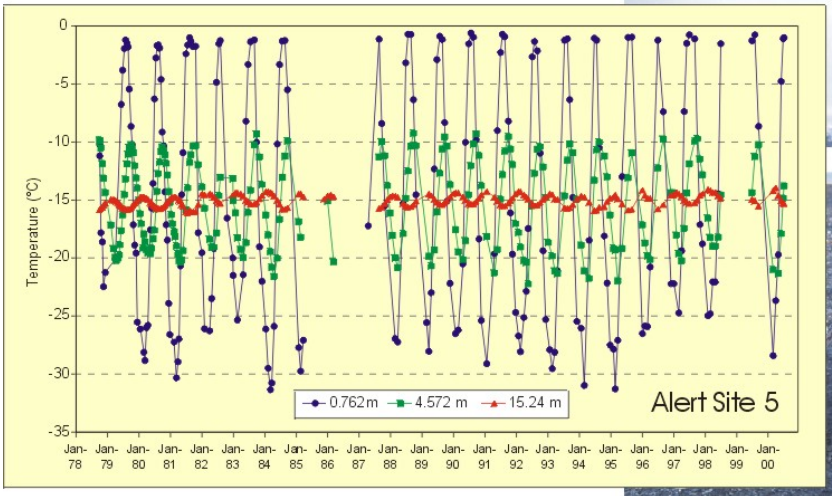
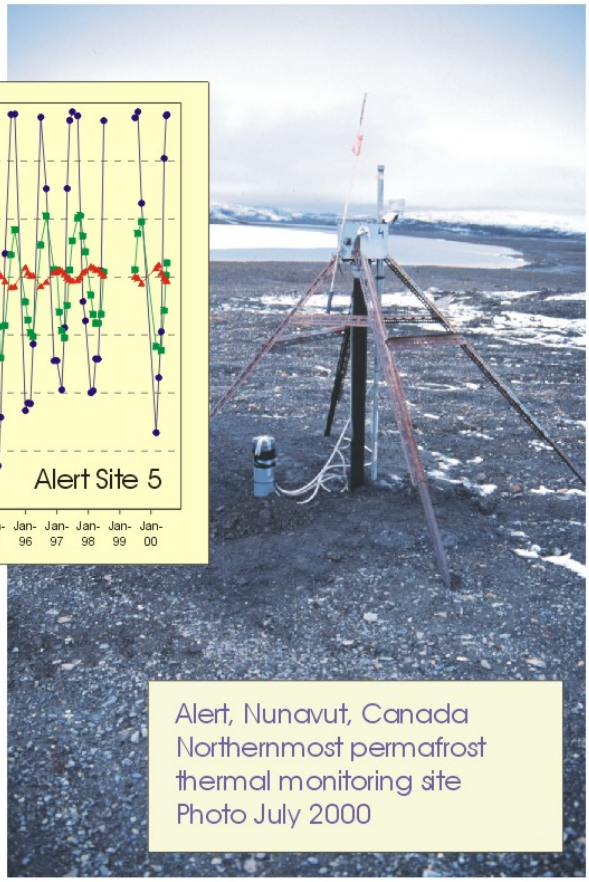
The Global Terrestrial Network for Permafrost (GTN-P)

GTN-P
Global Terrestrial Network for Permafrost

Status Report March 25, 2001





Alert, Nunavut, Canada
Northernmost permafrost thermal monitoring site
Photo July 2000

Submitted by

Margo Burgess[1],
Sharon Smith[1],
Jerry Brown[2]
and Vlad Romanovsky[3]

to the IPA Executive Committee Meeting, Rome

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2. IPA, Woods Hole, Mass., USA
3. University of Alaska, Fairbanks, USA

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Summary Status Report

In 1998 the International Permafrost Association (IPA) Council passed a resolution at the Yellowknife International Permafrost Conference to lead the development of a functional international network for permafrost monitoring. Active layer and permafrost thermal state had been identified by the World Meteorological Organization's (WMO) Global Terrestrial Observation System (GTOS) in 1997 as two key cryospheric variables for monitoring in permafrost regions (WMO, 1997). An ad-hoc steering committee was established to develop a strategy for the organization, implementation and management of a global monitoring network for active layer and borehole temperature monitoring. In 1999, the Global Terrestrial Network for Permafrost (GTN-P) was established under the Global Climate Observing System (GCOS) and the GTOS of the WMO, with the request that IPA plan and implement the GTN-P.

Since 1999, the IPA's ad hoc GTN-P committee has made considerable progress in organizing and implementing the GTN-P. This progress was recently outlined in the December 2000 *Frozen Ground* (No. 24, p.12-14). The status report presented here reviews and expands upon this progress through providing more detailed reference and background material, as well as updated summary tables and maps. In particular this status report emphasizes the borehole thermal monitoring component of the GTN-P. The active layer monitoring component is represented by the IPA's well established CALM program, and its activities are not covered here.

National and international workshops, in addition to PACE activities, occurred in 2000. Summary reports are included from the Canadian National Workshop on Permafrost Monitoring Network Requirements held in Ottawa, January 2000, and the Fairbanks Workshop on International Permafrost Monitoring and Database Management, held in Fairbanks, June 2000.

GTN-P overview paper and web site

An overview of the GTN-P programme, its goals and establishment, activities in the first year and planned future steps was published in the summer of 2000 in the Geological Survey of Canada's (GSC) Current Research report series (Burgess et al., 2000). A copy of this paper is provided in Appendix A. A GTN-P web site was initiated in the summer of 2000, with a focus on the borehole thermal monitoring component, and is still under development. The web site is housed on the GSC's permafrost web page at: http://sts.gsc.nrcan.gc.ca/gtnp/index.html. A copy of the home page is included at the end of Appendix A. The web site currently contains an inventory and location maps of candidate sites, borehole metadata forms for downloading, as well as background material on the GTN-P, with links to several related programmes and activities.

Candidate borehole site list, site maps and metadata compilation - Update

Some 370 boreholes from 16 countries have been identified as candidate sites for inclusion in the GTN-P borehole thermal measurement programme. Table 1 is a summary of boreholes locations by country by depth range. The majority of the borehole sites are between 10 and 125 m deep, and are in the Northern Hemisphere. Figure 1 provides a map showing the location of the candidate borehole sites in the Northern Hemisphere, while figure 2 shows the distribution by

broad region (Alaska, Canada, Europe/Nordic/Asia, Russia, and Southern Hemisphere) and depth range. Figure 3 shows the evolution of the distribution by region and total number of active layer monitoring sites in the CALM programme since its inception in 1990.

Table 1. Summary table of candidate boreholes by location and depth

Location	Borehole Depth				Total
	Surface <10 m	Shallow 10-25 m	Intermediate 25-125 m	Deep >125 m	
Alaska	2	6	24	21	53
Antarctica	6	1		1	8
Argentina	1				1
Canada	10	43	16	6	75
China		3	11	1	15
Greenland				1	1
Italy	2		1		3
Kazakstan		2	1		3
Kyrgyzstan				1	1
Mongolia	4	4	5		13
Norway	2	2	1	1	6
Russia	1	64	47	63	175
Spain		1	1		2
Sweden			2		2
Switzerland		2	10		12
Total	28	128	119	95	370

Metadata compilation for candidate sites began in earnest in 2000. Metadata forms were developed (available for downloading on the web site) and distributed to all investigators who submitted candidate sites. Appendix C provides a listing of all candidate borehole sites, and indicates investigating country and investigator, depth, latitude, longitude, elevation, permafrost depth, and whether metadata forms have been completed or not. To date metadata has been submitted for 58% of the sites.

The process of categorizing candidate boreholes according to the current level of activity is proceeding in tandem with the metadata submission. Three categories were agreed upon at the June 2000 Workshop on International Permafrost Monitoring and Database Management held in Fairbanks Alaska (further information on the Fairbanks Workshop is provided later in this report):

Figure1 Candidate Borehole for Permafrost Thermal Monitoring

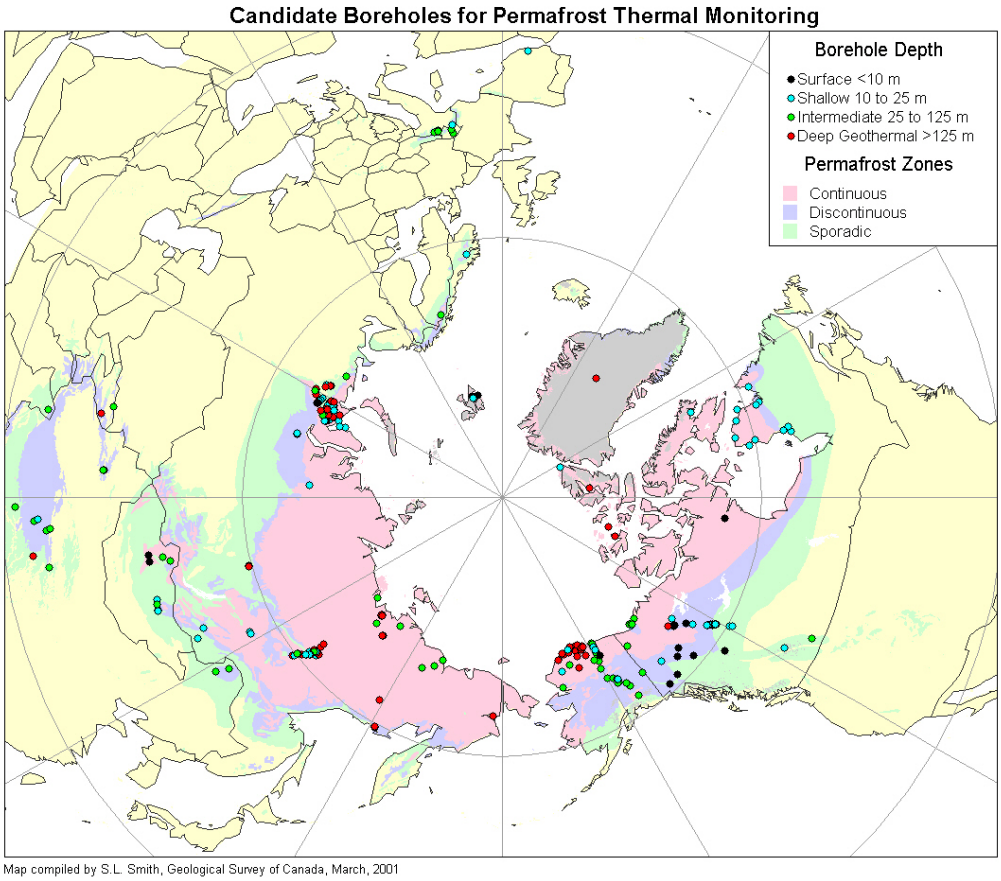


Figure 2. Distribution of candidate boreholes.

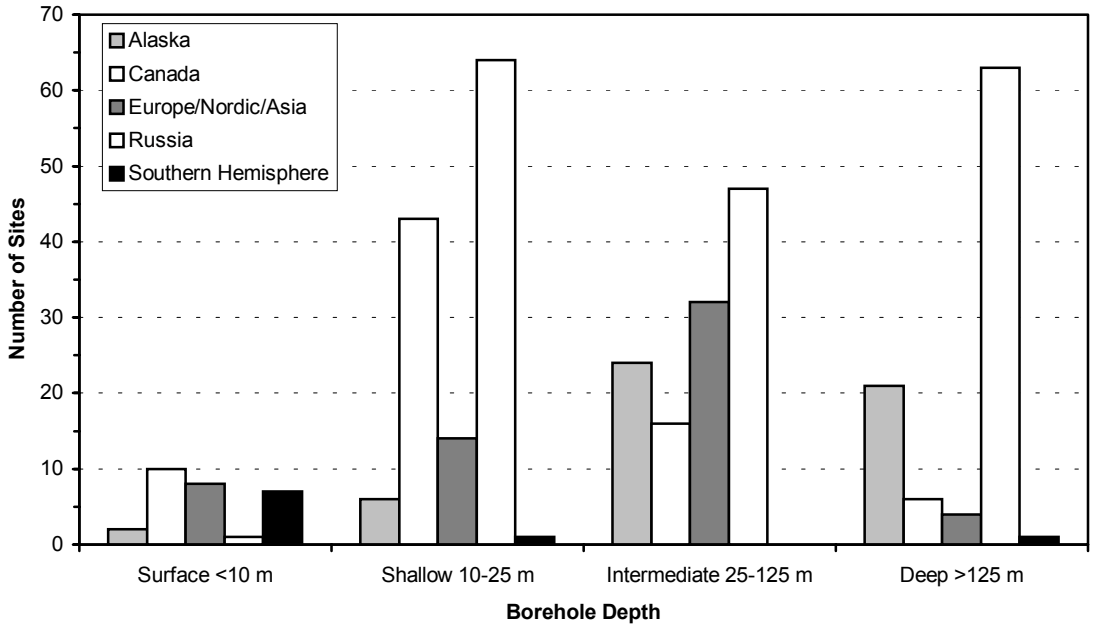
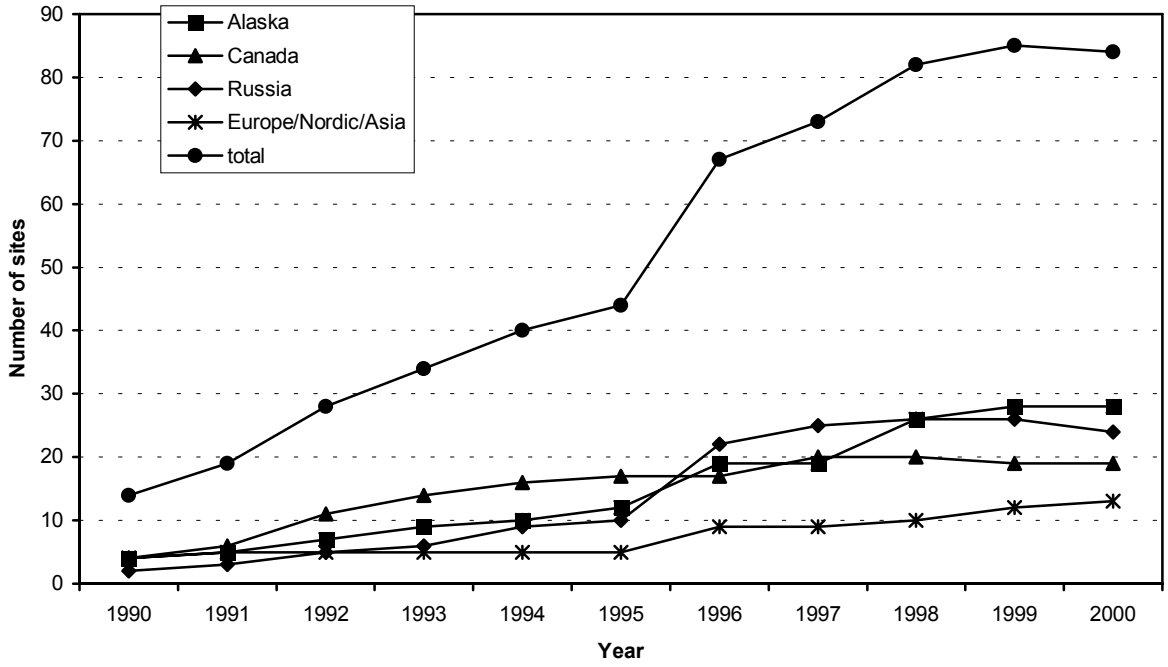


Figure 3. Distribution of CALM sites by regions and number of sites over time.



