

Date: July 31, 2000

Subj: Performance Evaluation Samples for PM<sub>2.5</sub> Chemical Speciation Network

From: Michael Clark, Team Leader, NAREL  
Mary Wisdom, Quality Assurance, NAREL

To: James Homolya, OAR, OAQPS

CC: Dr. R.K.M. Jayanty, RTI  
Rob Maxfield - EPA-NE  
Dick Siscanaw - EPA-NE  
Joanne Rice - OAQPS  
Chuck Lewis - ORD/NERL  
Dr. John Griggs, Chief, MASB, NAREL  
Jim Moore, Quality Assurance Coordinator, NAREL

This report is a summary of the results of the performance evaluation samples sent to Research Triangle Institute (RTI) as part of the PM<sub>2.5</sub> Chemical Speciation Quality Assurance Program. The performance evaluation samples were sent to RTI to evaluate their ability to perform total carbon, anion, and cation analyses on air filter samples collected by the PM<sub>2.5</sub> Chemical Speciation Network. A separate report will be issued to discuss the results of the performance evaluation samples for elemental analyses.

The results of each type of analysis will be discussed individually in this report.

#### **Total Carbon:**

On September 20, 1999 EPA-NE sent standard solutions and filter samples to RTI for total carbon analyses. On October 21, 1999 results of the RTI analyses were sent to EPA-NE. An evaluation of those results and discussion are contained in a report from Dick Siscanaw, EPA-NE, which is included as an attachment to this report.

#### **Anion and Cation:**

On October 21, 1999, ten samples were sent to RTI by NAREL for analysis of anions and cations. The following table identifies the samples sent to RTI for analysis.

| Sample ID          | # of Ampules | Analysis  | Concentration Range (mg/L) | Reporting Units | Sample Preparation     |
|--------------------|--------------|-----------|----------------------------|-----------------|------------------------|
| DI Water Blank     | 2            | Anions*   | NA                         | mg/L            | None, ready to analyze |
| Standard #1 Mix #1 | 2            | Anions*   | 0.2 -30                    | mg/L            | None, ready to analyze |
| Standard #1 Mix #2 | 2            | Anions*   | 0.2 -30                    | mg/L            | None, ready to analyze |
| Standard #1 Mix #3 | 2            | Anions*   | 0.2 -30                    | mg/L            | None, ready to analyze |
| Standard #1 Mix #4 | 2            | Anions*   | 0.2 -30                    | mg/L            | None, ready to analyze |
| DI Water Blank     | 2            | Cations** | NA                         | mg/L            | None, ready to analyze |
| Standard #2 Mix #1 | 2            | Cations** | 0.2 -30                    | mg/L            | None, ready to analyze |
| Standard #2 Mix #2 | 2            | Cations** | 0.2 -30                    | mg/L            | None, ready to analyze |
| Standard #2 Mix #3 | 2            | Cations** | 0.2 -30                    | mg/L            | None, ready to analyze |
| Standard #2 Mix #4 | 2            | Cations** | 0.2 -30                    | mg/L            | None, ready to analyze |

\*Anions - nitrate, sulfate

\*\*Cations - ammonium, sodium, potassium

Results of the RTI analyses were reported to Mary Wisdom on November 2, 1999. A summary table of the true value, acceptance limits, and reported value follows. As indicated in the RTI report of the analysis of the PE samples the cation samples were contaminated with approximately 1.7 mg/L of sodium. This was probably due to the glass ampules used to store the samples. If the 1.7 mg/L of sodium is subtracted from the reported value all sodium results are within the acceptance limits except for Standard #2 Mix #4.

A review of the RTI results also indicated a possible contamination of potassium in the PE samples of approximately 0.17 mg/L. If this value is subtracted from the Standard #2 Mix #4 potassium reported value the result is closer to the acceptance limits, but still high.

