# Status Report #2

**Project Year 1 Final Report**

**Redesigning the American Neighborhood:**
**Cost Effectiveness of Interventions in Stormwater Management at Different Scales**

**[Grant No. X98187601-0]**


<u>Prepared by:</u>

The University of Vermont
Rubenstein School of Environment and Natural Resources
and
The Gund Institute for Ecological Economics
Burlington, VT  05405-0088


<u>for:</u>

US EPA New England Region
Eric Perkins
One Congress Street, Suite 1100 (CVT)
Boston, MA 02114-2023

30 December 2004

Introduction

NOTE: This report is a cumulative report including and updating materials previously submitted.

This report provides a summary of work completed during the first year of the *Redesigning the American Neighborhood* (RAN) project (U.S. Environmental Protection Agency Grant Number 525809). The goal of this project is to quantify the balances among environmental, economic, and social costs and benefits for alternative stormwater management techniques at whole-watershed, neighborhood, and individual house scales in a typical New England landscape and climate. A full description of the RAN project, and the specific objectives and timelines for year 1 of the project as discussed below, were provided in the project work plan dated October 28, 2003. Briefly, the project objectives are:

*Objective #1 - Assessment:* Develop a framework to assess opportunities for intervention in adaptive stormwater management at various spatial scales and apply this framework to the Potash Brook case study.

*Objective #2 - Evaluation:* Complete a comparative cost/benefit analysis of the alternatives identified for the case study in Objective #1, which accounts for environmental and social/community factors as well as purely economic factors. Identify potential market-based incentives that could facilitate implementation of the identified alternatives.

*Objective #3 - Participation:* Involve community stakeholders in the development and evaluation of Objectives #1 and #2 through 'town or neighborhood meetings' that rely on whole-watershed visualization tools and multi-criteria decision aids to promote shared learning among the project participants.

*Objective #4 - Implementation:* Initiate a demonstration project that can be used as a focal point to test ideas and designs generated by Objectives #1-3.

The original one-year workplan was extended to a second year to accommodate new variations and extensions to these four objectives. At the end of year 1 substantial progress can be reported on all four of the original objectives. As this project has long-term goals and focuses on direct involvement with stakeholders, all of the objectives have evolved. Furthermore, weather-related issues have delayed some aspects of objective #4. Consequently, we are continuing to work on all four objectives in the year 2 workplan (date 30 July 2004). Details regarding the status and directions of these four objectives are provided below.

Progress on Project Objectives: The final work plan for the RAN project was accepted by US/EPA in fall 2003 and the team members immediately began work on all four objectives (Table 1). This project is a collaborative effort with the City of South Burlington and the Winooski Natural Resources Conservation District and so it was necessary to coordinate our activities closely with these partners. We have established three levels of working groups for this project (Table 2). The first group is the core research team which has primary responsibility for this grant. The second group includes key collaborators who have independent EPA projects that will be coordinated with this project. Finally, we have established an advisory group, which includes the core and partner members, plus additional members who have direct interests in this project. A full list of the group membership and associations is provided in Table 2. Several meetings were held in the fall to establish roles and responsibilities. The core group continues to meet at least twice each month for project management. The partner group meets approximately quarterly to manage inter-project interests. The advisory group meets semi-annually to review progress and obtain feedback.

**Table 1. Summarized list of deliverables for the University of Vermont RAN project with status noted.**

**Month 1**
- Coordinate team effort DONE
- Assign individual duties DONE
- Establish key boundaries and locations for field work DONE

**Months 2-4**
- Survey Tributary 7 of Potash Brook for pollution "hot spots" (Previous work by Pioneer and others will help inform the survey). DONE
- Establish key sampling points in Butler Farm focus area DONE
- Identify a stakeholder workgroup, hold the first workshop BOTH DONE
- Collect background 'desktop' data DONE BUT CONTINUING
- Conduct geomorphological assessments DONE
- Establish a project web site DONE

**Months 2-6**
- Survey and map points of opportunity IS THIS DONE
- Evaluate suitable eco-technologies for a pilot DONE AND CONTINUING
- Build a scoping model of the neighborhood and discuss it with the stakeholder group. DONE
- Conduct a survey on values and priorities in the neighborhood DONE
- Update website CONTINUING

**Months 6-9**
- Develop and refine the first draft of the interventions decision support tool DONE
- Refine the modeling tools. Start working on the full watershed model DONE AND CONTINUING
- Submit a status report to US EPA DONE
- Update website CONTINUING

**Months 8-9**
- Second workshop. Discuss modeling and design visualization tools that could benefit the neighborhood. DONE AS A FIELD DAY
- Update website CONTINUING

**Months 9-12**
- Present the model to stakeholders in a public workshop PLANNING UNDERWAY
- Conduct the bioassessments and monitor water quality DONE WITH AMENDMENTS NOTED

**Months 11-12**
- Further refine decision support tool DONE
- Chronicle results DONE
- Summarize the bioassessment and water quality data THIS REPORT AND FORTHCOMING
- Integrate report with team members THIS REPORT
- Conduct second survey to evaluate the project impact TOO EARLY. REPLACED WITH DESIGN CHARETTES.
- Update website and produce other media (brochure, CD/DVD) for public dissemination DONE
- Establish future work plan contingent on available funding DONE

**Table 2. List of key stakeholders in the RAN project. 'Core' members are the persons responsible for this research project. 'Partners' are key affiliates with this project. 'Advisors' are important stakeholders with direct interests in this project.**

| Name | Affiliation | Association |
|---|---|---|
| Allan McIntosh | University of Vermont | Core (UVM project manager) |
| Breck Bowden | University of Vermont | Core (UVM project manager) |
| John Todd | University of Vermont | Core |
| Bob Costanza | University of Vermont | Core |
| Alexey Voinov | University of Vermont | Core |
| Alex Hackman | University of Vermont | Core |
| Tim White | University of Vermont | Core |
| Helena Vladich | University of Vermont | Core |
| Eric Perkins | EPA Region 1 | EPA Project Manager |
| Peg Brakeley | BF/OC resident | Partner |
| Al Frank | BF/OC resident | Partner |
| Ben Gabos | Winooski Nat Res Consv Dist | Partner |
| Juri Homziak | UVM Sea Grant | Partner |
| Juli Beth Hoover | Town of South Burlington | Partner |
| Carol & Greg Lothrop | BF/OC resident | Partner |
| Jeff Nelson | Pioneer Environmental | Partner |
| Abby Willard | Winooski Nat Res Consv Dist | Partner |
| Karen Bates | DEC Watershed Coordinator | Advisor |
| Doug Burnham | VT ANR | Advisor |
| Bob Kort | US NRCS | Advisor |
| Rick Levey | VT ANR | Advisor |
| Jim Pease | VT ANR | Advisor |

Progress on Objective #1 - Assessment: Develop a framework to assess opportunities for intervention in adaptive stormwater management at various spatial scales and apply this framework to the Potash Brook case study.