Category	Description
1	***Active sites*** • those boreholes from which periodic measurements are currently obtained
2	***Nominated sites*** • those boreholes that have been identified and are potentially available for future measurements. If observations are not possible or no data is provided over the next 2-3 years, they would be removed from the GTN-P inventory of sites
3	***Potential sites*** • these are known boreholes reported in the literature, but not yet nominated

Candidate sites are also being assigned one of the five levels of the GTOS Global Hierarchical Observing Strategy (GHOST). Further details on the GHOST tiers are available on the GTN-P web site at http://sts.gsc.nrcan.gc.ca/gtnp/ghost.htm. Where known or assigned, the site category and GHOST level have been included in the site list in Appendix C. Once metadata submission has been completed, and all sites assigned categories and GHOST levels, final selection of sites for inclusion in the GTN-P will occur.

WMO letter requesting GTN-P participation

In September 2000, Secretary General Obasi of the WMO sent a letter to government officials of over 20 countries with permafrost programmes and interests, requesting their active participation in the GTN-P. The Secretary General requested that permafrost observations be included in each country's report on systematic observations to the Conference of Parties to the United Nations Framework Convention on Climate Change (UNFCCC) in November 2001. A copy of the letter is included in Appendix B. To date five countries, Canada, USA, Switzerland, Italy and China, have responded, and these responses are also provided in Appendix B. It is hoped that the WMO letter will provide added incentives and justification by national and international programmes to support the GTN-P.

Fairbanks Workshop on International Permafrost Monitoring and Database Management – June 2000

The workshop was organized by Vlad Romanovsky and sponsored by and held at the International Arctic Research Centre, University of Alaska, Fairbanks, Alaska, 11-14 June 2000. Twenty-five invited specialists from Canada, China, Japan, Kazakhstan, Mongolia, Russia, Switzerland and the United States participated. Each country and project reported on status of boreholes, past results, plans for future monitoring, equipment employed, and availability of data. Although emphasis was on borehole observations, an overview of the initial results and analyses of the CALM programme was presented, including plans for regional synthesis papers.

At the Workshop, a Borehole Quality Control Group (BQCG) was selected with initial membership consisting of Margo Burgess, Gary Clow, Vladimir Romanovsky, Alexandre Vasiliev, Daniel Vonder Muhll, and Li Shuxun. The Group will report to the IPA ad hoc Steering Committee established by the IPA council in 1998. The BQCG's responsibilities are to:

1) Prepare technical guidelines for site selection, ground surveys, drilling, installations, and measurements similar to those prepared for PACE (including anthropogenic/technogenic sites, i.e those related to or within areas of human disturbances /development)
2) Compile information on equipment to be used (specifications and vendors in addition to those on the CALM web site)
3) Specify data formats and methods for reporting
4) Review of metadata nominations and recommend borehole selection, and identify gaps in the network
5) Designate sites according to the GHOST strategy.

A final report on the Fairbanks workshop is in preparation and will be made available on the web. The report will include extended abstracts of the presentations. The agenda from the Workshop is reproduced in Appendix D.

Canadian Permafrost Monitoring Network Workshop

The Geological Survey of Canada convened this workshop, organized by Margo Burgess, in Ottawa, 28-29 January 2000, as part of a joint National Permafrost/Glaciers/Ice Caps Monitoring Network Workshop. Approximately 50 participants attended the joint meeting, with more than half representing the Canadian Permafrost Community (government, academia and the private sector). The Workshop was sponsored by the Government of Canada's Climate Change Action Fund (CCAF) to provide input to the development of Canada's Global Climate Observations System (GCOS) Plan for the Cryosphere. The workshop focussed on the requirements for coordinated national networks to observe the climate change signal, assess its regional variability, and evaluate impacts in permafrost regions.

Workshop sessions and discussion (see Agenda in Appendix E) covered: (1) an overview of international and national GCOS programmes, (2) current monitoring activities, (3) climate and process modelling needs, (4) monitoring technology and techniques, and (5) network requirements. Discussions on network requirements addressed a range of issues: (1) management and coordination, (2) membership and site selection, (3) data quality control, (4) data reporting, (5) data access and exchange, (6) data archiving, (7) expertise and capacity, (8) instrumentation, and (9) priorities, needs, and funding requirements.

The results of the workshop are considered an important contribution to the development of the GTN-P. These are summarized in the Executive Summary reproduced in Appendix E. A draft workshop report was posted on the web at http://sts.nrcan.gc.ca/permafrost/pfworkshop/ and includes summaries of the presentations, group discussions and recommendations. The final report will be released as a GSC Open File publication.

The Canadian GCOS Plan for the Cryosphere is currently being finalized. This CanGCOS Cryosphere plan builds upon the Permafrost/Glaciers/Ice Caps Monitoring Networks Workshop, an October 2000 Sea Ice and Snow Monitoring Networks Workshop held in Toronto, and an earlier February 1999 National GCOS planning workshop held in Victoria, B.C – all of which were sponsored by the CCAF.

Future steps/plans

Assembly of borehole thermal monitoring site metadata will continue in 2001 and metadata will be posted on the GTN-P web site. Investigators from each country will be asked to review their digital site metadata files, report any errors or omissions, and contribute metadata from any remaining sites. Sites will then be categorized according to level of activity and GHOST hierarchy by the BQCG, and revised location maps, revised metadata files and borehole inventory tables will be made available on the web. The metadata compilation will be published as a GSC Open File report.

The final selection of sites will proceed once these steps are completed. Selection of sites for inclusion in the GTN-P will emphasize representative regional and global coverage while taking maximum advantage of existing facilities. Monitoring data, in the format to be determined by the BQCG, will be requested of and submitted by investigators annually (or less frequently for deeper measurements). An annual update of summary monitoring data will made available on the web. Final archiving will be through the Snow and Ice Data Center and the WDC-A for Glaciology, Boulder, Colorado, as part of the IPA's Global Geocryological Database.

A first five-year summary report, consisting of a series regional reports, is planned for the year 2004, with a draft presented and reviewed at the Eighth International Conference on Permafrost in Switzerland in 2003.

References

Brown, J., Burgess, M. and Romanovsky, V. 2000. Frozen Ground – The News Bulletin of the International Permafrost Association, no 24, December 2000.

Burgess, M.M., Smith, S.L., Brown, J., Romanovsky, V. and Hinkel, K. 2000. Global Terrestrial Network for Permafrost (GTNet-P): permafrost monitoring contributing to global climate observations; Geological Survey of Canada, Current Research 2000-E14; 8 p. (online; http://www.nrcan.gc.ca/gsc/bookstore)

World Meteorological Organization. 1997. Global Climate Observing System: GCOS/GTOS Plan for terrestrial climate-related observations, Version 2.0, GCOS-32, WMO/TD-No 796, UNEP/DEIA/TR97-7, WMO, Geneva, Switzerland, 130 p.

Appendix A

- **July 2000, Geological Survey of Canada Current Research Paper on the GTN-P**

[Français]

Welcome to

Global Terrestrial Network for Permafrost (GTN-P)

What is GTN-P?

The Global Terrestrial Network for Permafrost (GTN-P) was initiated by the International Permafrost Association (IPA) to organize and manage a global network of permafrost observatories for detecting, monitoring, and predicting climate change. The network, authorized under the Global Climate Observing System (GCOS) and its associated organizations, consists of two observational components: the active layer (the surface layer that freezes and thaws annually) and the thermal state of the underlying permafrost.

This web site provides general information on the GTN-P and details of the permafrost thermal monitoring component. The second component of the GTN-P is the ongoing Circumpolar Active Layer Monitoring (CALM) network which was established in 1990 to monitor changes in active layer thickness and temperature. Further information on the CALM component can be found on the CALM web site. The European Community project, Permafrost and Climate in Europe (PACE), contributes to the GTN-P and plans to monitor nine boreholes in mountain permafrost.

- more on GTN-P

- *Location of Candidate Sites for Permafrost Thermal Monitoring*
- *Inventory of Candidate Boreholes*
- *GTN-P Borehole Metadata Forms* - *download*
- *Borehole Metadata* - *download*
- *Recent Activities*
- *Upcoming Related Events*
- *References*
- *Contact Us*
- *Useful Links*

This site is being maintained by the Geological Survey of Canada, Natural Resources Canada
Permafrost Research at the GSC

Questions, comments, suggestions? Send us feedback.

Last Modified: 2001 08 15

Natural Resources Canada Ressources naturelles Canada

Canada

Appendix B
• Responses to WMO letter

7 *bis*, avenue de la Paix
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World Meteorological Organization
Organisation météorologique mondiale

SECRETARIAT
Genève - Suisse

Our ref.: 10.059/P/GTN-P

GENEVA, 31 August 2000

Annexes: 2 (available in English only)

Sir/Madam,

I have the honour of informing you about the Global Terrestrial Network for Permafrost (GTN-P) and of inviting through you your country to participate in developing this important network of the Global Climate Observing System (GCOS). GCOS was established by the World Meteorological Organization (WMO), the Intergovernmental Oceanographic Commission of UNESCO, the United Nations Environment Programme, and the International Council for Science to ensure that the needs of users (such as the Parties to the United Nations Framework Convention on Climate Change (UNFCCC)) for climate data are met. As you are aware, a number of important decisions on research and systematic observations were taken by the fourth and fifth sessions of the Conference of Parties (COP) to the UNFCCC. Decision 14/CP.4 urged Parties to undertake programmes of systematic observations, including the preparation of specific national plans based on the information developed by GCOS and its partner programmes. Decision 5/CP.5 adopted the GCOS Reporting Guidelines. These Guidelines, which identify an initial set of climate observations (including permafrost observations) important for the detection, attribution, and monitoring of climate change, are to be used by the Parties in reporting on global observing systems for climate.

In early 1999, the GCOS Steering Committee approved the GTN-P, which was jointly developed under the aegis of GCOS and the Global Terrestrial Observing System (GTOS). The permafrost layer is one of the most sensitive indicators of climate change. The permafrost monitoring network will provide the data needed to determine changes in the conditions of the permafrost layer globally and will be used nationally in assessing the impacts of climate change and in designing adaptation and mitigation strategies. If the GTN-P is to fulfil these purposes, it will require the active support and cooperation of national programmes to obtain high-quality permafrost data. Adequate global coverage is required to determine global changes in permafrost that would allow for the interpretation of national data for national applications.

Annex 1 provides a list of the measurements comprising the GTN-P, and Annex 2, included only if your country conducts current permafrost activities, provides the list of permafrost sites in your country (and/or investigated by you in other countries or regions) that contribute to the GTN-P. I am requesting your country's continued backing for the GTN-P activities that you currently support or sponsor and also that you consider improvements to these activities in line with the assessments sponsored by the scientific panels of GCOS and GTOS. I would be most appreciative if your commitment to these activities could be reflected in your country's report on systematic observations to the Conference of Parties to the UNFCCC in November 2001.

To: Ministers of Foreign Affairs of the Members of the International Permafrost Association

Also, could you kindly identify a contact person or organization for permafrost activities in your country who could assist in coordinating permafrost activities internationally. The International Permafrost Association (IPA) has agreed to coordinate the activities of the GTN-P internationally, and each country with permafrost research or monitoring activities is represented in the IPA. Reports on the GTN-P will be issued periodically, and your national contact person would receive a copy of the first report in early 2001, which will be a survey of existing and proposed permafrost measurement sites.

On behalf of WMO and the other sponsors of the Global Climate Observing System, I am most appreciative of your interest and participation in this important climate observing network. I would be pleased to provide you with any further information that you might require with regard to the implementation of the Global Terrestrial Network for Permafrost.

A copy of this notification is being sent to the Permanent Representative of your country with WMO and to selected permafrost experts.

Accept, Sir/Madam, the assurances of my highest consideration.

(G.O.P. Obasi)
Secretary-General

ANNEX 1

Global Terrestrial Network for Climate (GTN-P)

The current measurements within the GTN-P include:

(1) Permafrost active layer - the thickness, and if possible, the temperatures of the seasonally freezing and thawing zone overlying permafrost - measurement of the thickness is to be determined at a minimum by soundings in late summer at the time of maximum thaw depth, through the installation of thaw tubes, or through temperature profiling; and

(2) Permafrost thermal state - the temperature profile within perennially frozen ground at frequencies ranging from weekly to monthly in the upper permafrost layer and at annual or lower frequency (for example, up to every 5 years) for greater depths.

These observations are important indicators of climate change, of ecosystem function, and of stability in high latitudes and high mountain areas and plateaus of both hemispheres.

Over 80 active layer and 300 borehole sites have been identified as potential long-term GTN-P observational and research sites in fifteen countries representing both Northern and Southern Hemispheres. Additional sites are required to assure spatial representation according to scientific guidelines developed by the Terrestrial Observation Panel for Climate (TOPC), jointly sponsored by the Global Terrestrial Observing System (GTOS) and Global Climate Observing System (GCOS).