An evaluation of the results shows that RTI performance is acceptable, with 96 percent of the reported results within the acceptance limits. The results do indicate a possible problem analyzing cations (sodium and potassium) at low levels, and this will be investigated in future performance evaluation samples and audits.

| Sample ID          | Analyte      | True Value | Acceptance Limits | Reported Value      | Within Acceptance Limits Y/N | Ratio TV/RV      |
|--------------------|--------------|------------|-------------------|---------------------|------------------------------|------------------|
| DI Water Blank     | Nitrate as N | 0.00       | NA                | 0.00                | NA                           | NA               |
| DI Water Blank     | Sulfate      | 0.00       | NA                | 0.023               | NA                           | NA               |
| Standard #1 Mix #1 | Nitrate as N | 19.0       | 16.9 - 21.1       | 19.3                | Y                            | 0.984            |
| Standard #1 Mix #1 | Sulfate      | 23.0       | 19.8 - 26.2       | 23.229              | Y                            | 0.990            |
| Standard #1 Mix #2 | Nitrate as N | 11.4       | 10.1 -12.7        | 11.584              | Y                            | 0.984            |
| Standard #1 Mix #2 | Sulfate      | 13.8       | 11.9 -15.7        | 14.267              | Y                            | 0.967            |
| Standard #1 Mix #3 | Nitrate as N | 4.56       | 4.06 -5.06        | 4.676               | Y                            | 0.975            |
| Standard #1 Mix #3 | Sulfate      | 5.52       | 4.75 - 6.29       | 5.700               | Y                            | 0.968            |
| Standard #1 Mix #4 | Nitrate as N | 0.228      | 0.203 - 0.253     | 0.231               | Y                            | 0.987            |
| DI Water Blank     | Ammonium     | 0.0        | NA                | 0.00                | NA                           | NA               |
| DI Water Blank     | Sodium       | 0.0        | NA                | 1.730               | NA                           | NA               |
| DI Water Blank     | Potassium    | 0.0        | NA                | 0.172               | NA                           | NA               |
| Standard #2 Mix #1 | Ammonium     | 21.0       | 17.85 - 24.1      | 21.029              | Y                            | 0.999            |
| Standard #2 Mix #1 | Sodium       | 18.0       | 15.3 - 20.7       | 19.529<br>(17.8)*   | Y *                          | 0.922<br>(1.011) |
| Standard #2 Mix #1 | Potassium    | 24.0       | 20.4 -27.6        | 25.722              | Y                            | 0.933            |
| Standard #2 Mix #2 | Ammonium     | 12.6       | 10.7 - 14.5       | 12.030              | Y                            | 1.047            |
| Standard #2 Mix #2 | Sodium       | 10.8       | 9.18 - 12.4       | 12.425<br>(10.7)*   | Y *                          | 0.869<br>(1.009) |
| Standard #2 Mix #2 | Potassium    | 14.4       | 12.2 - 16.6       | 15.420              | Y                            | 0.934            |
| Standard #2 Mix #3 | Ammonium     | 5.04       | 4.28 - 5.80       | 4.695               | Y                            | 1.073            |
| Standard #2 Mix #3 | Sodium       | 4.32       | 3.67 - 4.97       | 6.032<br>(4.332)*   | Y *                          | 0.716<br>(0.998) |
| Standard #2 Mix #3 | Potassium    | 5.76       | 4.90 - 6.62       | 6.326               | Y                            | 0.911            |
| Standard #2 Mix #4 | Ammonium     | 0.252      | 0.214 - 0.290     | 0.221               | Y                            | 1.140            |
| Standard #2 Mix #4 | Sodium       | 0.216      | 0.184 - 0.248     | 1.785<br>(0.085)*   | N *                          | 0.121<br>(2.541) |
| Standard #2 Mix #4 | Potassium    | 0.288      | 0.245 - 0.331     | 0.514<br>(0.344) ** | N **                         | 0.560<br>(0.837) |

\* As indicated in the RTI report of the analysis of the PE samples the cation samples were contaminated with approximately 1.7 mg/L of sodium. This was probably due to the glass ampules used to store the samples. If the 1.7 mg/L of sodium is subtracted from the reported value all sodium results are within the acceptance limits except for Standard #2 Mix #4.