The core group has discussed at length the nature and extent of the stormwater management support "toolbox" that was visualized as the primary output from this objective. Review of the literature and of existing web resources shows that there are numerous sources of information already available that describe various options available for both traditional and low-impact stormwater management designs and practices. While useful, this information is likely to be overwhelming to lay end-users who are seeking solutions to particular problems. Even developers or municipal planners are likely to find it difficult to identify which practices are best suited to the specific needs they are trying to address.

It would be impractical (and unhelpful, actually) for us to simply repackage or summarize these best management practices (BMP). This has been done, both nationally (e.g., the National Stormwater BMP Database, http://www.epa.gov/OST/stormwater/#nsbd) and by Vermont (e.g., the 2002 Vermont Stormwater Manuals, volumes I and II, http://www.vtwaterquality.org/stormwater/htm/sw_publications.htm). Furthermore, every local situation is different. Developments are of different ages, have different layouts, and interact with their environment in different ways. It is impossible to anticipate every situation in which a community member or stormwater manager might be interested and the end-users themselves have different interests and objectives. It is equally impossible to anticipate these varied outlooks. What is needed is a decision support tool that can guide these end-users through a process that includes self-examination, dialogue, and knowledge assessment leading to a narrower set of choices from among a wide number of options.

A major part of Objective #1 was focused on development of this decision support toolbox ("toolbox", for short) in a hypertext format that is suitable as either a web-based site or a stand-alone CD. A web-based option allows greater connectivity to related resources and is the delivery options we have decided to implement first. A CD version of the toolbox would perhaps allow wider dissemination of the product, but does not allow for connectivity and updating. Until there is a demand for a CD version of the toolbox, we will continue to offer it as a web-based product. We do think that there may be a place for both delivery mechanisms as it is possible that some end-users either do not use or do not feel entirely comfortable with products that are exclusively available on-line.

During the first project year we gathered materials (data, photos, documents, and links to other sites) that could be used for the toolbox. In addition, we developed our ideas for how the framework would actually function. We foresee that a community member or town planner will be able to employ the toolbox to identify BMPs that are relevant for the community, given a set of criteria identified by the user (such as budget, land base, zoning and density issues). The user will quickly be able to evaluate different BMP options from both environmental and economic viewpoints. Once a set of options has been identified, the toolbox leads the user to resources that elaborate on these options. Some of these resources are a part of the toolbox itself; others will be on-line. This latter functionality serves a dual purpose as an educational tool. For example, prior to selecting any options, users may simply need information about particular options. The user can respond by choosing a "tell me more about…" option, which will route them to pages that offer explanations and uses of the specific BMP. As mentioned above, much of this information already exists in on-line resources. Our efforts focus on the user interface and navigation through these existing resources in such a way that is comfortable for a community member who may not be familiar with the language or concepts regarding stormwater management.

A beta version of the toolbox web-site has been completed as a part of the Master's of Science project work by Tim White and was previewed to the RAN Advisory Group in November 2004. A final 'live' version of the toolbox will be linked to the main RAN website in January 2005 after several corrections and enhancements are implemented. It should be noted that we view this toolbox and the associated web-site as evolving resources. We expect that as the RAN project progresses, we will alter and enhance these tools.

As described in our work plan, the Butler Farm and Oak Creek neighborhoods in South Burlington, Vermont are a 'test bed' for our project. Thus during the first project year gathered specific data about these locales, which was needed for both descriptive and research purposes. These resources include, for example, historical GIS base soil data,and maps of watershed boundaries, streams, elevations, roads, and hydrology. In addition, we initiated the implementation and design aspects of our project by investigating specific low-impact, eco-technologies that may be suitable for use in this neighborhood. Our intention is to offer these options as concrete alternatives for the community (and the town managers) to consider for implementation in year 2 of this project.

Mid-way through the first year of this project we established a very productive collaboration with Ray Godfrey, of the US Natural Resources Conservation Service, who manages the Vermont portion of the National Resources Inventory (NRI). A part of the NRI effort is based on acquisition and interpretation of historic aerial photography that can be used to identify land cover and land use with high resolution and assurance. Ray Godfrey has developed an approach that allows him to reconstruct historical trends in land use and land cover, which he used to provide an extremely interesting and useful set of overlays that show how – and how quickly – development occurred in the Potash Brook watershed. This data set is important as a means to communicate with stakeholders and as input to our research models. One version of the data has been posted on our project website, as described below.

The RAN project website (http://www.uvm.edu/~ran) serves several functions. First, it describes the project mission, objectives, and collaborators. Second, it serves as the delivery mechanism for the toolbox, the community survey, and other related project deliverables, as described above. Third, it provides an archive for data, reports and media developed by the RAN project. Fourth, the RAN website provides links to other sites with general information about watershed management and stormwater management practices. Eventually, we intend to use the web site in an interactive mode to promote dialogue within the RAN team and to communicate the results of the partners' activities to the rest of the community.

Objective #2 - Evaluation: Complete a comparative cost/benefit analysis of the alternatives identified for the case study in Objective #1, which accounts for environmental and social/community factors as well as purely economic factors.

This objective has been directly integrated into Objective #1. Our efforts in Objective #2 during the first project year were focused on gathering data needed for the toolbox. The analysis we developed is in the form of a 'ranking tool' – an Excel spreadsheet that contains information about the main alternatives available and a set of priorities that the user can identify (installation, cost, operation and management, stormwater quantity, peak flow, base flow, stormwater quality, etc.). Once the priorities are chosen, the alternative technologies are ranked according to them. A simple prototype of the ranking tool has been developed and will be included in the toolbox. We expect to substantially enhance the functionality of this ranking tool during year 2 of the RAN project.