The specifications for these measurements, including "best practices", are:

VARIABLE:	Permafrost active layer
DATA SET:	Active layer depth
DATA ADDRESS:	http://www.geography.uc.edu/CALM
AUTHOR:	37 observers from 15 countries
UNITS:	Depth in cm
SOURCE:	Circumpolar Active Layer Monitoring (CALM) network
RESOLUTION:	Point measurement
COVERAGE:	Approximately 80 reporting sites mostly in Arctic and Sub-Arctic
METADATA :	Adequate
VALIDATION:	Annual by investigator
REVIEW (peer):	Funded National Science Foundation (NSF) peer reviewed grant; various papers published on individual or groups of sites are peer reviewed. Web master and IPA coordinator review annual inputs
USE in refereed papers:	Yes (bibliography being compiled)
APPLICATION:	Trace gas emission, climate index, soil nutrient availability, slope failures
RECOMMENDATION:	Fully accepted

VARIABLE:	Permafrost thermal state
DATA SET:	Temperature profile as measured in a borehole
DATA ADDRESS:	http://sts.gsc.nrcan.gc.ca/permafrost/

AUTHOR:	35 observers from 14 countries
UNITS:	Degrees C
SOURCE:	Jerry Brown, International Permafrost Association, POB 7, Woods Hole, MA 02543
RESOLUTION:	Point measurement
COVERAGE:	Approximately 300 potential sites in the Arctic, Sub-Arctic, Antarctica, and major mountain ranges and plateaus of both hemispheres
METADATA:	Metadata form circulated in second half of 1999
VALIDATION:	By individual investigators
REVIEW (peer):	Peer reviewed funded proposal in US, Canada, and Europe (Permafrost and Climate Change in Europe (PACE)); various papers published on individual or collective sites are peer reviewed
USE in refereed papers:	Yes (current bibliography to be compiled based on metadata forms)
APPLICATION:	Decadal to secular climate changes, trace gas emission, slope failures
RECOMMENDATION:	GCOS approved February 1999.

GLOBAL CLIMATE OBSERVING SYSTEM

of UNESCO WMO UNEP ICSU

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Our ref.: 10.070/P/GTN-P
Annex: 1

Geneva, 11 September 2000

Dear Colleague,

Recently, the Global Climate Observing System Steering Committee approved the establishment of the Global Terrestrial Network for Permafrost (GTN-P). This network was established to provide the data needed to determine changes in the conditions of the permafrost layer, one of the more sensitive indicators of climate change. To announce the new network, the WMO Secretary-General, Professor G.O.P. Obasi, recently sent a letter to the Foreign Ministers of those countries that currently undertake permafrost measurements at borehole sites in their own or other countries. Although your country is not currently engaged in this specific activity, and thus your Foreign Minister did not receive a letter, I am apprised that you have a special interest in permafrost research and thus wish to inform you of the action WMO has taken. A copy of the letter to Foreign Ministers and of Annex 1 to the letter is enclosed for your information. I would like to encourage you to support the new Global Terrestrial Network for Permafrost. For additional information on the implementation of the network you may contact Dr Jerry Brown, Secretary of the International Permafrost Association, at P.O. Box 7, Woods Hole, MA 02543, USA. Dr Brown's email address is: jerrybrown@igc.apc.org.

Yours sincerely,

Alan R. Thomas
Director
GCOS Secretariat

Natural Resources Canada
Geological Survey of Canada

Ressources naturelles Canada
Commission géologique du Canada

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December 21, 2000

Mr. G.O.P. Obasi
Secretary General
World Meteorological Organization
7 bis, avenue de la Paix
Case postale No. 2300
CH-1211 Genève 2
Suisse

Global Terrestrial Network for Permafrost (GTN-P)

Dear Mr. Obasi,

I am responding on behalf of the Geological Survey of Canada to your letter of August 31, 2000, inviting Canada to participate in the development of the Global Terrestrial Network for Permafrost (GTN-P), an important component of the Global Climate Observing System (GCOS).

The federal Department of Natural Resources Canada, through the Geological Survey of Canada (GSC), has been and continues to be an active participant in the creation and organization of the GTN-P. GSC scientists are members of the International Permafrost Association's (IPA) committees which oversee the development of the Network, and the establishment of its technical procedures, quality control and databases. As well as the active participation on these committees, the Geological Survey established and hosts the GTN-P web site, is assembling the borehole thermal monitoring site metadata and plans to provide the database management for the network.

The Geological Survey of Canada operates numerous sites contributing to the GTN-P, in particular regional active layer and thermal monitoring networks in the Mackenzie Valley, NWT and in the High Arctic of Nunavut. These regional networks have been in operation for over 10 and 20 years respectively. Our long standing commitment to these monitoring sites and our contributions in the last two years to the organization of the GTN-P reflect Canada's recognition of the importance of a national and global monitoring networks.

The GSC plans to maintain and, if possible, enhance our permafrost monitoring and GTN-P activities. We are hopeful that Canada's ongoing efforts to develop a national GCOS plan, and a related workshop defining the requirements of a National Permafrost Monitoring Network (organized by the Geological Survey in January 2000), will assist the formal establishment of a national network and the resources necessary for its operation. We envisage that the management of such a network and its associated database would be coordinated by the GSC. At present several monitoring sites in Canada are operated and funded by university researchers and other government departments. The Canadian GCOS plan, the above mentioned workshop and several permafrost climate change research projects have recently been sponsored by the Government of Canada's Climate Change Action Fund (CCAF), established in 1998. In the short term, the CCAF may be a continued source of support.

.../2

Canada's position on GCOS and GTN-P will be reflected in the report to the UNFCC in November 2001.

Should you wish further information on our involvement in the implementation of the GTN-P and the development of a national GCOS plan for the permafrost component of the cryosphere, we urge you to contact Ms Margo Burgess, member of the IPA's GTN-P committee and federal permafrost representative on the National GCOS Cryosphere Plan committee:

Margo Burgess
Natural Resources Canada
Geological Survey of Canada
601 Booth Street
Ottawa, Ontario
Canada K1A 0E8
mburgess@nrcan.gc.ca

For further information on the development of the Canadian National GCOS plan, please contact:

Dr. Barry Greer
Director General
Environment Canada
Atmospheric Monitoring and Water Survey
4905 Dufferin Street
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Yours truly,

Paul Egginton
Director, Terrain Sciences Division
Geological Survey of Canada

cc: D. Whelpdale
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I. Itzkovitch
M. Burgess
M. Allard
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中 国 地 理 学 会

THE GEOGRAPHICAL SOCIETY OF CHINA

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Sept. 26, 2000

Dear Secretary-General G. O. P. Obasi,

After having read your letter, I would like to express my appreciation to your work and will certainly support when we can.

Here, I want to recommend Prof. **Guodong Cheng**, Academician of China Academy of Sciences (*CAS*), former president of IPA, Director of the Cold and Arid Regions Environment and Engineering Research Institute, CAS (*CAREERI-CAS*) as the contact person, and the institute (*CAREERI-CAS*) as the organization in China to participate in GTN-P so as to improve the activities.

The Cold and Arid Regions Environment and Engineering Research Institute, CAS (*CAREERI-CAS*) was founded in June 1999, an newly integrated institute of Lanzhou Institute of Glaciology and Geocryology, Lanzhou Institute of Desert Research, and Lanzhou Institute of Plateau Atmospherics Research, CAS. Among the 15 Boreholes in Annex 1 you provided, 13 are directly observed by Lanzhou Institute of Glaciology and Geocryology, the other two are also supported by the same Institute. So, I believe that Prof. Cheng and the institute will perform well in the GTN-P activities.

Here is Prof. Cheng 's address:
The Cold and Arid Regions Environment and Engineering Research Institute, CAS
Lanzhou, 730000 China
Tel: 86-931-8822818; Fax: 86-931-8885241
E-mail: gdcheng@ns.lzb.ac.cn

Would you have any other questions, contact me please.

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D/EXR 4/10

EIDGENÖSSISCHES DEPARTEMENT FÜR AUSWÄRTIGE ANGELEGENHEITEN
DÉPARTEMENT FÉDÉRAL DES AFFAIRES ÉTRANGÈRES
DIPARTIMENTO FEDERALE DEGLI AFFARI ESTERI
DEPARTEMENT FEDERAL DALS AFFARS EXTERNS

K.759.0-16-SIB

Bitte dieses Zeichen in der Antwort wiederholen
Prière de rappeler cette référence dans la réponse
Pregasi rammentare questo riferimento nella risposta
Repeter questa referenza en vossa resposta p.pl.

DIRECTION POLITIQUE

3003 Berne, le 2 octobre 2000

Monsieur
G.O.P. Obasi
Secrétaire général
Organisation météorologique mondiale
7 bis, avenue de la Paix
Case postale no 2300
1211 Genève 2

Réseau terrestre mondial pour le pergélisol (GTN-P)

Monsieur le Secrétaire général,

Le Conseiller Fédéral, Monsieur Joseph Deiss, m'a prié de répondre à votre lettre du 31 août 2000 par laquelle vous invitez la Suisse à participer à la mise en place du réseau terrestre mondial pour le pergélisol, élément essentiel du Système mondial d'observation du climat (SMOC).

Comme vous le savez sans doute, la Suisse participe à la création du GTN-P. Depuis cette année, le programme national respectif "PERMOS" se trouve dans une phase pilote de quatre ans. Le réseau sera coordonné par la commission de glaciologie de l'Académie suisse des sciences naturelles avec le soutien de l'Hydrologie et de la Géologie nationale et de la Direction forestière fédérale. Ce groupe est dirigé par Dr. Daniel Vonder Mühll, collaborateur du Laboratoire de Recherches Hydrauliques, Hydrologiques et Glaciologiques de l'École Polytechnique Fédérale de Zurich et délégué pour le pergélisol de la commission glaciologique.

La Suisse est prête à assurer à long terme le maintien d'un réseau de surveillance du pergélisol. Les sondages concernant le financement et le soutien d'un tel système sont en cours. De plus, nous ferons état de nos activités dans le domaine de la surveillance du pergélisol dans le rapport suisse sur l'observation systématique du pergélisol qui sera soumis à la 8ème Conférence des Parties à la CCNUCC en novembre 2001.

Pour faciliter la communication dans ce domaine, j'ai le plaisir de vous informer que le Dr. Vonder Mühll à été désigné d'assurer la liaison pour les activités relatives au pergélisol. Les coordonnées du Dr. Vonder Mühll sont les suivantes :

Dr. Daniel Vonder Mühll
Versuchsanstalt für Wasserbau, Hydrologie und Glaziologie (VAW)
ETH Zürich
Gloriastrasse 37/39
8092 Zürich

Tél.: +41 1 632 41 13
Fax: +41 1 632 11 92
E-mail: vondermuehll@vaw.baug.ethz.ch

Sa nouvelle addresse dès le 1er novembre 2000 sera la suivante:

Dr. Daniel Vonder Mühll
Vizerektorat Forschung Universität Basel
Petersgraben 35
4003 Basel

Tél.: +41 61 267 30 29
Fax: +41 61 267 30 03
E-Mail: Daniel.VonderMuehll@unibas.ch

Dans cette fonction, le Dr. Vonder Mühll assumera également la coordination des activités sur le plan international.

Je vous prie d'agréer, Monsieur le Secrétaire général, les assurances de ma très haute considération.

DIVISION POLITIQUE V

p.o. Ivo Sieber

United States Department of the Interior

U.S. GEOLOGICAL SURVEY
Office of the Director
Reston, Virginia 20192

In Reply Refer To:
Mail Stop 906
#20000550

OCT 1 8 2000

Mr. G.O.P. Obasi
Secretary General
World Meteorological Organization
7 Bis, Avenue de la Paiz
CH-1211 Geneve 2
Switzerland

Dear Mr. Obasi:

Thank you for your letter dated August 31, 2000, (your reference 10.059/P/GTN-P) informing me about the Global Terrestrial Network for Permafrost (GTN-P) and its important role in the international Global Climate Observing System (GCOS) program.

I also want to thank you for recognizing the U.S. Geological Survey's (USGS) long-term support of borehole temperature measurements in Alaska. Your letter requested our continued support for these measurements, and I am pleased to inform you that the USGS considers its network of borehole temperature stations in Alaska to be an important component of the GCOS program and that we intend to continue to support it in the future.

Next year we plan a modest expansion of the USGS Alaska Climate-Monitoring network, which includes deep borehole temperatures, permafrost/active layer temperatures, air temperatures, reflected solar radiation, and some snow depth data. Gary Clow of the USGS in Denver will retrieve data from the network next summer and will make the data available on the internet and to the GCOS program soon thereafter. He will also expand the information about the USGS Alaskan borehole network that is presently available on the internet (http://climchange.cr.usgs.gov/data/bht/alaska/).

Gary Clow will continue to be the contact person for permafrost activities in our agency. His address and other contact information are:

Gary Clow
Earth Surface Processes Team
U.S. Geological Survey
Box 25046, MS980
Denver Federal Center
Denver, Colorado 80225-0046

Email: clow@usgs.gov
Phone: 303-236-5509
Fax: 303-236-5349

Thank you again for your interest in our climate monitoring activities in Alaska.

Sincerely,

Charles G. Groat
Director

0740

Rappresentanza Permanente d'Italia
presso le Organizzazioni Internazionali
10, Chemin du Tronchet
1209 Genève

The Permanent Mission of Italy to the International Organizations in Geneva presents its compliments to the World Meteorological Organization and with reference to the Secretary General's letter n. 10.059/P/GTN-P dated August 31, 2000 concerning the Global Terrestrial Network for Permafrost (GTN-P) has the honour to inform that the Italian Government has designated Prof. Francesco DRAMIS as contact person for the coordination of permafrost activities .

Prof. Francesco DRAMIS can be contacted at the following address:

Università Roma 3
Dip.to Scienze Geologiche
Largo S. Leonardo Murialdo 1
00146 ROMA
Tel/Fax 003906.54888022/003906.54888201
E.mail:dramis@uniroma3.it

The Permanent Mission of Italy avails itself of this opportunity to renew to the World Meteorological Organization the assurances of its highest consideration.

