415	1	5299893	11622382	4.5	5299866
Site3_Path1_9	1	3	2.395	113.3	50.6	38.8785714	35.811893	28.9158669	14.4579335	5299880	11622415	1	5299893	11622382	4.5	5299866
Site3_Path1_10	1	4	1.848	97.1	50.59	29.5478261	0.11747179	28.9158669	14.4579335	5299880	11622415	1	5299893	11622382	4.5	5299866
Site3_Path1_11	1	2	1.242	85.2	50.6	659.40303	674.18905	28.9158669	14.4579335	5299880	11622415	1	5299893	11622382	4.5	5299866
Site3_Path1_12	1	3	1.782	62.66	50.49	145.597143	369.747296	28.9158669	14.4579335	5299880	11622415	1	5299893	11622382	4.5	5299866
Site3_Path1_13	1	3	1.384	97.3	50.53	29.9352941	0.09965338	28.9158669	14.4579335	5299880	11622415	1	5299893	11622382	4.5	5299866
Site3_Path1_14	1	1	1.934	114.9	50.6	30.2735294	1.14411765	28.9158669	14.4579335	5299880	11622415	1	5299893	11622382	4.5	5299866
Site3_Path1_15	1	1	1.65	92.8	50.55	30.1529412	0.09466751	28.9158669	14.4579335	5299880	11622415	1	5299893	11622382	4.5	5299866
Site3_Path1_16	1	2	1.525	81.9	50.59	210.429412	418.233631	28.9158669	14.4579335	5299880	11622415	1	5299893	11622382	4.5	5299866
Site3_Path1_17	1	1	1.521	99.4	50.57	229.436364	465.632582	28.9158669	14.4579335	5299880	11622415	1	5299893	11622382	4.5	5299866
Site3_Path1_18	1	2	1.312	98.1	50.63	30.2885714	0.11897522	28.9158669	14.4579335	5299880	11622415	1	5299893	11622382	4.5	5299866
Site3_Path1_19	1	4	1.368	111.1	50.62	30.5	1.6744402	28.9158669	14.4579335	5299880	11622415	1	5299893	11622382	4.5	5299866
Site3_Path1_20	1	3	1.28	107.3	50.77	30.112	0.11771151	28.9158669	14.4579335	5299880	11622415	1	5299893	11622382	4.5	5299866
Site3_Path1_21	1	4	1.389	93.9	50.81	30.4	0.14142136	28.9158669	14.4579335	5299880	11622415	1	5299893	11622382	4.5	5299866
Site3_Path2_0	1	1	1.282	99.9	50.97	1103	902.1933	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870
Site3_Path2_1	1	3	1.689	105.6	51.1	58.05	5.75695232	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870
Site3_Path2_2	1	3	1.989	133.1	50.96	448.524	609.634497	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870