\*\* A review of the RTI results also indicated a possible contamination of potassium in the PE samples of approximately 0.17 mg/L. If this value is subtracted from the Standard #2 Mix #4 potassium reported value the result is closer to the acceptance limits, but still high.

To: Mary Wisdom, Quality Assurance Officer, NAREL  
 From: Rob Maxfield and Dick Siscanaw, EPA, Lexington, MA  
 Subject: Evaluation of Research Triangle Institute's (RTI) Initial Demonstration of Performance Evaluation Samples for PM2.5 Carbon Analyses  
 Date: 11/27/99  
 File: rtim.ltr

This report summarizes the results of a laboratory performance evaluation study performed in support of the PM2.5 speciation program. The EPA New England, Regional Laboratory (EPA) conducted this study to evaluate the proficiency of the PM2.5 contract laboratory, Research Triangle Institute (RTI), for analysis of carbon on air particulates samples.

### Approach:

On September 20, 1999, twenty one performance evaluation samples were shipped to RTI to evaluate their ability to meet the method performance criteria for the analyses of organic, elemental and total carbon. Three types of samples and reference materials were provided to access various aspects of the analytical method performance. The following table details the sample type, number, purpose and criteria used in this evaluation.

| Type                                                                    | Purpose                                                                                                                           | Initial Acceptance Criteria                                                                                                                                                                                                                                                                      |
|-------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Blanks                                                                  | Evaluate sample shipment, handling, and storage                                                                                   | Total carbon less than 1 ug/cm <sup>2</sup>                                                                                                                                                                                                                                                      |
| Standard Solutions<br>— Sucrose<br>— Potassium hydrogen phthalate (KHP) | Evaluate the instrument's linearity, calibration and precision                                                                    | — Within 5 %D of the true value<br>— Within 10% RPD for duplicates                                                                                                                                                                                                                               |
| Split Filters<br>— Collected by RTP<br>— Collected by NIST              | Evaluate the OC, EC and total carbon (TC) analysis of real world air particulate samples relative to reference lab average values | — For concentrations greater than 10 ug/cm <sup>2</sup> , within 15 % RPD of average value.<br>— For concentrations between 5 - 10 ug/cm <sup>2</sup> , within 20 % RPD of average value.<br>— For concentrations less than 5 ug/cm <sup>2</sup> , within 1 ug/cm <sup>2</sup> of average value. |

Split samples were placed in Gelman petri dishes, wrapped with aluminum foil, and sealed in a zip lock bag. Standard solution samples were sealed in glass vials with Teflon screw caps. All samples were shipped by overnight courier to RTI in a Styrofoam cooler containing blue ice.

Five reference laboratories provided comparison data for this study.

National Institute for Occupational Safety and Health (NIOSH),  
Cincinnati, OH;  
Desert Research Institute (DRI), Reno, NV,  
Sunset Laboratories, RTP, NC  
Environmental Protection Agency, Lexington, MA.

The RTI data was returned to the EPA for evaluation on October 21, 1999, well within the contract required 30 day turn around.

## II      **Discussion:**

Initial acceptance criteria are proposed as starting point for evaluating PM<sub>2.5</sub> carbon data. The criteria were developed based on the best available information from RTI's QAPP, method SOPs from the Sunset and DRI laboratories, discussions with various carbon analysis "experts", and region 1 internal QC tables. Due to the variable composition of PM 2.5 particles across the country and the expected range of filter loading from different types of sites these initial acceptance criteria may not be appropriate for the actual PM<sub>2.5</sub> program. It is anticipated that experience will dictate more appropriate operational data acceptance criteria which may be stricter or looser than those used for this preliminary study. These criteria will therefore be updated periodically by NAREL as outlined in the program QAPP.