Geneva, 02 MARS 2001

World Meteorological Organization
GENEVA

Read WMO REGISTRY (2) - 7 MARS 2001
N° 47522 / P IGTN-P
ISC
Annexes: Filed:

Appendix C

Table of GTN-P candidate sites summary information

Description of select fields in the Table

Class = depth range, where DB = deep = >125 m,
IB = intermediate =25-125 m,
SH = shallow = 10-25 m
SU = surface = <10 m

Metadata = have metadata forms been submitted, Y = Yes, N = No

Category = site category according to level of data collection
1 = active
2 = nominated, identified but not presently active
3 = potential sites, not yet nominated

GHOST = Global Hierarchical Observing Strategy Level 1 to 5

Borehole Name	Depth metres	Class	Investigator(s)	lat deg	lat min	lat sec	N/S	long deg	long min	long sec	W/E	elev masl	pf-depth metres	metadata	Category	GHOST
Atigaru/ATI	648	DB	Gary Clow/Art Lachenbruch	70	33	22	N	151	43	1.85	W	2	405	N	1	
Awuna */AWUN	884	DB	Gary Clow/Art Lachenbruch	69	9	12	N	158	1	21.3	W	336	295	N	1	
Drew Point */DRP	640	DB	Gary Clow/Art Lachenbruch	70	52	47	N	153	53	59.9	W	5	324	N	1	
East Simpson 1/ESN	600	DB	Gary Clow/Art Lachenbruch	70	55	4	N	154	37	4.75	W	4	370	N	1	
East Teshepuk/ETK	727	DB	Gary Clow/Art Lachenbruch	70	34	12	N	152	56	36.9	W	2	262	N	1	
West Fish Ck 1*/FCK	735	DB	Gary Clow/Art Lachenbruch	70	19	36	N	152	3	38	W	27	268	N	1	
Ikpikpuk/IKP	615	DB	Gary Clow/Art Lachenbruch	70	27	20	N	154	19	52.8	W	10	347	N	1	
J.W. Dalton/JWD	483	DB	Gary Clow/Art Lachenbruch	70	55	14	N	153	8	15.1	W	6	411	N	1	
Kugrua/KAG	582	DB	Gary Clow/Art Lachenbruch	70	35	13	N	158	39	43.3	W	20	287	N	1	
Koluktak/KOL	227	DB	Gary Clow/Art Lachenbruch	69	45	8.6	N	154	36	40.1	W	56	>227	N	1	
Kuyanak/KUY	856	DB	Gary Clow/Art Lachenbruch	70	55	53	N	156	3	53.1	W	3	328	N	1	
Lisburne/LBN	532	DB	Gary Clow/Art Lachenbruch	68	29	5.4	N	155	41	35.5	W	559	295	N	1	
North Inigok/NING	625	DB	Gary Clow/Art Lachenbruch	70	15	27	N	152	45	57.5	W	41	294	N	1	
North Kalikpik/NKP	660	DB	Gary Clow/Art Lachenbruch	70	30	33	N	152	22	4.17	W	5	213	N	1	
Peard Bay/PEA	591	DB	Gary Clow/Art Lachenbruch	70	42	56	N	159	0	2.52	W	23	310	N	1	
Seabee */SBE	393	DB	Gary Clow/Art Lachenbruch	69	22	49	N	152	10	31.3	W	89	309	N	1	
South Meade/SME	549	DB	Gary Clow/Art Lachenbruch	70	36	54	N	156	53	23.6	W	12	201	N	1	
South Harrison/SOH	399	DB	Gary Clow/Art Lachenbruch	70	25	29	N	151	43	52.5	W	7	>399	N	1	
Tunalik */TLK	556	DB	Gary Clow/Art Lachenbruch	70	12	21	N	161	4	9.16	W	26	296	N	1	

Borehole Name	Depth metres	Class	Investigator(s)	lat deg	lat min	lat sec	N/S	long deg	long min	long sec	W/E	elev masl	pf-depth metres	metad ata	Category	GHOST
Tulageak/TUL	756	DB	Gary Clow/Art Lachenbruch	71	11	22	N	155	44	0.82	W	3	304	N	1	
West Dease/WDS	823	DB	Gary Clow/Art Lachenbruch	71	9	33	N	155	37	45.2	W	2	282	N	1	
West Dock 1 *	56	IB	Tom Osterkamp/Vlad Romanovsky	70	23		N	148	33		W	3		N	1	1
Deadhorse *	60	IB	Tom Osterkamp/Vlad Romanovsky	70	10		N	148	28		W	17		N	1	1
Franklin Bluff *	60	IB	Tom Osterkamp/Vlad Romanovsky	69	41		N	148	44		W	88		N	1	1
Happy Valley 1 *	40	IB	Tom Osterkamp/Vlad Romanovsky	69	10		N	148	50		W			N	1	1
Galbraith Lake *	75	IB	Tom Osterkamp/Vlad Romanovsky	68	29		N	149	30		W	823		N	1	1
Chandalar Shelf *	61	IB	Tom Osterkamp/Vlad Romanovsky	68	4		N	149	35		W	976		N	1	1
Old Man *	63	IB	Tom Osterkamp/Vlad Romanovsky	68	27		N	150	37		W			N	1	1
Coldfoot		IB	Tom Osterkamp/Vlad Romanovsky	67	14		N	150	10		W			N	1	1
Yukon Bridge	60	IB	Tom Osterkamp/Vlad Romanovsky	65	53		N	149	44		W	122		N	1	1
Livengood	42	IB	Tom Osterkamp/Vlad Romanovsky	65	31		N	148	36		W	214		N	1	1
College Peat		IB	Tom Osterkamp/Vlad Romanovsky	64	52		N	147	45		W			N	1	1

Borehole Name	Depth metres	Class	Investigator(s)	lat deg	lat min	lat sec	N/S	long deg	long min	long sec	W/E	elev masl	pf-depth metres	metad ata	Category	GHOST
Bonanza *	43.5	IB	Tom Osterkamp/Vlad Romanovsky	64	45		N	148	0		W			N	1	1
Birch Lake		IB	Tom Osterkamp/Vlad Romanovsky	64	15		N	146	15		W			N	1	1
Eagle		IB	Tom Osterkamp/Vlad Romanovsky	64	5		N	141	15		W			N	1	1
Donnelly		IB	Tom Osterkamp/Vlad Romanovsky	63	45		N	145	50		W			N	1	1
Gulkana	59	IB	Tom Osterkamp/Vlad Romanovsky	62	15		N	145	30		W			N	1	1
Kotzebue		IB	Tom Osterkamp/Vlad Romanovsky	66	55		N	162	10		W			N	3?	1
Nome (TBA)		IB	Tom Osterkamp/Vlad Romanovsky											N	3?	
Healy (TBA)		IB	Tom Osterkamp/Vlad Romanovsky											N	3?	
Bethel TBA)		IB	Tom Osterkamp/Vlad Romanovsky											N	3?	
Glennellen (TBA)		IB	Tom Osterkamp/Vlad Romanovsky											N	3?	
ANWR (TBA)		IB	Tom Osterkamp/Vlad Romanovsky											N	3?	
Franklin Bluffs	10	SH	Doug Kane/Larry Hinzman	69	50		N	148	45		W			N	1	
Sagwon	10	SH	Doug Kane/Larry Hinzman	69	25		N	148	45		W			N	1	

Borehole Name	Depth metres	Class	Investigator(s)	lat deg	lat min	lat sec	N/S	long deg	long min	long sec	W/E	elev masl	pf-depth metres	metad ata	Category	GHOST
Imnavait *	8.5	SU	Doug Kane/Larry Hinzman	68	37	26	N	148	19	1	W	ridge		N	1	
Imnavait	8.5	SU	Doug Kane/Larry Hinzman	68	37	26	N	148	17	1	W	valley		N	1	
Caribou-Poker/T1	10.8	SH	K Yoshikawa/Larry Hinzman	65	9		N	147	29	20	W	215	>11	N	1	2?
Caribou-Poker/MD	33	IB	K Yoshikawa/Larry Hinzman	65	10	27	N	147	31	2	W	314	3?	N	1	2?
Caribou-Poker/C4	30	IB	K Yoshikawa/Larry Hinzman	65	9	52	N	147	30	6	W	258	22-24	Y	1	2?
Caribou-Poker/TJ	24.5	SH	K Yoshikawa/Larry Hinzman	65	9	21	N	147	29	34	W	234	>25	N	1	2?
Caribou-Poker/CMET	14.7	SH	K Yoshikawa/Larry Hinzman	65	9	12	N	147	29	18	W	225	>15	N	1	2?
Caribou-Poker/CONF	19.8	SH	K Yoshikawa/Larry Hinzman	65	9	12	N	147	29	18	W	217	>20	N	1	2?
Antarctic	>282	DB	Gary Clow	77	35		S	163	25		E	20	>282	N	1	
Antarctic	19	SH	Ron Sletten/David Gilichinsky											N		
Simpson Crags	8	SU	Mauro Guglielmin	74	34	0	S	162	45	30	E			N		
Boulder Clay	3.6	SU	Mauro Guglielmin	74	44	45	S	164	1	17	E			N		
M. Keinath	1	SU	Mauro Guglielmin	74	33	30	S	164	0	10	E			N		
Marble Point	1.2	SU	Campbell/Paetzold	77	25		S	163	40.9		E?	60	unknown	Y	1	
Bull Pass	1.2	SU	Campbell/Paetzold	77	31		S	163	51.9		E?	150		Y	1	
Scott Base	1.2	SU	Campbell/Paetzold	77	51		S	166	45.5		E?	80	unknown	Y	1	
El BalcUn I, Morenas Coloradas Rock Glacier	5	SU	D Trombotto	32	58	42	S	69	21	14	W	3560	na	Y	2	
Involuted Hill/IH88-1	35	IB	Mark Nixon	69	28	22	N	132	37	37	W	25		Y	1	1
Involuted Hill/IH88-2	35	IB	Mark Nixon	69	28	25	N	132	37	51	W	14		Y	1	1
Taglu */C4	30	IB	Mark Nixon	69	22	9	N	134	56	55	W	2		Y	1	1

Borehole Name	Depth metres	Class	Investigator(s)	lat deg	lat min	lat sec	N/S	long deg	long min	long sec	W/E	elev masl	pf-depth metres	metad ata	Category	GHOST
Lousy Point */C5	30	IB	Mark Nixon	69	13	0	N	134	17	5	W	40		Y	1	1
Lousy 1/91GSC6	30	IB	Mark Nixon	69	14	27	N	134	26	27	W	50		Y	1	1
Lousy 8/91GSC13	30	IB	Mark Nixon	69	13	6	N	134	17	6	W	40		Y	1	1
Swimming Pt1/91GSC1	30	IB	Mark Nixon	69	6	30	N	134	23	56	W	8		Y	1	1
Swimming Pt2/91GSC2	30	IB	Mark Nixon	69	6	35	N	134	22	50	W	3		Y	1	1
Swimming Pt5/91GSC5	25	SH	Mark Nixon	69	6	31	N	134	20	53	W	11		Y	1	1
Lousy 5/91GSC10	30	IB	Mark Nixon	69	13	45	N	134	20	58	W	25		Y	1	1
Lousy 10/91GSC12	30	IB	Mark Nixon	69	12	58	N	134	17	40	W	16		Y	1	1
YaYa Lake/90SI1	18	SH	Mark Nixon	69	8	44	N	134	42	45	W	40		Y	1	1
Fort Simpson/FS deep	20	SH	Mark Nixon	61	50	15	N	121	20	0	W	175		Y	1	1
Liard spruce/97TC4	10	SH	Mark Nixon	61	32	42	N	121	23	30	W	180		Y	1	1
Wrigley trans/97TC5	10	SH	Mark Nixon	61	58		N	121	53		W	165		Y	1	1
Liard shrub/97TC3	10	SH	Mark Nixon	61	32	42	N	121	23	30	W	180		Y	1	1
Pump Station 1/T4/84-1	13.6	SH	Margo Burgess	65	17	23	N	126	53	10	W	61	55	Y	1	1
Canyon Creek 2A/HT/84-2A	128	DB	Margo Burgess	65	14	0	N	126	31	21	W	123	33	Y	1	1
Canyon Creek 2A/T4/84-2A	13	SH	Margo Burgess	65	14	0	N	126	31	21	W	123	33	Y	1	1
Canyon Creek North Slope - T4/84-2B	21	SH	Margo Burgess	65	13	56	N	126	31	14	W	110	30	Y	1	1
Canyon Creek South Slope - T4/84-2C	21	SH	Margo Burgess	65	13	51	N	126	30	49	W	119	53	Y	1	1
Great Bear River B -T4/84-3B	20	SH	Margo Burgess	65	54	44	N	125	34	45	W	93	57	Y	1	1
Table Mountain A/HA/85-7A	93	IB	Margo Burgess	63	36	43	N	123	38	31	W	255	40	Y	1	1
Table Mountain A/T4/85-7A	20	SH	Margo Burgess	63	36	43	N	123	38	31	W	255	40	Y	1	1
Table Mountain B/T4/85-7B	20	SH	Margo Burgess	63	36	34	N	123	37	52	W	265	70	Y	1	1
Table Mountain B/T5/85-7B	20	SH	Margo Burgess	63	36	34	N	123	37	52	W	265	70	Y	1	1
Table Mountain C/T4/85-7C	20	SH	Margo Burgess	63	36	24	N	123	37	47	W	259	50	Y	1	1
Table Mountain C/T5/85-7C	20	SH	Margo Burgess	63	36	24	N	123	37	47	W	259	50	Y	1	1
Manner's Creek A/T4/85-8A	20	SH	Margo Burgess	61	36	18	N	121	5	33	W	191	12	Y	1	1
Manner's Creek B/T4/85-8B	20	SH	Margo Burgess	61	36	9	N	121	5	27	W	190	4	Y	2	1