Objective #3 - Participation: Involve community stakeholders in the development and evaluation of Objectives #1 and #2 through 'town or neighborhood meetings' that rely on whole-watershed visualization tools and multi-criteria decision aids to promote shared learning among the project participants.

We have established a good connection with a group of concerned neighbors in the Butler Farm/Oak Creek (BF/OC) neighborhoods. While there is no formal Homeowners' Association (HOA) in either neighborhood, this informal connection should adequately meet the needs for the RAN project. Our efforts to establish neighborhood connections within the framework of the RAN project have been viewed favorably and may be important as the town of South Burlington moves to implement a Stormwater Utility. We understand that the new utility framework will require that individual developments be sufficiently organized (by whatever means) to ensure that they hold valid permits for all stormwater discharges and facilities within their boundaries before they development can be included in the utility. Our outreach to the BF/OC neighborhoods may help in this transition. Furthermore, we believe the RAN toolbox could be instrumental in helping this and other neighborhoods make this transition from unpermitted to permitted status.

We have had three meetings with the BF/OC neighborhood group and have held one 'field day' for the entire neighborhood and other interested stakeholders. The first meeting was to describe our project and get initial input about the problems and concerns of the residents. We met a second time to discuss the draft of the survey that was developed. The group was very helpful in framing some of the questions in a way that the residents could better understand and give clearer responses. The neighborhood group volunteered to help us distribute the survey in the neighborhood. It was agreed that if the survey was regarded as a neighbor-to-neighbor activity, we could expect higher return rates.

The survey was developed with three goals in mind:

1. to understand how people perceive the stormwater issues and determine what they know about storm water related problems;

2. to collect information about the behavior patterns and daily practices related to stormwater in the neighborhood; and,

3. to evaluate the overall level of environmental awareness and willingness to act and/or change in the neighborhood.

We received 99 completed surveys (out of 200, nearly a 50% return) and all surveys have now been processed. The survey will also serve certain educational purposes, as it makes people think about issues that they may not have been considering before. Results from the survey have been posted on the RAN project website. We have found that stakeholders report a very high environmental concern and have a much higher than average educational level. We may hope that if the project is successful, the residents may become instrumental in disseminating the findings to a broader community. However, so far the higher educational level does not necessarily translate into more benign stormwater related practices (Fig. 1). We hope the survey can help us start a dialogue to get more people involved in the decision making process. Most (95%) of the residents did not expect flooding to be a problem when they purchased their properties, even though the geomorphology of the site suggests the risk of flooding is high. The residents so far are mostly concerned with the local flooding problems and are less involved in the broader stormwater issues. They are more willing to adopt certain "good" stormwater practices rather than contribute their time and money to solve the problems (Fig. 2). At the same time the majority are expecting large-scale engineering solutions to solve their problems, rather than small-scale interventions. Apparently this also means that they are expecting external sources of funding for this kind engineering.

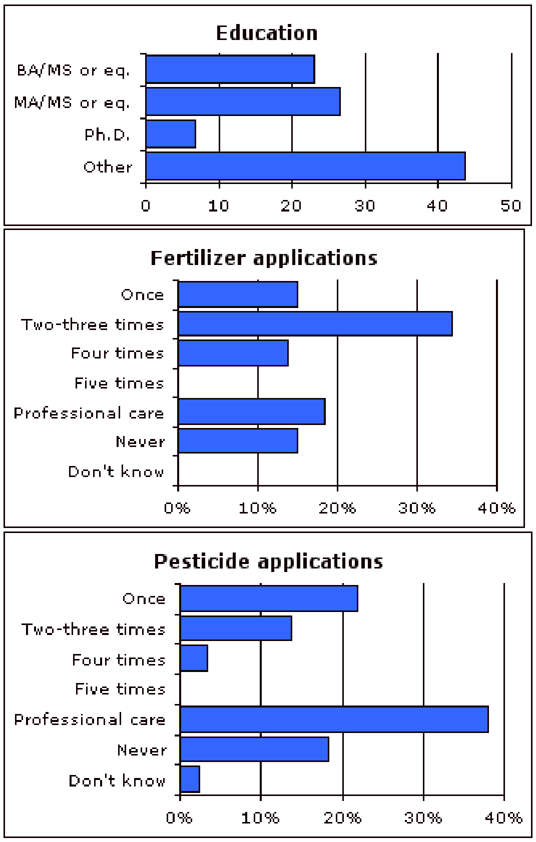



**Fig.1 More than 50% of residents have a college degree or more. Yet, they tend to use quite high rates of fertilizer and pesticide applications.**

The third meeting with BF/OC stakeholders occurred on 14 April 2004 and consisted of a major project presentation to the stakeholders at the South Burlington Town Hall. At that time, results from the survey were reported to the stakeholders and discussed. This meeting was our first extensive outreach to the whole community and provided the basis for a wider working group, which will be our liaison for future work on the project.

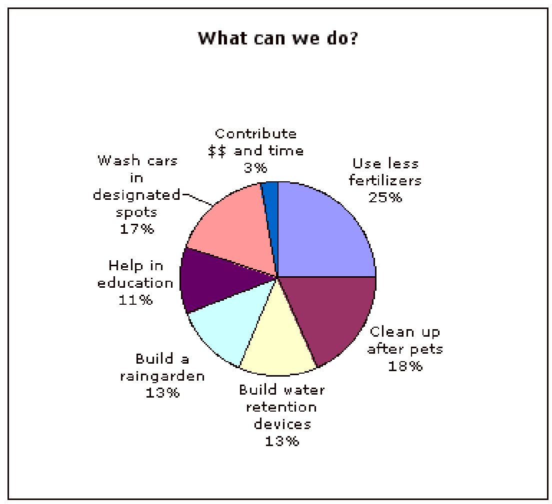



**Fig.2. Residents are willing to adopt a mix of practices to improve stormwater quality. However they are rarely interested in contributing time and money for this cause.**

On the 17 September 2004 the RAN team hosted a Watershed Field Day along tributary 7 of the Potash Brook in Oak Creek Village. The RAN partners and community members discussed personal and watershed stormwater issues. The RAN project was described and South Burlington's stormwater-related efforts were described. In addition, we organized presentations on pesticide-free lawn care, soil testing, and rain barrel installation. Watershed and macro-invertebrate identification for the kids plus tours of the stream monitoring stations gave children and adults alike a chance to see and better understand their potential impact on the local stream. An estimated 45 residents participated throughout the morning and the event garnered good attention in the local media.