Study data provided in the attached table are reported in units of ug/cm<sup>2</sup>, rather than ug/m<sup>3</sup> to simplify the data evaluation. It is anticipated that future round robins studies may be expressed in ug/m<sup>3</sup>, and evaluation criteria would then be converted to this unit. Lastly, three of the laboratories ran internal duplicates as internal quality control, only the average values have been reported in the attached evaluation table.

The EPA trip blank was a 1.5 cm<sup>2</sup> quartz filter punch that was pre-cleaned in the EPA total carbon analyzer, immediately analyzed and then sealed in a Gelman petri dish. This trip blank was used to evaluate any handling contamination that might have occurred during transport or analysis. Two additional blank quartz filters were provided by NIST. Both filters had total carbon values greater than the 1 ug/cm<sup>2</sup> criteria established by EPA for blank filters. Therefore RTI data for these "blanks" was evaluated against the criteria established for split samples.

Instrument calibration(accuracy) and linearity was checked with several primary sucrose and potassium hydrogen phthalate solutions. Two sets of duplicate solutions were used to evaluate analysis precision. A high standard was used to evaluate the attenuated FID2 signal and the instrument's methanator. This high sucrose standard failed the 5% D criteria for both EPA and RTI. As a result this data has been omitted from the evaluation. Both laboratory values were within the 15% D, criteria stated in the RTI QAPP. It is anticipated that actual values for real samples would never approach the concentration of this high standard, though understanding method variability at this level is important to the evaluation. Five levels were used within a typical sample range. The formula used to measure the accuracy is listed below.

$$\%D = \frac{\text{observed value} - \text{true value}}{\text{true value}} * 100$$

Actual filter samples collected by NIST and RTP were split and portions were analyzed by RTI and the reference laboratories. Since there is no true value for these samples, average observed results from the reference laboratories were used for evaluation of RTI data.

The RTP samples were collected by Chuck Lewis at Fort Cornelia's airport in Nashville, TN. All of the samples were collected over an 11.5 hour period on 90 mm quartz filters (sampling data is provided below).

| Sample Number     | StartDate/Time    | Flow Rate<br>(L/min) |
|-------------------|-------------------|----------------------|
| NAS99A-MSP-10     | 21 June 1999 0800 | 300                  |
| NAS99A-MSP-29     | 02 July 1999 1900 | 300                  |
| NAS99A-MSP-30     | 03 July 1999 0700 | 300                  |
| NASA99A-URG-1Q-16 | 02 July 1999 1900 | 100                  |
| NASA99A-URG-1Q-17 | 03-July 1999 0700 | 100                  |

NIST samples consisted of five filters artificially loaded with SRM 1649a urban dust. The loadings are listed in the table below. Even with a 1 cm<sup>2</sup> punch it was difficult to obtain 4 uniform samples because of the small size of the filter and variability in the deposit. For samples, SCG00164 and ACG00661, only 3 good punches were obtained. One of the five samples provided by NIST, ACG00661, was discarded because data from the reference laboratories had a relative difference greater than 15%. For sample ACG00682, one reference laboratory reported a scuff on the punch, suggesting the possibility of sample loss. All of the samples were orange after the total carbon analyses indicating a large amount of inorganic material. Most of the misses were with the NIST split samples, suggesting that the evaluation criteria may not be suitable. Reported elemental carbon variability may have been due to sample uniformity, complexity of the composition, leakage (undefined border), variability of the loading or the small differences in the thermal programs.

| Sample Number | SRM 1649a<br>(mg) |
|---------------|-------------------|
| ACG00164      | 3.6157            |
| ACG00167      | 3.4278            |
| ACG00238      | 3.2306            |
| ACG00661      | 3.1577            |
| ACG00682      | 3.4173            |

Relative percent difference was calculated using the following formula:

$$\% \text{ RPD} = \frac{(\text{observed value} - \text{average value of reference labs}) * 100}{\text{Average value of observed value and average of reference labs}}$$