Borehole Name	Depth metres	Class	Investigator(s)	lat deg	lat min	lat sec	N/S	long deg	long min	long sec	W/E	elev masl	pf-depth metres	metadata	Category	GHOST
Mackenzie Hwy S/T4/85-10B	10.5	SH	Margo Burgess	61	21	15	N	120	51	53	W	244	2	Y	1	1
Jean Marie Ck B/T4/85-12B	16	SH	Margo Burgess	61	11	29	N	120	42	21	W	300	3.9	Y	1	1
Petitot River N. A/T4/84-5A	21	SH	Margo Burgess	59	45	30	N	119	30	59	W	552	17	Y	1	1
Petitot River N. B/T4/84-5B	21	SH	Margo Burgess	59	45	25	N	119	30	47	W	552	13.5	Y	1	1
Petitot River S/T4/84-6	21	SH	Margo Burgess	59	27	41	N	119	14	46	W	575	6	Y	1	1
Kee Scarp	128	DB	Margo Burgess	65	18	6	N	126	43	8	W	365	UF	Y	1	1
Gibson Gap	100	DB	Margo Burgess	65	46	0	N	127	55	0	W	229		Y	1	1
KP2 - offrow	4	SU	Margo Burgess	65	17	54	N	126	50	45	W	63		Y	1	1
KP5 - offrow	4	SU	Margo Burgess	65	17	20	N	126	47	17	W	65		Y	1	1
KP182 - offrow	2	SU	Margo Burgess	64	16	46	N	124	28	1	W	140		Y	1	1
Gemini E-10	876	DB	Margo Burgess	79	59		N	84	4.2		W	126	501	Y	1	3
Pat Bay A-72	488	DB	Margo Burgess	77	21		N	105	27		W	17	>300	Y	1	3
Marryatt K-71	1028	DB	Margo Burgess	76	21		N	108	58.4		W	80	354	Y	2	3
Alert 1	60.96	IB	Margo Burgess	82	30		N	62	25		W	15	>600	Y	1	2?
Alert 2	60.96	IB	Margo Burgess	82	30		N	62	25		W	90	>600	Y	1	2?
Alert 3	57.3	IB	Margo Burgess	82	30		N	62	25		W	168	>600	Y	1	2?
Alert 4	15.24	SH	Margo Burgess	82	30		N	62	25		W	60	>600	Y	1	2?
Alert 5	15.24	SH	Margo Burgess	82	30		N	62	25		W	75	>600	Y	1	2?
Fox Lake	6.3	SU	Stu Harris	61	10	8.5	N	135	23	4	W	800		N		
MacMillan Pass	5	SU	Stu Harris	63	13	5	N	130	35		W	1175		N		
Marmot Basin	17.1	SH	Stu Harris	52	47	53	N	118	6	58	W	2195		Y	1	
Plateau Mountain	30	IB	Stu Harris	50	15	3	N	114	31	9	W	2286		N		
Sheldon Lake	2.6	SU	Stu Harris	62	37		N	132	15		W	890		N		
Summit Lake A	2.5	SU	Stu Harris	58	38		N	124	38		W	1524		N		
Tuchitua km 161	4.4	SU	Stu Harris	61	19	1.4	N	129	36	11	W	1220		N		
Sulphur Lake	3.5	SU	Stu Harris	60	57		N	137	59		W	852		N		
Aupaluk/HT289	20	SH	Michel Allard	58	18		N	69	36		W			N		
Akulivak/HT230	20	SH	Michel Allard	60	48		N	78	12		W			N		
George River	20	SH	Michel Allard	58	43		N	65	58		W			N		
Manitounuk	16	SH	Michel Allard	55	36		N	77	13		W			N		
Petite Riviere/PBA	20	SH	Michel Allard	55	52		N	76	10		W			N		

Borehole Name	Depth metres	Class	Investigator(s)	lat deg	lat min	lat sec	N/S	long deg	long min	long sec	W/E	elev masl	pf-depth metres	metad ata	Category	GHOST
Povungnituk/HT177	20	SH	Michel Allard	60	2		N	77	16		W			N		
Quaqtaq/HT156	20	SH	Michel Allard	61	2		N	69	37		W			N		
Salluit/HT154	20	SH	Michel Allard	62	14		N	75	38		W			N		
Tasiujaq/HT157	20	SH	Michel Allard	58	42		N	69	56		W			N		
Umiujaq/HT174	20	SH	Michel Allard	56	30		N	76	32		W			N		
Wakeham/HT159	20	SH	Michel Allard	61	31		N	71	56		W			N		
Old Crow	60	IB	Richard Trimble EBA	67	34	10	N	139	50	22	W	251		N		
Pangnirtung Res.	13	SH	J.A. Hyatt	66	9		N	65	45		W	60		N		
Baker Lake	3	SU	Josef Svoboda/Burgess	64	10		N	95	30		W			Y	1	2
Mayo	20	SH	Chris Burn	63	37		N	135	52		W	504		N	1	
Pump Station 3 85-9-T4	20	SH	M. Burgess	61	23	50	N	120	54	15	W	223	UF	Y	1	1
Trail River 84-4A-T2 (off row)	20	SH	M. Burgess	62	4	12	N	121	59	14	W	153	UF	Y	1	1
Jean Marie Ck A 85-12A-T4	12	SH	M. Burgess	61	11	33	N	120	42	24	W	298	UF	Y	1	1
Moraine South 85-11-T4	12	SH	M. Burgess	61	16	56	N	120	48	4	W	251	UF	Y	1	1
Yitulihe *		IB	Liu Futao	50	56		N	121	20		E			N	1	
Fenghuoshan *	40	IB	Zhao Lin	34	20		N	92	54		E	4780		N	1	
Fenghuoshan P.	18	SH	Wang Shaoling									5031		N		
West QTP/Tianshuihai	57	IB	Wang Shaoling	35	6		N	79	6		E	5000		N		
Qingshuihe R. QTH/HMS68	203	DB	Li Shuxun	33	48		N	97	8		E	4415		N		
Buddongquan/HMS66	18	SH	Li Shuxun	34	50		N	92	42		E	4450		N		
CK123-4	20	SH	Zhao Lin	31	55		N	91	8		E			N		
Liangdaohe/CK123-7	60	IB	Zhao Lin	31	55		N	91	8		E	4760		N		
North limit QTH,Xidatan	30	IB	Zhao Lin	35	44		N	94	15		E	4420		N		
Kunlun Pass	30	IB	Zhao Lin	35	45		N	94	12		E	4760		N		
Urumuqi River	59	IB	Ye Baisheng/Zhao Lin	43	6		N	86	9		E	33-3900		N		
South limit QTP,JingXianGu	30	IB	Li Shuxun	36	17		N	94	1		E	4480		N		
East limit QTP,Huashixia	40	IB	Li Dongqing	35	39		N	98	48		E	4300		N		
Daxinganlin Mts./Amue,Mohe	60	IB	Liu Futao	52	30		N	122	12		E	600		N		
Kuixian Pass	60	IB	Zhao Lin	42	57		N	86	6		E	3270		N		

Borehole Name	Depth metres	Class	Investigator(s)	lat deg	lat min	lat sec	N/S	long deg	long min	long sec	W/E	elev masl	pf-depth metres	metad ata	Category	GHOST
Greenland/Ice core	>3048	DB	Gary Clow	72	34	34	N	38	27	51.7	W	3205	>3048	N	1	
La Foppa RG *	3	SU	Mauro Guglielmin	46	29		N	10	11		E			N		
Foscagno	6	SU	Frncesco Dramis/M. Guglielmin	46	28		N	10	13		E	2520		N		
PACE/Stelvio Pass	100.3	IB	Frncesco Dramis/M. Guglielmin	46	30	59	N	10	28	35	E	3000		Y	1	1
N. Tien Shan *	14	SH	S. Marchnenko	43	5		N	76	55		E	3328	20	Y	1	
N. Tien Shan #1	25	SH	S. Marchnenko	43	5		N	76	55		E	3337	30	Y	1	
N. Tien Shan/M72	70	IB	S. Marchnenko	43	5		N	76	55		E	3330	85-90	Y	1	
Tien Shan 46K	230	DB	S. Marchnenko	41	50		N	78	10		E	4090	250	Y	1	
Baganuur depression (Lake Bank)	15	SH	N. Sharkhuu/UBN12	47	41	20	N	108	15	45	E	1345	13.4	Y	1	
Baganuur depression (plain)	21	SH	N. Sharkhuu/UBN142	47	41	40	N	108	17	40	E	1350	30	Y	1	
Nalaikh depression (north slope)	50	IB	N. SharkhuuNAN524	47	45	16	N	107	15		E	1512	37	Y	1	
Nalaikh depression (north slope)	10	SU	N. Sharkhuu	47	45	16	N	107	15		E	1512	37	Y	1	
Nalaikh depression (pingo)	8	SU	N. Sharkhuu/NAN07	47	46	35	N	107	20	18	E	1400	50-60	Y	1	
Nalaikh depression (south western slope)	10	SH	N. Sharkhuu	47	46	15	N	107	17	15	E	1441	16.7	Y	1	
Argalant Valley	12	SH	N. Sharkhuu/ARGN06	47	55	25	N	106	32	50	E	1385	13.5	Y	1	
Burenkhan Mt.	50	IB	N. Sharkhuu/BUNO1	49	47	18	N	100	1	50	E	1705	52	Y	1	
Ardag Mountain (slope)	60	IB	N. Sharkhuu/ARDN2	50	37	30	N	100	50	5	E	1845	29.5	Y	1	
Ardag Mountain (watershed)	60	IB	N. Sharkhuu/ARDN37	50	39	20	N	100	49	30	E	2058	240	Y	1	
Terkh River Valley	2.5	SU	N. Sharkhuu/TERN	48	5		N	99	23		E	2080	105	N	1	
Cnuluut River Valley	2.5	SU	N. Sharkhuu/CNUN	48	4		N	100	22		E	1860	36	N	1	
Nalaikh Depression (SE slope)	30	IB	N. Sharkhuu	47	46	22	N	107	17	13	E	1439	27	Y	1	

Borehole Name	Depth metres	Class	Investigator(s)	lat deg	lat min	lat sec	N/S	long deg	long min	long sec	W/E	elev masl	pf-depth metres	metadata	Category	GHOST
PACE/Juvvasshoe 1	129	DB	Bernd Etzelmuller/K. Isaksen	61	40	32	N	8	22	4	E	1894		Y	1	1
PACE/Juvvasshoe 2	20	SH	Bernd Etzelmuller/K. Isaksen	61	40	32	N	8	22	4	E	1894		Y	1	1
Yukechi 1	40	IB	Masami Fukuda, Japan	61	45	40	N	130	28	20	E	202		N		
Yukechi 2	40	IB	Masami Fukuda, Japan	61	45	40	N	130	28	20	E	201		N		
Yukechi 3	20	SH	Masami Fukuda, Japan	61	45	40	N	130	28	20	E	202		N		
Umaibit 1	20	SH	Masami Fukuda, Japan	61	28	17	N	128	49	51	E	181		N		
Umaibit 2	20	SH	Masami Fukuda, Japan	61	28	17	N	128	49	51	E	181		N		
Spasskaya Pad 1	20	SH	M. Fukuda/Fedorov/P.Y. Konstaninov	62	15	15	N	129	37	5	E	211		N		
Spasskaya Pad 2	20	SH	M. Fukuda/Fedorov/P.Y. Konstaninov	62	15	15	N	129	37	5	E	213		N		
Silgilir	340	DB	V.T.Babobaev/V.G. Rusakov	60	37	3	N	128	10	0	E	443		N		
Uluu	251	DB	V.T.Babobaev/V.G. Rusakov	60	20	13	N	127	27	15	E	401	720	N		
V.Amga	495	DB	V.T.Babobaev/V.G. Rusakov	59	39	30	N	127	5	10	E	289		N		
Namsi	510	DB	V.T.Babobaev/V.G. Rusakov	62	53	20	N	129	33	9	E	84	490	N		
K-Kunku	19	SH	V.T.Babobaev/V.G. Rusakov	59	47	5	N	127	15	20	E	422		N		
Kirbikan	30	IB	V.T.Babobaev/V.G. Rusakov	60	11	30	N	127	17	35	E	427		N		
Kitil	200	DB	V.T.Babobaev/V.G. Rusakov	63	17	12	N	129	32	17	E	81		N		
Lyutenga	100	IB	V.T.Babobaev/V.G. Rusakov	61	0	47	N	128	53	25	E	293		N		
Kirzavod	500	DB	V.T.Babobaev/V.G. Rusakov	62	2	7	N	129	43	19	E	118	250	N		

Borehole Name	Depth metres	Class	Investigator(s)	lat deg	lat min	lat sec	N/S	long deg	long min	long sec	W/E	elev masl	pf-depth metres	metad ata	Category	GHOST
Vladimir	590	DB	V.T.Babobaev/V.G. Rusakov	61	54	30	N	129	24	0	E	243	520	N		
Kenkeme	500	DB	V.T.Babobaev/V.G. Rusakov	62	5	5	N	129	0	10	E	220	390	N		
Tiksi	30	IB	V.T.Babobaev/V.G. Rusakov	71	35	7	N	128	55	10	E	43		N		
Yakutsk 1	70	IB	V.T.Babobaev/V.G. Rusakov	62	1	9	N	129	43	20	E	99		N		
Tabaga	28	IB	V.T.Babobaev/V.G. Rusakov	61	46	10	N	129	36	20	E	228		N		
Tyungyulyu	540	DB	V.T.Babobaev/V.G. Rusakov	62	9	25	N	130	40	10	E	137	470	N		
Tehtyur	260	DB	V.T.Babobaev/V.G. Rusakov	62	3	49	N	130	2	15	E	90		N		
Ugol.Kopi	170	DB	V.T.Babobaev/V.G. Rusakov	64	45	27	N	177	40	15	E	25	160	N		
Yakutsk 2/69(95)	21	SH	P.N.Skryabin/S.P. Varlamov/Y.B. Skachkov	62	1	9	N	129	43	19	E	105	350	Y	1	
Chabyda 8/82	30	IB	P.N.Skryabin/S.P. Varlamov/Y.B. Skachkov	61	55	40	N	129	26	40	E	205	400	Y	1	
Tamma 11/87	11	SH	P.N.Skryabin/S.P. Varlamov/Y.B. Skachkov	61	42	0	N	129	50	0	E	97		Y	1	
Tamma 12/87	12	SH	P.N.Skryabin/S.P. Varlamov/Y.B. Skachkov	61	42	0	N	129	50	0	E	98		Y	1	
Bes-Kyuel 59/87	24	SH	P.N.Skryabin/S.P. Varlamov/Y.B. Skachkov	61	20	0	N	129	18	20	E	194	4	Y	1	
Taryng 57/87	11	SH	P.N.Skryabin/S.P. Varlamov/Y.B. Skachkov	61	16	20	N	129	18	30	E	193		Y	1	
VerhnyaLutenga 11/95	11	SH	P.N.Skryabin/S.P. Varlamov/Y.B. Skachkov	60	55	40	N	128	50	0	E	430		Y	1	
Kuropatochya R. *	15	SH	David Gilichinsky	70	55		N	156	38		E	15		N	1	