The citizens attending the field day were also introduced to our plan to conduct a series of four design and planning charettes to identify the most appropriate stormwater management strategies for retrofitting the Oak Creek Village and Butler Farm communities. These sessions are an essential part of the year 2 workplan for the RAN project and will be a collaborative effort among the BF/OC residents and RAN partners. The charettes will be used to reflect on the key stormwater management issues collectively, develop and evaluate designs holistically, and choose the most appropriate management strategies at the household, street, and community scales.

*<u>Objective #4 - Implementation</u>: Initiate a demonstration project that can be used as a focal point to test ideas and designs generated by Objectives #1-3.*

In the fall of 2003, area reconnaissance work was performed to identify potential sampling locations and assess subwatershed conditions. Tributary 7 was surveyed during several heavy rain events, and well as under normal base flow conditions, and sampling locations were selected above and below the Butler Farms and Oak Creek Neighborhoods. Property access and installation permission were coordinated through the City of South Burlington. Different options for stream monitoring were investigated and discussed, and preliminary calculations for weir installations were completed. Selection of the specific equipment to use for this aspect of the project was completed and orders were placed. Unfortunately, the final sign-off on the workplan was not completed until October 2003 and because of the lengthy lag time required to negotiate, order, test, and install equipment, we were unable to implement this objective during the fall 2003 period as was hoped. Furthermore, because it is difficult to install new field equipment in the spring high flow period, we were unable to acquire spring samples in 2004.

However, the delayed weir installation proved to be beneficial as it provided additional time to consider monitoring strategies and experimental design. Detailed field reconnaissance in the fall revealed that persistent low base flows in Tributary 7 posed serious technical problems for the proposed functional assessments and brought into question what these assessments would really reveal. Furthermore, we found that a tributary between the proposed second and third sampling stations was more important than initially thought and compromised the utility of the lower sampling site (well below the neighborhood within city-owned conservation land). Consequently, we decided (after consultation with the EPA Project Managers, Beth Alafat and Eric Perkins) to eliminate this lower station and instead expand significantly the functional assessment portion of this objective.

The functional assessment component of Objective #4 was expanded to include a set of six ‘paired’ watersheds: three stormwater impaired watersheds and three reference (or ‘attainment’) watersheds. Lower Potash Brook was retained as one of the impaired watersheds and a survey was mounted to identify a set of 5 other matching stream reaches. This survey involved both extensive field reconnaissance and consultation with other knowledgeable faculty at the University of Vermont (UVM) and staff at the Vermont Agency of Natural Resources (ANR). Including more functional assessments will capitalize on an opportunity to contribute to the specific needs identified by the Vermont Water Resources Board (WRB) during the recently completed stormwater docket, concerning the use of stormwater ‘impaired’ and ‘attainment’ reaches. For example, while the original work plan described several *days* worth of whole-stream metabolism experiments in only 2 locations, the newly expanded plan will entail nearly *continuous* monitoring on 6 sites (3 paired ‘impaired’ and ‘attainment’ reaches) from late-May to November. A full description of the expanded functional assessment workplan was submitted with the year 2 work plan and will be reported in future status reports. The same methodology is being employed; the primary differences from the original workplan are the locations (larger tributaries) and numbers (from 2 to 6) of installations. We believe that this expanded assessment will provide valuable information concerning the nature of the ecological impairment resulting from stormwater impacts, as well as potential new methods for assessing stream recovery.

In May 2004, stream monitoring stations were constructed at the two sites identified on Tributary 7 of Potash Brook (Fig. 3) for the purpose of describing the water quality and quantity impacts associated with the study neighborhoods. Further analysis of site characteristics resulted in a decision not to install temporary weirs as originally planned to due insufficient slope, excessive sedimentation, and ponding issues. In order to address these problems, cross-sectional control areas were instead installed within the stream channel to provide a regular boundary through which stage and discharge could be more accurately measured. The bottom of the tiled cross section also provided a level base on which to mount the pressure transducers that monitor stage height. Following the construction of tiled cross-sections at each monitoring station, ISCO automatic water samplers, protective housing and signage, and associated probes were installed. In addition, a rain gauge was installed at the upper monitoring station. Photographs of both monitoring stations shortly after completion are provided below.

**Figure 3: Tributary 7 Monitoring Stations**

Upper Monitoring Station (T7SW1)

Lower Monitoring Station (T7SW2)

Stream flow and rainfall data collection from the Tributary 7 monitoring stations commenced in late May 2004. Through a combination of grab sampling and automated sampling using the ISCO devices, storm-event water samples were collected and analyzed from April through September 2004. Twelve (12) rounds of sampling were conducted at the upper station, and sixteen (16) rounds of sampling were conducted at the lower station. Samples could not be collected from the upper station during some storms due to no (zero) flow conditions. No samples were possible in late fall 2004 due to a lack of storm events of sufficient size to result in elevated flow conditions.

Based upon the results to date, total suspended solids, bacteria, conductivity, and nutrient levels all increase within the stream during storm events as it flows through the study neighborhoods. Figs. 4-6, below, present a summary of this data, with comparisons to national event mean concentrations (EMCs) provided where possible (VT DEC Stormwater Manual Vol. II, 2002).