### III Conclusion and Recommendation:

In summary, RTI missed 4 data points out of a 37 total measurements. RTI's result for the EPA trip blank was excellent, 0.14 ug/cm<sup>2</sup>, showing little, if any, background contamination. This measurement is below the statistical error at this level. For the sucrose and KHP solutions, RTI was outside the accuracy criteria for the SS4 sucrose solution and for the precision criteria for the SS2 and SS4 duplicate pair. The error appears to be a pipetting error because one value was low and the other high. Also, the other duplicate samples, SS5 and SS8, and the RTI's internal duplicates for SS1, SS8 and sample MSP-030 were excellent (RTI's raw data). RTI had excellent agreement with the remaining performance evaluation solutions and missed only 2 on the split filter samples. These two misses on the RTP split filters missed the 20% evaluation criteria by less than 2%. Overall evaluation of the RTI carbon analysis performance has been determined to be satisfactory with 89% of the reported data within the evaluation criteria.

| Laboratory   | Total Measurements | Measurements Within Criteria | Completeness (%) |
|--------------|--------------------|------------------------------|------------------|
| RTI          | 37                 | 33                           | 89               |
| Laboratory 1 | 35                 | 32                           | 91               |
| Laboratory 2 | 21                 | 20                           | 95               |
| Laboratory 3 | 15                 | 15                           | 100              |
| Laboratory 4 | 14                 | 13                           | 93               |

Complete Data

file:RTI\_Final2.XLS

| Lab                   | Sample   | OC<br>(ug/cm2) | AVE OC<br>(ug/cm2) | OC Difference        | EC<br>(ug/cm2) | AVE EC<br>(ug/cm2) | EC Difference        | TC<br>(ug/cm2) | AVE TC<br>(ug/cm2) | TC Difference          |
|-----------------------|----------|----------------|--------------------|----------------------|----------------|--------------------|----------------------|----------------|--------------------|------------------------|
| Part 1: Trip Blanks   |          |                |                    |                      |                |                    |                      |                |                    |                        |
| 1a - EPA Trip Blank   |          |                |                    |                      |                |                    |                      |                |                    |                        |
| lab 1                 | B-1      | (-0.01)        |                    |                      | (-0.04)        |                    |                      | -0.05          |                    | OK                     |
| RTI                   |          | ( 0.14)        |                    |                      | ( 0)           |                    |                      | 0.14           |                    | OK                     |
| 1b - NIST Trip Blanks |          |                |                    |                      |                |                    |                      |                |                    |                        |
| lab 1                 | ACG00330 | 3.75           | 3.02               | (Difference)<br>0.73 | 0.12           | 0.07               | (Difference)<br>0.05 | 3.87           | 3.09               | (Difference)<br>0.780K |
| lab 4                 |          | 2.29           |                    | -0.73                | 0.02           |                    | -0.05                | 2.31           |                    | -0.780K                |
| RTI                   |          | 2.66           |                    | -0.36                | 0              |                    | -0.07                | 2.66           |                    | -0.430K                |
| lab 1                 | ACG00869 | 3.48           | 2.49               | 0.99                 | 0.24           | 0.12               | 0.12                 | 3.72           | 2.61               | 1.11greater than 1     |
| lab 4                 |          | 1.5            |                    | -0.99                | 0              |                    | -0.12                | 1.5            |                    | -1.110K                |
| RTI                   |          | 1.6            |                    | -0.89                | 0              |                    | -0.12                | 1.6            |                    | -1.010K                |

Part 2: Standards

2a - Sucrose Standard

|       |     |        |        |                 |                   |
|-------|-----|--------|--------|-----------------|-------------------|
| lab 1 |     | 290.76 | 322.17 | (%D)            |                   |
| RTI   | SS1 |        | 274.57 | 10.80 (omitted) |                   |
|       |     |        |        | -5.57 (omitted) |                   |
| lab 1 |     | 58.15  | 58.93  | 1.340K          |                   |
| RTI   | SS2 |        | 55.21  | -5.060K         | (%RPD)            |
|       | SS4 |        | 64.68  | 11.23outside 5% | -15.80outside 10% |
| lab 1 |     | 11.63  | 11.49  | -1.200K         |                   |
| RTI   | SS3 |        | 11.75  | 1.030K          |                   |