Borehole Name	Depth metres	Class	Investigator(s)	lat deg	lat min	lat sec	N/S	long deg	long min	long sec	W/E	elev masl	pf-depth metres	metad ata	Category	GHOST
Cape Chukochii *	30	IB	David Gilichinsky	70	5		N	159	59		E			N	1	
Chukochya R *	25	IB	David Gilichinsky	69	10		N	158	4		E	35		N	1	
Konkovaya R *	50	IB	David Gilichinsky	69	5		N	158	6		E	7		N	1	
Lake Akhmelo *	15	SH	David Gilichinsky	68	50		N	161	1.5		E	10		N	1	
Alazeya *	23	IB	David Gilichinsky	68	19		N	154	58.4		E	60		N	1	
Nadym *	10	SH	E.S. Melnikov/11/23	65	18		N	72	49		E	25		N	1	
Nadym	10	SH	E.S. Melnikov/1/18	65	17		N	72	46		E	25		N		
Vachiny Dachy *	10	SH	Marina Leibman/178/191	70	17	10	N	65	54		E	25-33		N	1	
Sutorma 2C	300	DB	Melnikov/An											N	1	
Lek-Vorkuta	100	IB	N. Oberman/N. Kakunov	67	24		N	63	23		E			N		
Rogovsky	20	SH	N. Oberman/N. Kakunov	67	18		N	62	17		E			N		
Korotaikha	20	SH	N. Oberman/N. Kakunov	68	17		N	62	45		E			N		
Vashutkin-Sarrmbo	15	SH	N. Oberman/N. Kakunov	67	58		N	61	30		E			N		
Sherniadeitin	15	SH	N. Oberman/N. Kakunov	67	23		N	61	14		E			N		
Lemva-Kokpel	15	SH	N. Oberman/N. Kakunov	66	15		N	62	10		E			N		
Hamburtsevsky	600	DB	N. Oberman/N. Kakunov	67	46		N	60	30		E			N		
Usinsk	15	SH	N. Oberman/N. Kakunov	66	3		N	57	25		E			N		
Vosei	15	SH	N. Oberman/N. Kakunov	66	34		N	56	55		E			N		
Buriadan	225	DB	N. Oberman/N. Kakunov	68	28		N	65	4		E			N		
Liadgei	15	SH	N. Oberman/N. Kakunov	68	16		N	65	48		E	150		N		
Tumbolovsky	15	SH	N. Oberman/N. Kakunov	66	8		N	62	50		E			N		
Pachvoch	100/200	DB	N. Oberman/N. Kakunov	65	33		N	61	6		E	500		N		

Borehole Name	Depth metres	Class	Investigator(s)	lat deg	lat min	lat sec	N/S	long deg	long min	long sec	W/E	elev masl	pf-depth metres	metadata	Category	GHOST
Nydysei-Pelingich	350	DB	N. Oberman/N. Kakunov	65	13		N	60	1		E			N		
Oberman 1 UP33	130	DB	I. Derevyanko/N. Kakunov	67	24		N	64	29		E	145	200	Y	1	
Oberman 2 UP34	90.2	IB	I. Derevyanko/N. Kakunov	67	25		N	64	30		E	150	0	Y	1	
Oberman 3 UK-289	105.4	IB	I. Derevyanko/N. Kakunov	67	33		N	64	12		E	214		Y	1	
Oberman 4 PK-3711	691	DB	I. Derevyanko/N. Kakunov	67	58		N	64	48		E	213	170	Y	2	
Oberman 5 ZC-14/227	90.2	IB	I. Derevyanko/N. Kakunov	67	25		N	64	30		E	150	0	Y	1	
Oberman 6 3C-65	25.2	IB	I. Derevyanko/N. Kakunov	67	23		N	63	20		E	192	20.6 to 23.5	Y	1	
Oberman 7 3C-124/124 A	31.2	IB	I. Derevyanko/N. Kakunov	67	24		N	63	23		E	155	70	Y	1	
Oberman 8 DC-4/VI-74g	25	SH	I. Derevyanko/N. Kakunov	67	23	83	N	63	22	54	E	154	70	Y	1	
Oberman 9 EK-67	150	DB	I. Derevyanko/N. Kakunov	67	23		N	63	20		E	194	44	Y	1	
Oberman 10 BK-1615	200.8	DB	I. Derevyanko/N. Kakunov	67	28		N	63	21		E	205	70	Y	1	
Oberman 11 P-9	28	IB	I. Derevyanko/N. Kakunov	67	20		N	52	21		E	86.6	0	Y	2	
Oberman 12 P-10	42.2	IB	I. Derevyanko/N. Kakunov	67	20		N	62	20		E	89.6	100	Y	2	
Oberman 13 P-53A	17.3	SH	I. Derevyanko/N. Kakunov	67	20		N	62	22		E	81.1	90	Y	2	
Oberman 14 P-57	16.6	SH	I. Derevyanko/N. Kakunov	67	19		N	62	24		E	91.4	100	Y	2	
Oberman 15 P-60	19.2	SH	I. Derevyanko/N. Kakunov	67	21		N	62	22		E	88.6	30	Y	2	
Oberman 16 KT-3B	25.6	IB	I. Derevyanko/N. Kakunov	68	17		N	62	33		E	20.6	350	Y	2	
Oberman 17 KT-6	25	SH	I. Derevyanko/N. Kakunov	68	15		N	62	29		E	53.5	350	Y	2	
Oberman 18 KT-12	23.5	SH	I. Derevyanko/N. Kakunov	68	15		N	62	28		E	51.1	300 to 350	Y	2	

Borehole Name	Depth metres	Class	Investigator(s)	lat deg	lat min	lat sec	N/S	long deg	long min	long sec	W/E	elev masl	pf-depth metres	metad ata	Category	GHOST
Oberman 19 K-2	16.35	SH	I. Derevyanko/N. Kakunov	69	14		N	64	56		E	4	750	Y	2	
Oberman 20 K-19	13.25	SH	I. Derevyanko/N. Kakunov	69	14	45	N	64	55	40	E	6.74	750	Y	2	
Oberman 21 15	250	DB	I. Derevyanko/N. Oberman	69	5		N	63	5		E	215	700	Y	2	
Oberman 22 16	276	DB	I. Derevyanko/N. Oberman	69	5		N	63	5		E	213	700	Y	2	
Oberman 23 C-14	188	DB	I. Derevyanko/N. Oberman	68	27		N	64	37		E	166	550	Y	2	
Oberman 24 C-17	280	DB	I. Derevyanko/N. Oberman	68	28		N	64	40		E	151	550	Y	2	
Oberman 25 C-143	463	DB	I. Derevyanko/N. Oberman	68	1		N	66	35		E	314	586	Y	2	
Oberman 26 C-164	297.8	DB	I. Derevyanko/N. Oberman	68	2		N	66	34		E	358	550	Y	2	
Oberman 27 C-267	690	DB	I. Derevyanko/N. Oberman	68	1		N	66	36		E	374	684	Y	2	
Oberman 28 3	10.6	SH	I. Derevyanko/N. Oberman	67	50		N	66	45		E	87.5	500	Y	2	
Oberman 29 8	14.5	SH	I. Derevyanko/N. Oberman	67	50		N	66	46		E	96	500	Y	2	
Oberman 30 12	13.5	SH	I. Derevyanko/N. Oberman	67	50		N	66	39		E	109	500	Y	2	
Oberman 31 13	11.6	SH	I. Derevyanko/N. Oberman	67	50		N	66	48		E	80.6	500	Y	2	
Oberman 32 EK-102	28	IB	I. Derevyanko/N. Oberman	67	19		N	65	34		E	260	300-400	Y	2	
Oberman 33 116	38	IB	I. Derevyanko/N. Oberman	67	19		N	65	34		E	257	300-400	Y	2	
Oberman 34 41	300	DB	I. Derevyanko/N. Oberman	66	49		N	64	23		E	929	600	Y	2	
Oberman 35 95	15	SH	I. Derevyanko/N. Oberman	66	5		N	62	52		E	383	unknown	Y	2	
Oberman 36 100	7	SU	I. Derevyanko/N. Oberman	66	5		N	62	52		E	381	6.5	Y	2	
Oberman 37 6	14.1	SH	I. Derevyanko/N. Oberman	66	26		N	61	4		E	422	200-300	Y	2	

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Oberman 38 PV-72	516	DB	I. Derevyanko/N. Oberman	65	33		N	61	7		E	358		Y	2	
Oberman 39 PV-94	327	DB	I. Derevyanko/N. Oberman	65	34		N	61	7		E	367	unknown	Y	2	
Oberman 40 KCK-11	421	DB	I. Derevyanko/N. Oberman	65	15		N	59	44		E	508	0	Y	1	
Oberman 41 3G	572	DB	I. Derevyanko/N. Oberman	65	12		N	60	15		E	660	40	Y	1	
Oberman 42 202	141	DB	I. Derevyanko/N. Oberman	65	13		N	60	13		E	1187	500	Y	1	
Oberman 43 210	102	IB	I. Derevyanko/N. Oberman	65	14		N	60	13		E	1179	500	Y	1	
Oberman 44 13	12.7	SH	I. Derevyanko/N. Oberman	66	18		N	61	54		E	89.5	8.5	Y	2	
Oberman 45 15	15.8	SH	I. Derevyanko/N. Oberman	66	18		N	61	56		E	90	40-50	Y	2	
Oberman 46 72	13	SH	I. Derevyanko/N. Oberman	66	12		N	62	24		E	138	13	Y	2	
Oberman 47 33	17	SH	I. Derevyanko/N. Oberman	67	58		N	61	30		E	159	500	Y	2	
Oberman 48 45	16	SH	I. Derevyanko/N. Oberman	67	58		N	61	34		E	156	500	Y	2	
Oberman 49 51	14	SH	I. Derevyanko/N. Oberman	67	56		N	61	40		E	186	500	Y	2	
Oberman 50 62	16.5	SH	I. Derevyanko/N. Oberman	67	57		N	61	26		E	131	500	Y	2	
Oberman 51 100	15.9	SH	I. Derevyanko/N. Oberman	67	57		N	61	31		E	154	500	Y	2	
Oberman 52 BGK-1	510	DB	I. Derevyanko/N. Oberman	67	24		N	60	34		E	120	500	Y	2	
Oberman 53 BGK-7	600	DB	I. Derevyanko/N. Oberman	67	44		N	60	26		E	123	515	Y	2	
Oberman 54 1023	520	DB	I. Derevyanko/V. Maligin	66	27		N	57	11		E	47.7	135-165	Y	2	
Oberman 55 102	480	DB	I. Derevyanko/V. Maligin	66	5	40	N	57	59		E	100	290-393	Y	2	
XBO-1	11	SH	Y Kronik	67	50		N	86	20		E	59.6	20-30	Y	2	
XBO-2	12	SH	Y Kronik	67	49		N	86	20		E	62.8	30-40	Y	2	

Borehole Name	Depth metres	Class	Investigator(s)	lat deg	lat min	lat sec	N/S	long deg	long min	long sec	W/E	elev masl	pf-depth metres	metad ata	Category	GHOST
TRB1, #1-6	15-25	SH	V Kondratiev	56	50		N	118	10		E	670	475	Y	2	
TRB2, #1-3	10	SH	V Kondratiev	56	50		N	118	30		E	860	130	Y	2	
TRB3, #1-5	11	SH	V Kondratiev	52	2		N	113	40		E	660	25	Y	1	
TRB4, #1-3	10-25	SH	V Kondratiev	50	56		N	114	51		E		21	Y	2	
0	88	IB	A Vasiliev	69	0		N	139	19		E	491	>250	Y	2	
08	96	IB	A Vasiliev	69	0		N	139	20		E	496	>250	Y	2	
8	80	IB	A Vasiliev	69	1		N	139	20		E	506	>505.7	Y	2	
16	82	IB	A Vasiliev	69	0		N	139	19		E	488	>250	Y	2	
24	198	DB	A Vasiliev	69	1		N	139	15		E	460	>250	Y	2	
26	60	IB	A Vasiliev	69	1		N	139	18		E	484	>250	Y	2	
40	200	DB	A Vasiliev	68	59		N	139	20		E	426	>250	Y	2	
120	200	DB	A Vasiliev	68	59		N	139	18		E	421	>250	Y	2	
200	200	DB	A Vasiliev	68	59		N	139	17		E	422	>250	Y	2	
90	60	IB	A Vasiliev	70	38		N	134	9		E	86	>150	Y	2	
97	201.5	DB	A Vasiliev	70	39		N	134	15		E	189	>200	Y	2	
146	142.2	DB	A Vasiliev	70	37		N	134	21		E	145	>200	Y	2	
148	200	DB	A Vasiliev	70	36		N	134	21		E	145	>200	Y	2	
150	142.2	DB	A Vasiliev	70	36		N	134	20		E	142	>200	Y	2	
152	76.2	IB	A Vasiliev	70	37		N	134	22		E	124	>200	Y	2	
201	220	DB	A Vasiliev	70	39		N	134	30		E	285	>250	Y	2	
207	104.5	IB	A Vasiliev	70	38		N	134	31		E	245	>250	Y	2	
230	116.4	IB	A Vasiliev	70	36		N	134	16		E	169	>250	Y	2	
231	76.2	IB	A Vasiliev	70	37		N	134	17		E	142	>250	Y	2	
302	201	DB	A Vasiliev	70	36		N	134	15		E	266	250-300	Y	2	
304	171.1	DB	A Vasiliev	70	37		N	134	20		E	201	>250	Y	2	
306	133	DB	A Vasiliev	70	37		N	134	20		E	242	250-300	Y	2	
307	211	DB	A Vasiliev	70	38		N	134	32		E	217	>250	Y	2	
336	83.9	IB	A Vasiliev	70	38		N	134	22		E	163	>250	Y	2	
337	198	DB	A Vasiliev	70	38		N	134	20		E	156	250-300	Y	2	
375	147	DB	A Vasiliev	70	39		N	134	33		E	240	>300	Y	2	
19	95	IB	A Vasiliev	69	32		N	135	5		E	119	>250	Y	2	
39	95	IB	A Vasiliev	69	33		N	135	7		E	108	>250	Y	2	