**Figure 4. Average total suspended solids (TSS) concentrations**

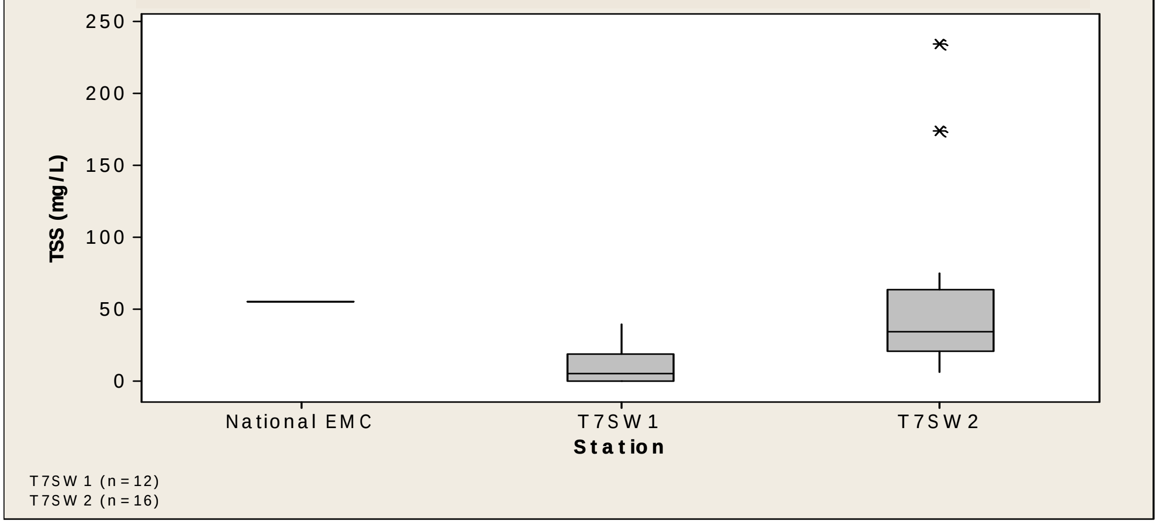



**Figure 5. Average conductivity (µS/cm)**

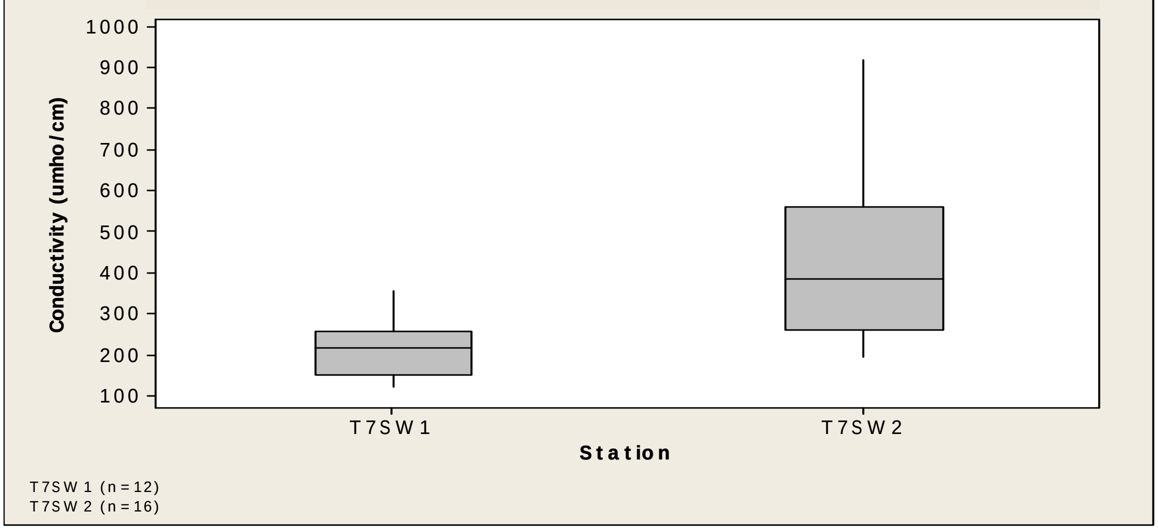
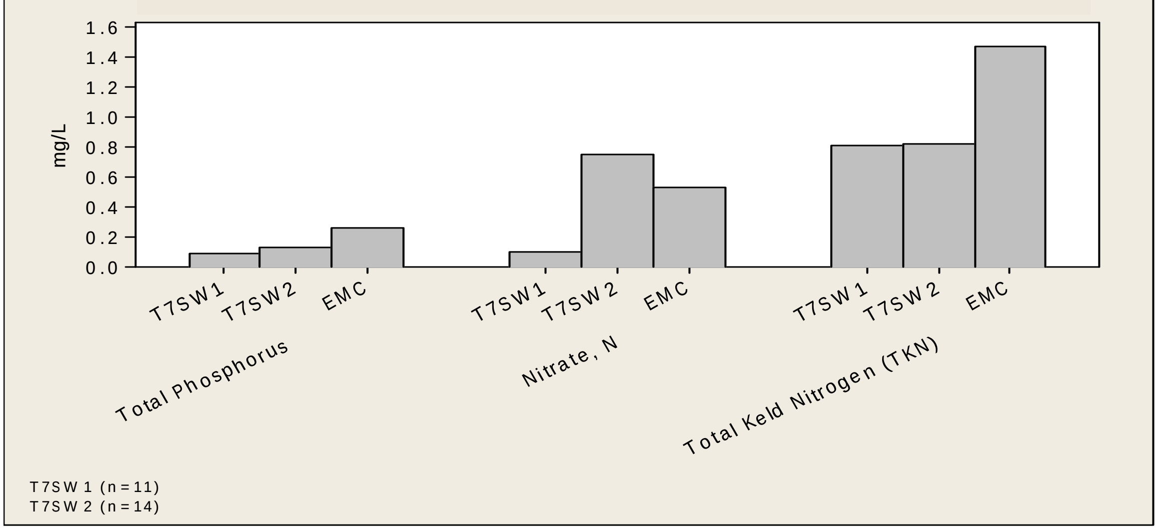



**Figure 6. Average total phosphorus and nitrogen (mg P or N/L)**



Several surveys were conducted in Tributary 7 to aid in the evaluation of baseline conditions. A benthic macroinvertebrate survey was completed in late October pursuant to VT DEC guidelines using a 500-micron D-net. Samples were preserved in alcohol and will be identified and analyze during early 2005 to develop appropriate biometric ratings. In addition, a benthic habitat survey was completed, including a pebble count and algal community survey. Throughout the field season, hundreds of photographs and pages of notes were collected to document changes in stream condition. Lastly, a rapid geomorphic/habitat survey was completed. Samples and data from these surveys are still being evaluated and results will be reported in subsequent status reports.