| Lab | Sample | OC<br>(ug/cm2) | AVE OC<br>(ug/cm2) | Difference | EC<br>(ug/cm2) | AVE EC<br>(ug/cm2) | Difference | TC<br>(ug/cm2) | AVE TC<br>(ug/cm2) | Difference |
|-----|--------|----------------|--------------------|------------|----------------|--------------------|------------|----------------|--------------------|------------|
|-----|--------|----------------|--------------------|------------|----------------|--------------------|------------|----------------|--------------------|------------|

2b - Potassium Hydrogen Phthalate Solution

|       |     |       |       |         |        |
|-------|-----|-------|-------|---------|--------|
| lab 1 |     | 24.76 | 24.30 | (%D)    |        |
| RTI   | SS5 |       | 24.96 | -1.860K |        |
|       | SS8 |       | 24.52 | 0.810K  | (%RPD) |
|       |     |       |       | -0.970K | 1.780K |
| lab 1 |     | 12.98 | 12.81 | -1.310K |        |
| RTI   | SS6 |       | 12.75 | -1.770K |        |
| lab 1 |     | 2.6   | 2.57  | -1.150K |        |
| RTI   | SS8 |       | 2.58  | -0.770K |        |

Part 3: Split Samples

3a - RTP Samples

|       |         |        |       | (Difference) |      | (Difference) |         |       |       |         |             |
|-------|---------|--------|-------|--------------|------|--------------|---------|-------|-------|---------|-------------|
|       |         | (%RPD) |       |              |      |              |         |       |       |         |             |
| lab 1 | IQ-017  | 4.96   | 4.70  | 0.260K       | 0.46 | 0.77         | -0.310K | 5.42  | 5.44  | -0.310K |             |
| lab 2 |         | 4.35   |       | -0.350K      | 0.84 |              | 0.070K  | 5.19  |       | -4.640K |             |
| lab 3 |         | 4.8    |       | 0.100K       | 1    |              | 0.230K  | 5.7   |       | 4.730K  |             |
| RTI   |         | 4.02   |       | -0.680K      | 0.37 |              | -0.400K | 4.38  |       | -21.53  | outside 20% |
| lab 1 | IQ-016  | 4.88   | 4.64  | 0.240K       | 0.55 | 0.90         | -0.350K | 5.42  | 5.53  | -2.010K |             |
| lab 2 |         | 4.63   |       | -0.010K      | 1.04 |              | 0.140K  | 5.67  |       | 2.500K  |             |
| lab 3 |         | 4.4    |       | -0.240K      | 1.1  |              | 0.200K  | 5.5   |       | -0.540K |             |
| RTI   |         | 4.14   |       | -0.500K      | 0.35 |              | -0.550K | 4.49  |       | -20.76  | outside 20% |
|       |         |        |       | (RPD)        |      |              |         |       |       |         |             |
| lab 1 | MSP-010 | 22.89  | 22.05 | 3.750K       | 1.34 | 1.57         | -0.230K | 24.23 | 23.65 | 2.420K  |             |

|       |         |       |       |         |      |      |         |       |       |         |
|-------|---------|-------|-------|---------|------|------|---------|-------|-------|---------|
| lab 2 |         | 21.05 |       | -4.630K | 1.67 |      | 0.100K  | 22.72 |       | -4.010K |
| lab 3 |         | 22.2  |       | 0.690K  | 1.7  |      | 0.130K  | 24    |       | 1.470K  |
| RTI   |         | 23.16 |       | 4.930K  | 1.03 |      | -0.540K | 24.18 |       | 2.220K  |
| lab 1 | MSP-029 | 13.84 | 12.69 | 8.670K  | 1.25 | 1.48 | -0.230K | 15.09 | 14.17 | 6.260K  |
| lab 2 |         | 11.83 |       | -7.010K | 1.6  |      | 0.120K  | 13.43 |       | -5.390K |
| lab 3 |         | 12.4  |       | -2.310K | 1.6  |      | 0.120K  | 14    |       | -1.230K |