Borehole Name	Depth metres	Class	Investigator(s)	lat deg	lat min	lat sec	N/S	long deg	long min	long sec	W/E	elev masl	pf-depth metres	metad ata	Category	GHOST
142	95	IB	A Vasiliev	69	32		N	135	2		E	91.3	>250	Y	2	
270	76	IB	A Vasiliev	69	33		N	135	6		E	112	>250	Y	2	
287	95	IB	A Vasiliev	69	32		N	135	6		E	115	>250	Y	2	
316	95	IB	A Vasiliev	69	32		N	135	4		E	71.3	>250	Y	2	
346	95	IB	A Vasiliev	69	32		N	135	3		E	73.1	>250	Y	2	
403	95	IB	A Vasiliev	69	32		N	135	4		E	116	>250	Y	2	
411	95	IB	A Vasiliev	69	33		N	135	6		E	112	>250	Y	2	
23	207	DB	A Vasiliev	71	7		N	141	49		E	97	>500	Y	2	
28a	500	DB	A Vasiliev	71	7		N	141	46		E	204	>700	Y	2	
32	260	DB	A Vasiliev	71	7		N	141	46		E	238	>700	Y	2	
36	83.3	IB	A Vasiliev	71	7		N	141	46		E	155	>700	Y	2	
37	156.4	DB	A Vasiliev	71	7		N	141	47		E	150	>700	Y	2	
45	116.4	IB	A Vasiliev	71	7		N	141	47		E	172	>500	Y	2	
60	226	DB	A Vasiliev	71	7		N	141	46		E	154	>700	Y	2	
66	276	DB	A Vasiliev	71	7		N	141	46		E	193	>700	Y	2	
69	123.2	IB	A Vasiliev	71	7		N	141	46		E	155	>700	Y	2	
1	233	DB	GZ Perlshtein	59	42		N	105	4		E	3.5	150	Y	2	
2	200	DB	GZ Perlshtein	59	40		N	105	16		E	655	120	Y	2	
3	376	DB	GZ Perlshtein	62	42		N	148	49		E	1044	270	Y	2	
4	201	DB	GZ Perlshtein	59	37		N	151	0		E	201	60	Y	2	
5	233	DB	GZ Perlshtein	59	38		N	151	2		E	455	160	Y	2	
Marre Sale *	10	SH	E.S. Melnikov/1/204	69	42		N	66	30		E	0-30		Y	1	
Marre Sale N1	10	SH	A.V. Pavlov	69	42		N	66	30		E	11.5	250	Y	2	
Marre Sale N2	10	SH	A.V. Pavlov	69	42		N	66	30		E	13.3	250	Y	2	
Marre Sale N3	10	SH	A.V. Pavlov	69	42		N	66	30		E	15.4	250	Y	2	
Marre Sale N5	10	SH	A.V. Pavlov	69	42		N	66	30		E	22	250	Y	2	
Marre Sale N9	10	SH	A.V. Pavlov	69	42		N	66	30		E	22	250	Y	2	
Marre Sale N17	10	SH	A.V. Pavlov	69	42		N	66	30		E		250	Y	2	
Marre Sale N32	10	SH	A.V. Pavlov	69	42		N	66	30		E	22	250	Y	2	
Marre Sale N36	10	SH	A.V. Pavlov	69	42		N	66	30		E	5	250	Y	2	
Marre Sale N44	10	SH	A.V. Pavlov	69	42		N	66	30		E	19	250	Y	2	
PACE/Pico del Veleta	100	IB	David Palacios	37	3	24	N	3	22	5	W	3371		Y	1	1

Borehole Name	Depth metres	Class	Investigator(s)	lat deg	lat min	lat sec	N/S	long deg	long min	long sec	W/E	elev masl	pf-depth metres	metadata	Category	GHOST
PACE/Corral del Veleta	20	SH	David Palacios	37	3	24	N	3	22	5	W	3106		Y	1	1
Kapp Linne *	7	SU	Jonas Akerman	78	3		N	13	37		E			N	1	
Svea	8	SU	Odd Gregerson,NGI	77	54		N	16	41		E			N	2	
PACE/Janssonhaugen 1	102	IB	Bernd Etzelmuller/K. Isaksen	78	10	45	N	16	28	15	E	275		Y	1	1
PACE/Janssonhaugen 2	15	SH	Bernd Etzelmuller/K. Isaksen	78	10	45	N	16	28	15	E	275		Y	1	1
PACE/Tarfala 1	100	IB	Per Holmlund/K Isaksen	67	55		N	18	38		E	1540		Y	1	1
PACE/Tarfala 2	15	IB	Per Holmlund/K Isaksen	67	55		N	18	38		E	1540		Y	1	1
PACE/Stockhorn1,CH	100	IB	Lorenz King/Thomas Herz	45	59	17	N	7	40	31	E	3410		Y	1	1
PACE/Stockhorn2,CH	17	SH	Lorenz King/Thomas Herz	45	59	17	N	7	40	31	E	3410		Y	1	1
PACE/Murtel-Corvatsch *	58	IB	Dani Vonder Muhll	46	26		N	9	49.5		E	2670	>50	Y	1	1
Murtel-Corvatsch BL2/2000	63	IB	Dani Vonder Muhll	46	26		N	9	49.5		E	2670		N	1	1
Muragel 1/1999 (rock glacier	72	IB	Dani Vonder Muhll	46	30		N	9	56		E			N	1	
Muragel 2/1999 (rock glacier	64	IB	Dani Vonder Muhll	46	30		N	9	56		E			N	1	
Muragel 3/1999 (rock glacier	70	IB	Dani Vonder Muhll	46	30		N	9	56		E			N	1	
Muragel 4/1999 (rock glacier	71	IB	Dani Vonder Muhll	46	30		N	9	56		E			N	1	
PACE/Schilthorn 1	100	IB	Dani Vonder Muhll	46	33	34	N	7	50	10	E	2940		Y	1	1
PACE/Schilthorn2	14	SH	Dani Vonder Muhll	46	33	34	N	7	50	10	E	2940		Y	1	1
Schafberg 1/B11/90	60	IB	Dani Vonder Muhll	46	29	45	N	9	55	50	E	2755		N		
Schafberg 2/B12/90	36	IB	Dani Vonder Muhll	46	29	50	N	9	55	48	E	2733		N		

APPENDIX D

Agenda, Workshop on International Permafrost Monitoring and Database Management, June 2000, Fairbanks

Provisional Agenda
Workshop on International Permafrost Monitoring and Database Management, June 10-14, 2000, Fairbanks

Workshop Languages: English and Russian (a full oral translation of all presentations will be provided)

SATURDAY: 10 JUNE 2000

Arrivals: University of Alaska Fairbanks Summer Housing
Evening: barbecue dinner for all arrived participants at the home of Vladimir Romanovsky

Sunday: 11 June 2000 (International Arctic Research Center, room 401)

0830 - 0900 Registration and breakfast
0900 - 0910 Opening: Welcomes and objectives
0910 - 0920 Suyn-Ici Akasofu, IARC Director: IARC and Permafrost Studies
0920 - 0955 Jerry Brown, International Permafrost Association: Global Terrestrial Network-Permafrost (GTNet-P) as a Part of the Global Climate Observing System (GCOS)
0955 - 1030 Thomas Osterkamp, UAF: Permafrost in Alaska: Changes and Impacts
1030 - 1100 Break
1100 - 1140 Margo Burgess, Canadian Geological Survey: Canadian National Plan for GCOS and GTNet-P
1140 - 1220 Frederick Nelson, University of Delaware: the IPCC developments and possible contribution of GTNet-P to the IPCC process
1220 - 1320 Lunch
1320 - 1400 Daniel Vonder Mühll, Swiss Federal Institute of Technology, Zurich, Switzerland: The PACE Project
1400 - 1440 Kenneth Hinkel, University of Cincinnati: CALM developments and report on Pushchino (CALM)
1440 - 1520 Break
1520 - 1700 Discussion

MONDAY: 12 JUNE 2000 (INTERNATIONAL ARCTIC RESEARCH CENTER, ROOM 401)

0830 - 0900 Breakfast
0900 - 0920 Vladimir Romanovsky, UAF: Questions to by discussed

PRESENTATIONS ON THE SPECIFIC REGIONS

0920 - 1000 Thomas Osterkamp and Vladimir Romanovsky, UAF: Alaskan Transect
1000 - 1040 Margo Burgess, Canadian Geological Survey: Canadian GTN-P Sites
1040 - 1110 Break

1110 - 1150 Daniel Vonder Mühll, Swiss Federal Institute of Technology, Zurich, Switzerland: Permafrost Monitoring Network in Switzerland (PERMOS)
1150 - 1230 Naum Oberman, Polarnouralgeologia, Vorkuta, Russia: Possible Russian GTNet-P sites, European Part of Russia
1230 - 1330 Lunch
1330 - 1410 Alexander Pavlov, Institute of Earth's Cryosphere, Moscow, Russia: Possible Russian GTNet-P sites, West Siberia
1410 - 1440 Vladimir Rusakov, Mel'nikov Permafrost Institute, Yakutsk, Russia: Possible Russian GTNet-P sites, East Siberia
1440 - 1500 Break
1500 - 1530 Larry Hinzman and Kenji Yoshikava, UAF: Interior Alaska and North Slope
1530 - 1600 Masami Fukuda, University of Hokkaido, Sapporo, Japan: Yakutia and Alaska
1600 - 1630 Alexander Vasiliev, Institute of Earth Cryosphere, Moscow, Russia: Possible Russian GTNet-P sites, East Siberia
1630 - 1700 Valentin Kondratiev, Chitinsky Politechnical Institute, Chita, Russia: Possible Russian GTNet-P sites, Transbaikal Region
1700 - 1730 Jakov Kronik, Moscow State University of Civil Engineering, Moscow, Russia: Possible Russian GTNet-P sites in the areas of engineering impacts
1730 - 1800 Sharkhuu Natsagdorj, Institute of Geography, Ulaanbaatar, Mongolia: Possible Mongolian GTNet-P sites

TUESDAY: 13 JUNE 2000 (INTERNATIONAL ARCTIC RESEARCH CENTER, ROOM 401)

0830 - 0900 Breakfast
0900 - 0920 Vladimir Romanovsky, UAF: Questions to by discussed

PRESENTATIONS ON THE SPECIFIC REGIONS (CONTINUED)

0920 - 1000 Gary Clow, U. S. Geological Survey: Alaska and Antarctic
1000 - 1040 David Gilichinsky, Institute for Physical-Chemical and Biological Problems of Soil Science, Pushchino, Russia: Possible Russian GTNet-P Sites, Chukotka (Antarctic ?? Greenland ??)
1040 - 1100 Break
1100 - 1140 Sergei Marchenko, Almaaty, Kazakhstan: Possible GTNet-P sites in Kazakhstan
1140 - 1220 Zhao Lin, Cold and Arid Regions Environmental and Engineering Research Institute, Lanzhou, China: Possible GTNet-P sites in China
1220 - 1320 Lunch
1320 - 1500 Discussion

INSTRUMENTATION AND MEASURING TECHNIQUE

1500 - 1600 Thomas Osterkamp, Vladimir Romanovsky and Kenji Yoshikava, UAF: Equipment for soil temperature and moisture measurements
1600 - 1800 Field excursion: visiting several research sites on UAF campus and measurement technique demonstration

WEDNESDAY: 14 JUNE 2000 (INTERNATIONAL ARCTIC RESEARCH CENTER, ROOM 401)

0830 - 0900 Breakfast
0900 - 0910 Vladimir Romanovsky, UAF: Questions to by discussed

Permafrost Database and Modeling

0910 - 0950 Sharon Smith, Geological Survey of Canada: Permafrost Database, Structure and Potentials
0950 - 1030 Vladimir Romanovsky, UAF: Numerical Analysis of the Permafrost Data
1030 - 1050 Break
1050 - 1130 Jerry Brown, International Permafrost Association: GTN-P: Where are we going and how are we going to do it?
1130 - 1230 Discussion
1230 - 1320 Lunch
1320 - 1500 Discussion continues, Recommendations
1500 - 1530 Final Remarks
1530 - 1800 Excursion to the Permafrost Tunnel

APPENDIX E

Canadian National Permafrost Monitoring Network Workshop, Ottawa, Canada, January 2000

- **Workshop Agenda**
- **Executive Summary**

Workshop Agenda

Canadian GCOS- Global Climate Observing System- Cryosphere

Glaciers/Icecaps and Permafrost Monitoring Network Workshop

Geological Survey of Canada, 601 Booth St
Ottawa, January 28-29, 2000

DAY 1 "What have we done, where are we and what are our needs ?"

8:30 - 10:00 JOINT SESSION - OPENING REMARKS and OVERVIEWS
(Why are we doing it and who cares)

Introduction - Jean-Serge Vincent, GSC/ESS/NRCan
GCOS Overview - invited
International Networks
- GTN-G - Mike Demuth (on behalf of Haeberli)
- GTN-P - Jerry Brown, IPA

Can GCOS - Cryosphere - overview including CLIC by Ross Brown, EC
- Glaciers/Icecaps by Koerner and Demuth, GSC
- Permafrost by Burgess, GSC

10:00-10:20 Refreshment break

BREAKOUT PRESENTATIONS/DISCUSSIONS: (separate Permafrost and Glacier/Ice-caps)

10:20-12:30 Current Permafrost Monitoring Activities -
(*Who, what, where, how, how much)* - series of invited presentations by researchers, ranging from 5-15 minutes each, and covering geographic and thematic aspects of:
Active Layer and Thermal Monitoring
Processes/Landscape/Impact Monitoring
Carbon Cycle (sources/sinks)

12:30 - 13:30 LUNCH - to be provided on site

13:30 - 15:00 Current Permafrost Monitoring Activities (continuation of morning session)

15:00 - 15:15 Refreshment Break

15:15 - 16:15 Gaps and Redundancy - Permafrost; group discussion, no formal presenters

16:15- 17:30 JOINT SESSION - Climate and Process Modelling Needs
(invited presentations and group discussion)
GCMs
Permafrost modelling - backwards and forwards
Glacier/Climate/Process/Hydrology modelling

DAY 2: "Where are we going and how are we going to do it ?"

TASKS FOR A THE DAY - Laying out a network foundation/structure

Breakout Presentations and Discussions Continue

8:30 - 10:15 Permafrost Monitoring Technology and Techniques, Present and Future
invited presentations including discussion of protocols and data frequency requirements

Active Layer	- thaw tubes, probing, cables
Temperature	- cables
	- single probe borehole logging
	- data frequency as function of depth
Geophysics	- current and potential uses, surface and borehole surveys
Remote Sensing	- what does, can it or could it do

10:15- 10:30 Refreshments

10:30 - 12:30 Permafrost Network Requirements - Group Discussion

Membership criteria, site selection
Measurement Protocols
Data quality control
Data reporting/submission , web availability
Data access and exchange
Data archiving
Expertise and Capacity
Priorities/Needs - thematic, geographic, research, analysis, technology development
Funding Requirements - low, moderate, high programs ; implementation and operation
Coordination/Management -Federal government role/mandate?