Date: 20-Sep-06																
Name	Duration	StabilityClass	Spd_Res_mph	Dir_Res_deg	Temp_F	PathLoad	LoadSigma	BkgPathLoad	PathLength	SourceN	SourceE	SourceZ	TransceiverN	TransceiverE	TransceiverZ	RetroN
Site3_Path2_3	1	2	2.227	122.1	50.92	168.927273	281.84622	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870
Site3_Path2_4	1	2	2.166	117.2	50.89	1057.87879	928.343193	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870
Site3_Path2_5	1	5	1.54	103	50.95	523.30303	417.873439	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870
Site3_Path2_6	1	1	1.973	70.4	50.94	1325.59375	636.620956	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870
Site3_Path2_7	1	1	1.768	91.5	50.8	307.684848	560.759433	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870
Site3_Path2_8	1	1	1.517	120.3	50.82	354.267647	409.052336	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870
Site3_Path2_9	1	1	1.627	54.07	50.56	369.418182	482.707397	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870
Site3_Path2_10	1	1	1.976	150.9	50.44	100.574286	181.451853	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870
Site3_Path2_11	1	1	1.783	111.7	50.27	40.6823529	0.54203895	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870
Site3_Path2_12	1	1	1.968	90.6	50.16	40.5735294	0.16504692	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870
Site3_Path2_13	1	2	1.863	139.4	50.16	58.3294118	32.9236597	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870
Site3_Path2_14	1	1	1.309	213.1	49.99	40.9970588	1.53593913	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870
Site3_Path2_15	1	1	1.132	70.7	50	242.005882	548.441451	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870
Site3_Path2_16	1	4	1.475	103.1	49.97	1051.50606	758.262498	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870
Site3_Path2_17	1	2	2.033	109.2	49.98	323.590625	372.443219	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870
Site3_Path2_18	1	1	0.999	94	49.95	716.461765	622.526027	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870
Site3_Path2_19	1	1	1.69	152.9	49.98	829.848485	611.736545	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870
Site3_Path2_20	1	1	1.728	174	49.88	124.241176	102.217867	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870
Site3_Path2_21	1	2	1.899	134.4	49.71	514.220588	678.90871	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870
Site3_Path2_22	1	3	2.429	136.2	49.65	653.511765	556.585267	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870
Site3_Path2_23	1	2	1.631	112.8	49.78	42.2911765	3.16946531	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870
Site3_Path2_24	1	2	1.512	85.5	49.88	362.705882	553.905075	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870
Site3_Path2_25	1	1	1.504	93.9	49.92	766.936364	693.631238	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870
Site3_Path2_26	1	1	1.394	148.7	50.05	43.1942857	5.92288264	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870
Site3_Path2_27	1	4	1.459	79.2	50.08	244.19697	450.192518	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870
Site3_Path2_28	1	1	0.917	146.3	50.15	149.264706	145.637879	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870
Site3_Path2_29	1	4	1.329	187	50.29	40.1352941	0.41008059	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870

Date: 20-Sep-06																
Name	Duration	StabilityClass	Spd_Res_mph	Dir_Res_deg	Temp_F	PathLoad	LoadSigma	BkgPathLoad	PathLength	SourceN	SourceE	SourceZ	TransceiverN	TransceiverE	TransceiverZ	RetroN
Site3_Path2_30	1	1	1.363	142.6	50.3	40.0941176	0.13271193	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870
Site3_Path2_31	1	1	2.254	43.98	50.36	40.0181818	0.142392	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870
Site3_Path2_32	1	5	1.772	66.9	50.34	40.0735294	0.14206217	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870
Site3_Path2_33	1	5	1.468	71.4	50.44	169.358824	306.465778	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870
Site3_Path2_34	1	3	1.61	74.4	50.51	1691.875	800.025615	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870
Site3_Path2_35	1	1	2.78	142.1	50.54	1075.12121	878.037897	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870
Site3_Path2_36	1	1	2.713	132.6	50.97	553.49697	838.770981	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870
Site3_Path2_37	1	1	1.818	157.7	50.91	1748.73333	477.253876	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870
Site3_Path2_38	1	2	2.085	96.2	51.01	105.697059	156.279152	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870
Site3_Path2_39	1	1	0.444	128.4	51.08	40.1352941	0.35220511	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870
Site3_Path2_40	1	4	2.458	143.4	51.41	175.393939	435.893906	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870
Site3_Path2_41	1	3	1.92	123.9	51.33	655.215152	463.100631	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870
Site3_Path2_42	1	1	2.269	114.9	51.32	1077.51515	687.655751	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870
Site3_Path2_43	1	1	0.872	143.1	51.29	1451.19655	838.482273	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870
Site3_Path2_44	1	1	1.452	58.62	51.42	521.491176	634.387763	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870
Site3_Path2_45	1	1	0.645	160.4	51.28	65.0352941	62.9950926	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870
Site3_Path2_46	14 35	1	1.727	147.9	51.88	314.739506	419.02995	46.6573042	23.3286521	5299880	11622415	1	5299893	11622382	4.5	5299870

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