Stage height was continuously monitored in Tributary 7 using a data-logging pressure transducer attached to the stream bottom. The stage height measurements were translated to discharge measurements using a rating curve developed from individual discharge surveys (e.g., Fig. 7). Technical difficulties with the ISCO units unfortunately resulted in some gaps in the continuous record during June and early July. In general, flow patterns of the upper and lower stations differed significantly. With primarily undeveloped land upstream from the upper monitoring station, stream flow was characterized by generally low flows and gradual increases and decreases. However, stream flow at the lower monitoring site, below the study neighborhood, was characterized by a more ‘urban’ pattern with higher flows and much more rapid rises and falls (Fig. 8). A thorough analysis of runoff and stream flow dynamics will be completed during year 2 of the project and will be provided in subsequent reports.

**Figure 7. Tributary 7 Hydrologic Rating Curves**

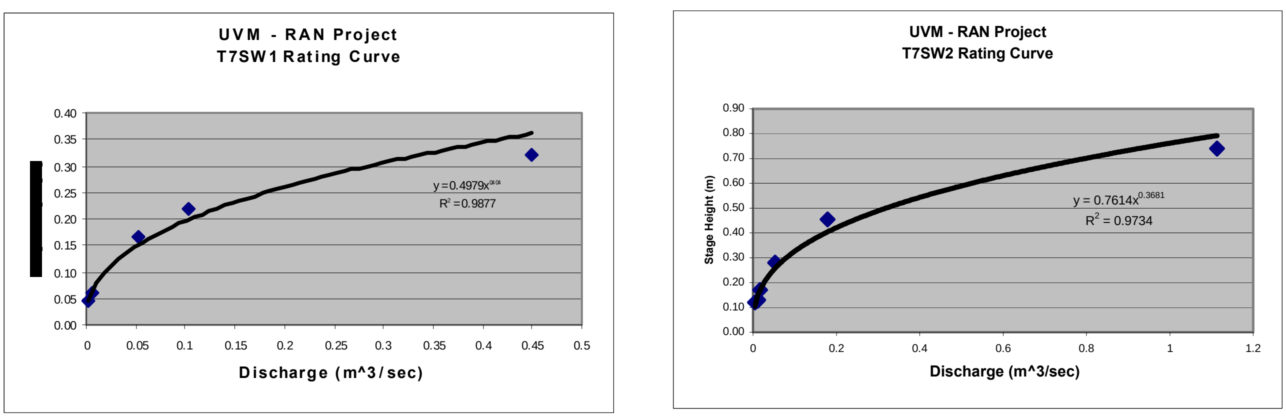
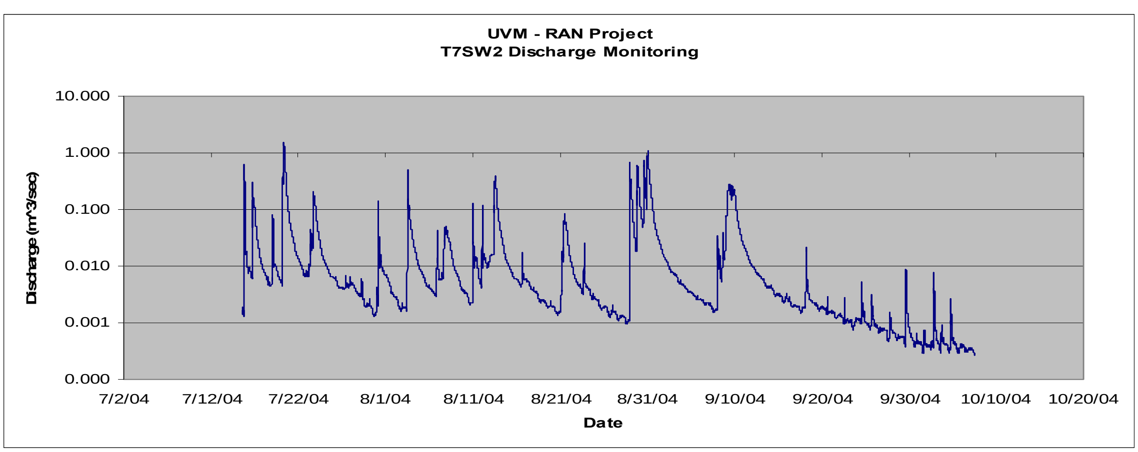



**Figure 8. Tributary 7 Discharge Monitoring (Lower Station)**



As noted above and in the Year 2 Work Plan, the expansion of the functional assessment component of Objective #4 required the identification of six (6) matched study stream reaches. Following extensive field surveys and collaboration with staff from the VT DEC, the final selections were completed in June 2004. The three impaired streams selected were Potash Brook (South Burlington), Munroe Brook (Shelburne), and Indian Brook (Essex). The matched 'attainment' condition streams are Patrick Brook (Hinesburg), Mill Creek (Jericho), and Johnnie Brook (Richmond). Immediately thereafter, stream gauges were installed at each site along with YSI 600 XLM monitoring probes (for continuous monitoring of temperature, conductivity and dissolved oxygen), ONSET photosynthetically active radiation (PAR) sensors, and rain gauges (only at two sites). Several photographs of the standard equipment setup for the functional assessment sites are provided below in Figure 9.

**Figure 9. Functional Assessment Site Equipment Photographs**

Mill Creek Stream Gauge

Patrick Brook PAR sensor

Munroe Brook YSI (attached to rebar in streambed)