| Lab   | Sample  | OC<br>(ug/cm2) | AVE OC<br>(ug/cm2) | Difference | EC<br>(ug/cm2) | AVE EC<br>(ug/cm2) | Difference   | TC<br>(ug/cm2) | AVE TC<br>(ug/cm2) | Difference |
|-------|---------|----------------|--------------------|------------|----------------|--------------------|--------------|----------------|--------------------|------------|
|       |         |                |                    | (%RPD)     |                |                    | (Difference) | (%RPD)         |                    |            |
| RTI   |         | 11.86          |                    | -6.760K    | 0.92           |                    | -0.560K      | 12.8           |                    | -10.340K   |
| lab 1 | MSP-030 | 14.89          | 14.32              | 3.930K     | 0.88           | 1.14               | -0.260K      | 15.75          | 15.45              | 1.940K     |
| lab 2 |         | 13.66          |                    | -4.690K    | 1.13           |                    | -0.010K      | 14.79          |                    | -4.340K    |
| lab 3 |         | 14.4           |                    | 0.580K     | 1.4            |                    | 0.260K       | 15.8           |                    | 2.260K     |
| RTI   |         | 14.05          |                    | -1.880K    | 0.7            |                    | -0.440K      | 14.76          |                    | -4.550K    |

**Part 3b - NIST Samples**

|       |          |       |       |          |       |       |                   |        |        |          |
|-------|----------|-------|-------|----------|-------|-------|-------------------|--------|--------|----------|
| lab 1 | ACG00164 | 76.93 | 75.75 | 1.550K   | 29.44 | 26.13 | 11.910K           | 106.36 | 101.88 | 4.310K   |
| lab 4 |          | 74.57 |       | -1.570K  | 22.82 |       | -13.520K          | 97.39  |        | -4.500K  |
| RTI   |          | 72.66 |       | -4.160K  | 26.29 |       | 0.610K            | 98.95  |        | -2.910K  |
| lab 1 | ACG00167 | 69.89 | 66.31 | 5.250K   | 26.85 | 25.42 | 5.480K            | 96.73  | 91.70  | 5.340K   |
| lab 4 |          | 59.08 |       | -11.540K | 23.5  |       | -7.840K           | 82.59  |        | -10.450K |
| lab 2 |          | 69.97 |       | 5.370K   | 25.9  |       | 1.880K            | 95.77  |        | 4.350K   |
| RTI   |          | 69.14 |       | 4.170K   | 23.5  |       | -7.840K           | 92.64  |        | 1.020K   |
| lab 1 | ACG00238 | 68.83 | 63.28 | 8.410K   | 19.15 | 22.60 | -16.53outside 15% | 97.99  | 89.25  | 9.340K   |
| lab 4 |          | 62.16 |       | -1.780K  | 21.29 |       | -5.970K           | 83.55  |        | -6.590K  |
| lab 2 |          | 58.84 |       | -7.270K  | 27.36 |       | 19.06outside 15%  | 86.2   |        | -3.470K  |
| RTI   |          | 67.19 |       | 6.000K   | 19.57 |       | -14.370K          | 86.76  |        | -2.830K  |
| lab 1 | ACG00682 | 58.22 | 54.09 | 7.350K   | 26.39 | 21.91 | 18.55outside 15%  | 84.61  | 76.17  | 10.490K  |
| lab 4 |          | 55.7  |       | 2.930K   | 16.92 |       | -25.70outside 15% | 73.13  |        | -4.080K  |
| lab 2 |          | 48.36 |       | -11.190K | 22.42 |       | 2.300K            | 70.78  |        | -7.340K  |
| RTI   |          | 62.03 |       | 13.670K  | 20.33 |       | -7.480K           | 82.36  |        | 7.800K   |