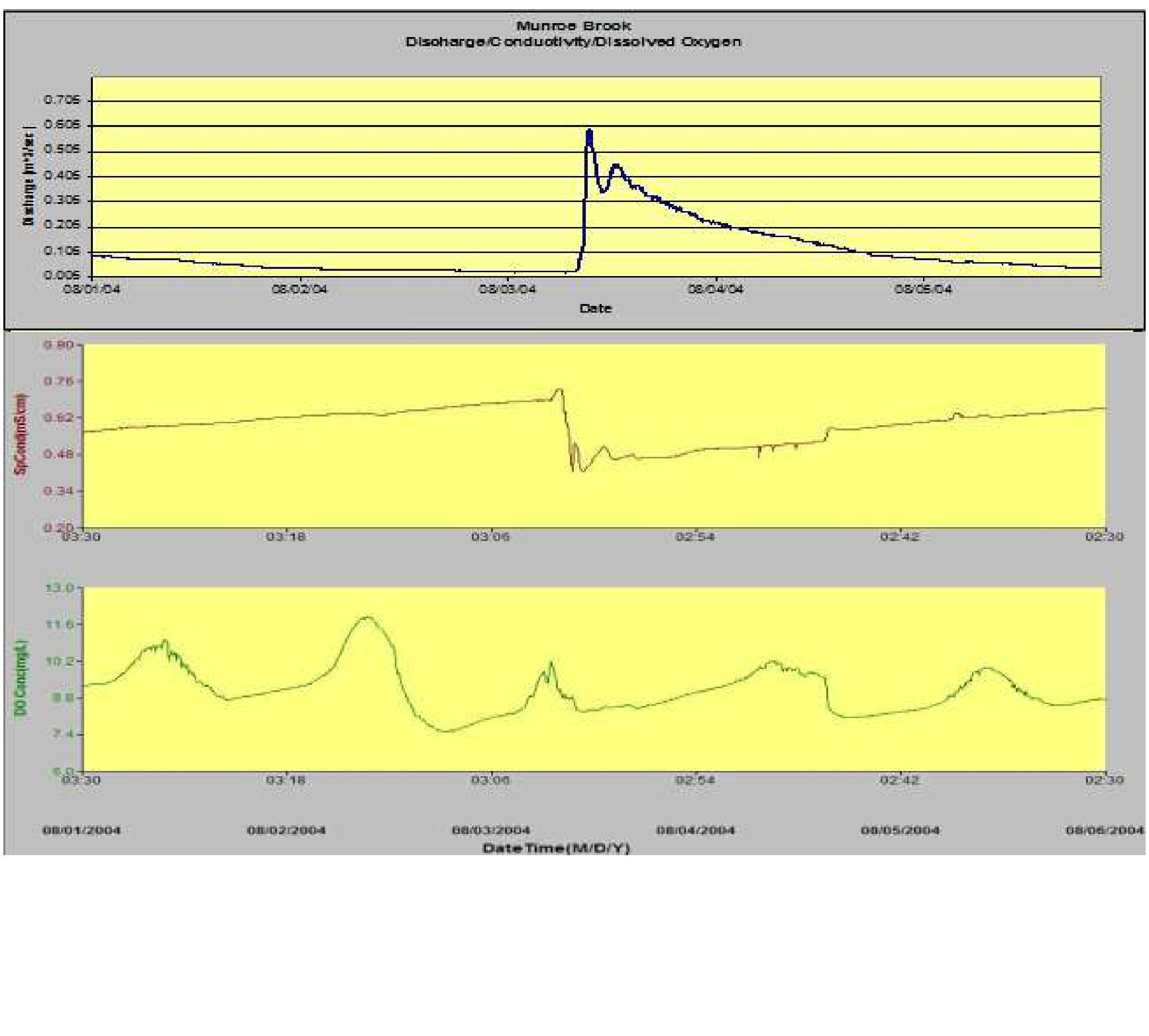
Johnnie Brook Stream Gauge

Installation of all field equipment was completed by early July, and continuous monitoring commenced. With record rainfall this summer, operation and maintenance work occupied much of our efforts this summer. All functional assessment sites were visited two to four times per week. Each time, data was downloaded, minor repairs made, and calibrations checked and noted for all equipment. A total of fifty-five (55) hydrologic profiles were completed to develop rating curves for each functional assessment stream reach. Benthic macroinvertebrate surveys were completed for all sites in early October following training from VT DEC biomonitoring staff, and will be analyzed this winter. Rapid geomorphic/habitat assessments were completed in the early fall pursuant to the VT Geomorphic Assessment Protocols. A second additional cross-sectional characterization survey (every 5m) was completed at each stream reach to further assess geomorphic conditions. Three (3) rounds of grab sampling were conducted at each site for background nutrient level analysis. Extensive photographic evidence was collected to track to biological and geomorphic changes that were observed from week to week, and between seasons. Numerous sound pressure surveys were conducted to develop the reaeration coefficient component of the whole-stream metabolism calculations (further details will be forthcoming in the technical report this winter). Lastly, pebble count and benthic algae community surveys were completed. In summary, a great deal of information was collected in order to confirm the classification of the stream reaches as 'impaired' or 'reference condition'.

Stream flow monitoring has been ongoing at each site since July. This information has been provided to the VT DEC to assist in their watershed modeling efforts associated with new stormwater initiatives. The stream gauges will be maintained throughout the winter as well (weather permitting) to assist the VT DEC and to further assess seasonal discharge characteristics. All hydrologic monitoring data, including rating curves, stage, and discharge monitoring records, have been organized on a network drive at UVM and will ultimate be available on-line via the RAN web-site.

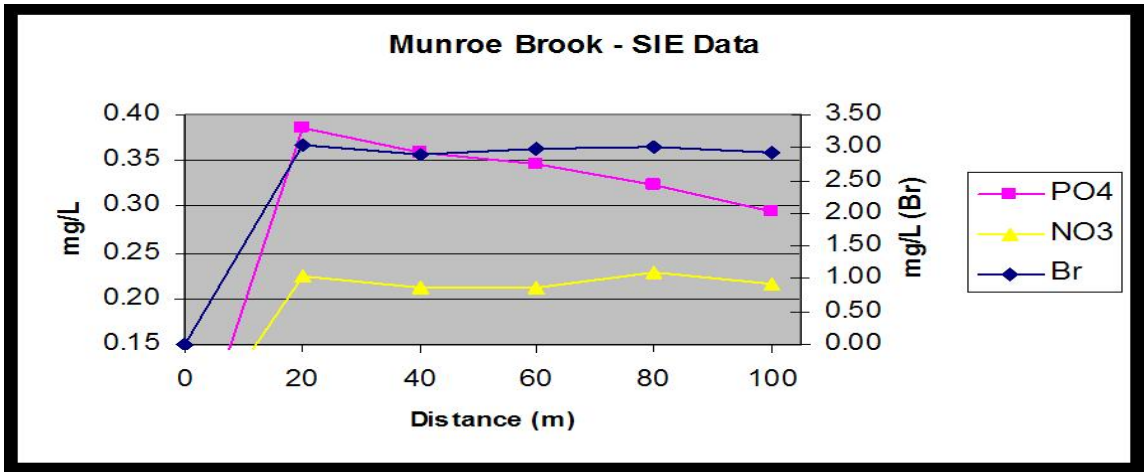
Stream flow is monitored at all functional assessment sites for the timing of storm events and to assess hydrologic characteristics. However, it may be also used in conjunction with the other long-term monitoring data (temperature, conductivity, and dissolved oxygen) to assess how the different streams respond chemically, physically, and biologically during storm events. For example, Figure 10 presents a sample storm event hydrograph for Munroe Brook. Note the initial spike in conductivity (representing a 'first flush' effect) followed by rapid dilution. Also note the reduced amplitude of the oxygen curve compared to before and several days after the storm event. This reduced amplitude may indicate disturbance effects to the in-stream biological community.

**Figure 10. Munroe Brook Storm Event – Hydrograph, Conductivity, and Dissolved Oxygen**



Solute injection experiments (SIE) were successfully completed in fall 2004. We hoped to run the SIEs earlier, in the summer 2004 as well, but additional time was required to collect and analyze background data, calculate loadings, and obtain a permit from the VT DEC for these experiments. Data collected from these experiments is currently being compiled and analyzed and will be presented in a later technical report. Figure 11 presents a graph of the raw data from the SIE at Munroe Brook involving the injection of nitrate, phosphate, and bromide. Note that while the bromide and nitrate concentrations remain fairly stable, the phosphate concentrations appear to decrease substantially, indicating increased biological activity.

**Figure 11: Munroe Brook SIE Data – Nitrate, Phosphate, and Bromide**




With the exception of the stream gauges, all functional assessment equipment was removed from the field in late November 2004. Analysis of the data collected this summer and fall is underway. The dissolved oxygen and PAR monitoring information, along with the developed reaeration coefficients, will be used in the calculation of whole-stream metabolism estimates for the functional assessment sites. From these calculations, we will assess primary productivity, community respiration, and the balance of the two that provides information on the fundamental energy dynamics (autotrophic vs. heterotrophic) of a stream ecosystem.

Table 3 provides a summary of all data collected for all monitoring sites this field season, including Tributary 7 (Potash Brook) and the six (6) functional assessment sites. As noted above, further analysis of this data will be performed as soon as possible, and we anticipate the submittal of a technical appendix or report in early 2005.

Next Steps

A workplan for the second year of this project was submitted earlier (dated 30 July 2004) and describes in greater detail the evolution of our objectives in this project. Briefly, the year 2 workplan includes simple extensions and modifications of the year 1 workplan and so, is an evolution of those efforts. The most significant modifications of the work plan are the addition of a low-impact, eco-technology demonstration project driven by a series of design charettes that will engage the Butler Farm/Oak Creek residents directly and the addition of a revised functional assessment project. This first modification is a direct outgrowth from our initial work in Objectives 1 and 2 and was signaled in the year 1 workplan. The

**Table 3. Data inventory summary**

| Data Type | Research Site(s) | Approx. Date Range | Notes |
|---|---|---|---|
| Stage and Discharge | Tributary 7<br>Functional Assessment Sites | 7/13/04 – 11/17/04<br>7/1/04 – present | There is additional record for T7 in 6/04, but it is not continuous. |
| Stormwater Sampling | Tributary 7 | 4/2/04 – 9/9/04 | 12 rounds at T7SW1 and 16 rounds at T7SW2 |
| Background Nutrient Sampling | Functional Assessment Sites | 8/20/04 – 11/12/04 | 3 rounds at all sites |
| Stream Temperature | Functional Assessment Sites | 7/1/04 – 11/17/04 | |
| Stream Conductivity | Functional Assessment Sites | 7/1/04 – 11/17/04 | |
| Stream Dissolved Oxygen | Functional Assessment Sites | 7/1/04 – 11/17/04 | |
| PAR | Functional Assessment Sites | 7/1/04 – 11/17/04 | |
| Rainfall | Tributary 7<br>Mill Cr., Patrick Bk. | 6/1/04 – 11/17/04<br>7/1/04 – 11/17/04 | |
| Whole-stream metabolism | Functional Assessment Sites | 7/1/04 – 11/17/04 | Calculations in progress |
| SIE Results | Functional Assessment Sites | 11/04 | Calculations in progress |
| Benthic Macroinvertebrate Metrics | All Sites | 10/04 | Collection complete, analysis in progress |
| Rapid Geomorphic/Habitat Metrics | All Sites | 10/04 | T7 survey this month, analysis in progress |
| X-sectional characterization | Functional Assessment Sites | 11/04 | Analysis in progress |
| Pebble Count/Algae Survey | Functional Assessment Sites | 11/04 | Analysis in progress |
| Sound Surveys for Reaeration Calculations | Functional Assessment Sites | 7/04 – 11/04 | Reaeration-rating curve work in progress |
| Hydrologic Profile Surveys | All Sites | 5/04 – 11/04 | 68 total at T7 and Functional Assessment Sites |

second modification is an evolution of our work in Objective 4, which had to be modified due to technical difficulties encountered in the field. This latter change was discussed with the US/EPA Project Manager (Eric Perkins) by conference call in February 2004. This workplan documents the changes agreed to in that conversation.

It should be noted as well that the RAN project has generated two new collaborations with the Vermont Agency of Natural Resources that build on and strengthen the RAN initiative. The first project is designed to develop a practical integration of the flow duration curve (FDC) and stormwater impact analysis (SIA) approaches suggested in the 2004 Water Resources Board final report for the Stormwater Docket. A Stormwater Advisory Group (SWAG) has continued to meet to progress this initiative and data from the RAN project has been used in the SWAG efforts. The second project is designed to better integrate knowledge about stormwater dynamics into the Vermont Stream Geomorphic Assessment protocols. This project has not yet begun. However, the various partners who are a part of this initiative (including RAN and the SWAG) recognize the connections between these various efforts.

______________________________________________________________

Alan McIntosh, UVM Project Lead Manager                                   Date

______________________________________________________________

William (Breck) Bowden, UVM Project co-Manager                              Date