12:30 - 13:30 LUNCH - to be provided on site

13:30 - 15:00 Permafrost Network Requirements Discussions, continuation of above session

15:15 - 16:45 JOINT SESSION Glaciers/Ice-caps/Permafrost
(Invited presentations and group discussion)

Synergies, logistics, partnerships, commonalities
Data archiving - the WGMS model
Summary of what was achieved in the workshop

16:45 - 17:00 Closing/wrap-up remarks - next steps

EXECUTIVE SUMMARY

In Ottawa, January 28-29, 2000, over 50 participants attended a Canadian Permafrost and Glaciers/Ice Caps Monitoring Network Workshop organized and hosted by the Geological Survey of Canada (GSC). The Workshop, sponsored by the federal government's Climate Change Action Fund (CCAF), was held to review the status of current monitoring activities and to formulate a plan of action and recommendations for the development of a national monitoring network in support of Canada's contribution to the Global Climate Observing System (GCOS).

More than half of the Workshop participants were involved in permafrost monitoring activities. A series of joint and parallel sessions addressed: national and international GCOS programs, current monitoring activities, gaps and weaknesses, techniques and instrumentation, modelling, network requirements and related issues. The deliberations and recommendations of the permafrost sessions are summarized in this report.

To date, there has not been a central agency with a clear mandate to organize and coordinate a national permafrost monitoring network. The Canadian permafrost community (government, universities, industry and other partners) have invested considerable efforts and financial resources in the last two decades for regional and local research and monitoring projects. These activities have been supported through a variety of short-term research programs. They form an impressive, albeit incomplete and currently ad hoc, infrastructure upon which a coordinated and comprehensive national program can be built.

GCOS, Can-GCOS and the GTN-P

The Global Climate Observing System (GCOS) program was established in 1992 by the WMO and other international agencies to address the requirements for global observations of climate change. Since the establishment of GCOS, the importance of systematic observations of the climate system has been given additional emphasis in the UN Framework Convention on Climate Change and by the Kyoto Conference. The five main goals of GCOS are: 1) to characterize the current climate, 2) to detect climate change, determine the rate of change and assist in attributing the causes of change, 3) to determine climate forcing resulting from changing concentrations of greenhouse gases and other anthropogenic causes, 4) to validate models and assist in prediction of the future climate, and 5) to understand and quantify impacts of climate change on human activities and natural systems.

GCOS focuses on implementing global networks for atmospheric, ocean and terrestrial observations, built on existing observing and data management systems and relying on national programs. A Canadian ad hoc GCOS committee was established in 1992. Five component plans are being developed for the Canadian GCOS program, each by a federal or multi-agency lead: oceans, atmosphere, terrestrial, hydrosphere and cryosphere. The cryosphere plan is also being developed by an ad hoc working group, coordinated through the CRYSYS project (Cryospheric System in Canada), and includes five components: glaciers, permafrost, sea ice, lake ice and snow. With recent support from CCAF, background scoping documents were prepared for the February 1999 Victoria Can GCOS Workshop and priority action items identified. The goal is to submit a Canadian Cryospheric IOS plan and cost estimates to the Canadian GCOS committee by March 31, 2001.

In 1999, the Global Terrestrial Network for Permafrost (GTN-P) was established under GCOS by the International Permafrost Association (IPA) to organize and manage a global network of permafrost observatories, most importantly to monitor changes of permafrost temperature and active layer. The GSC is a member of the GTN-P organizing committee tasked with establishing site selection criteria, protocols for data collection and submission, data dissemination and archiving.

The GTN-P includes the Circumpolar Active Layer Monitoring (CALM) program, established by the IPA in 1991 to obtain long-term active layer measurements. Canada contributes 20 of the more than 80 CALM sites. The current efforts of the GTN-P committee are thus focused on establishing the borehole temperature monitoring component. Most of these boreholes were drilled for either research, geotechnical or resource exploration purposes in the last two-three decades, and they range from single sites, to transects, to regional networks. Canada has proposed over 60 of the 200 candidate borehole sites.

The Geological Survey of Canada (GSC) is providing the national coordination and the international data management for the GTN-P. A GTN-P web site has been established as part of the GSC Permafrost Web site (http://sts.gsc.nrcan.gc.ca/permafrost/). Metadata for network sites will ultimately be accessible as well as regularly submitted summary data. GTN-P data would be subsequently archived through the National Snow and Ice Data Centre, Boulder, Colorado, as part of the IPA's Global Geocryological database and the WCD_A for Glaciology.

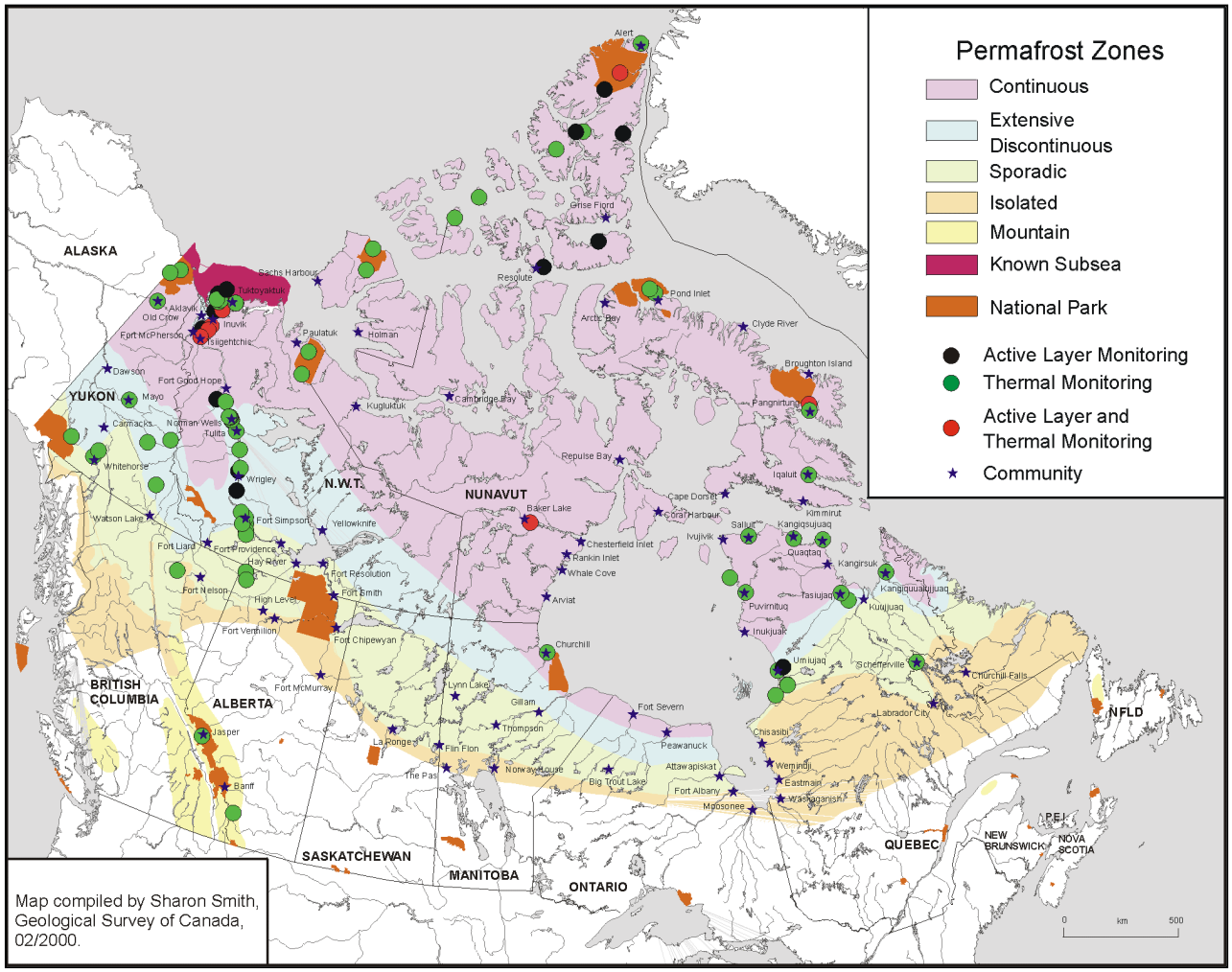
Current Canadian Permafrost Monitoring Activities

A pre-workshop survey and the workshop presentations allowed a compilation of monitoring site metadata and summary information. Presentations on active layer, thermal and process monitoring were made by government, universities, and private sector researchers. Each presenter addressed the "who, what, when, where and why" of their monitoring program, as well as provided their insights, lessons learnt, and recommendations for the establishment of a national network. Example metadata and survey forms are given in Appendix E, while a summary table of monitoring sites, including responsible agency and partners, is given in Appendix F. Over 17 researchers or agencies are leading permafrost monitoring activities. Including partners, the total number of agencies involved is 13. The following maps show the location of existing active layer and thermal monitoring sites, and the location of permafrost process monitoring sites.

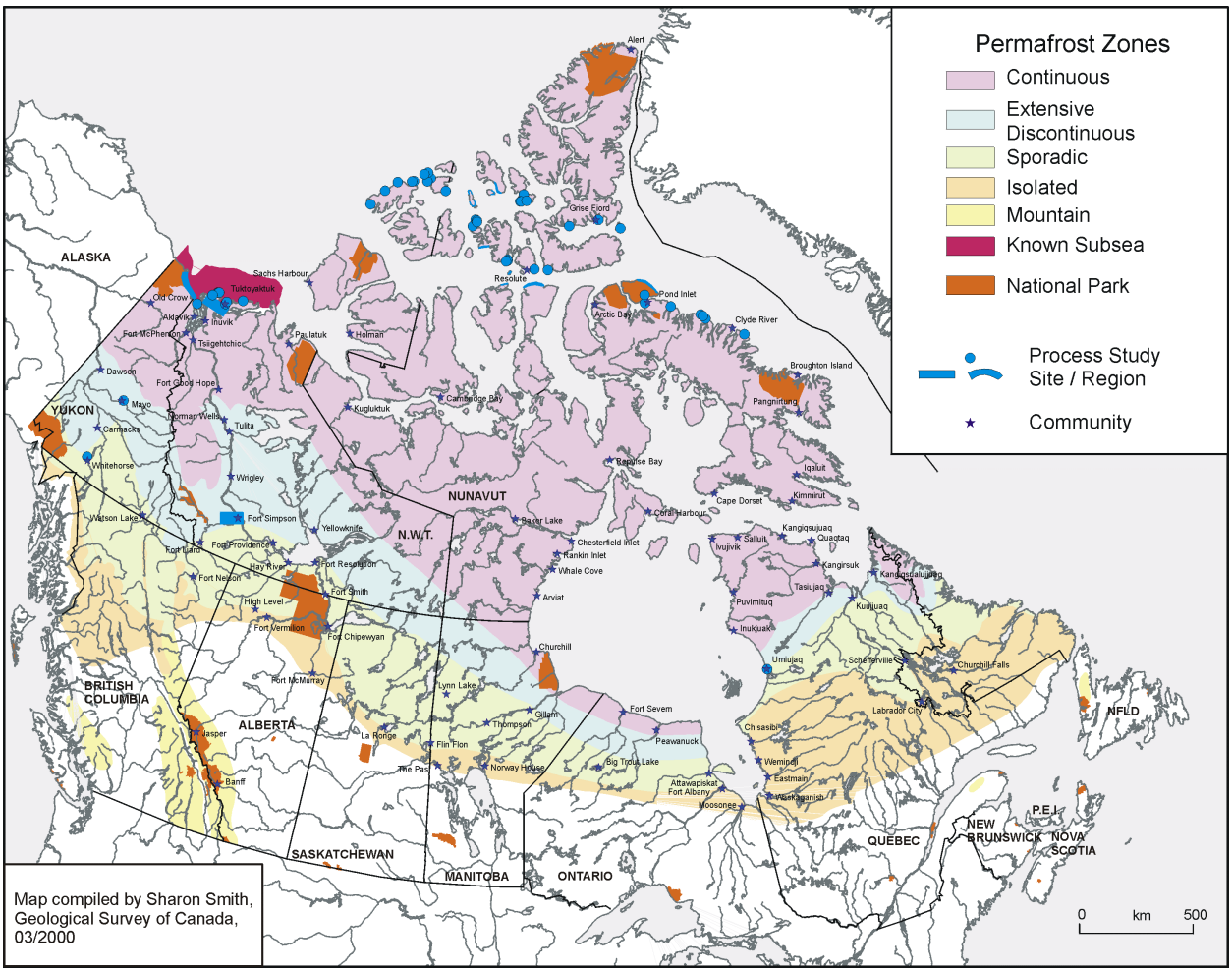
Existing Canadian permafrost monitoring is largely ad-hoc, woven into short-term research projects. Traditionally "monitoring" projects have not been looked upon favourably, and hence not funded, by agencies or programs granting university or government research funds.

Monitoring has been (mostly indirectly) funded from some 9 sources; e.g. several universities, NSERC, PERD, Natural Resources Canada (GSC), Environment Canada, Agriculture Canada, and Parks Canada.

Existing Active Layer and Permafrost Thermal Monitoring Sites



Permafrost Process Study Sites



Permafrost Network Requirements

The network requirement group discussions addressed several topics: management and coordination, membership and site selection criteria, data quality control, data reporting and submission, data access and web availability, data archiving, expertise and capacity, priorities and needs, funding requirements. The related key points and recommendations arising from these workshop discussions and the presentations are summarized in point form below. While these relate to an IOS of permafrost thermal and active layer monitoring, process monitoring was identified as being an important component of a comprehensive national network, because of its direct ties to impacts and links to user requirements. Modelling was also seen as part of this network , and important to site selection as well as impact assessment.

Management and Coordination

- need national lead agency for coordination and data management; federal agency buy-in and funding (GSC identified as natural lead)
- move from personal (ad-hoc) to institutional commitment (i.e.mandate)

- the monitoring community will need to lobby CCAF and Government bodies to include monitoring activities as part of the management plan for Arctic science. It is important to change policy, which means speaking directly to policy-makers.
- partnerships critical to maintain existing sites and to network expansion; communities, industry could be further drawn in, build on existing programs
- steering committee or board of directors to oversee operation

Membership Criteria, Site Selection
- representative of eco-regions, terrain and permafrost conditions
- assess and capture regional variability
- sites with long term data and meteorological data
- accessible sites, close to communities or where partnerships can support or reduce logistics
- many regional gaps; sites in discontinuous zone should be given a priority as should sites in the high Arctic (sentinel)
- commitment to submit data

Measurement Protocols
- Canadian network will follow protocols of CALM, GTN-P
- different measurement protocols for different depth ranges in boreholes
- monitoring infrastructure: standards, protocols, perhaps a bank of equipment meeting the standards, maintenance and capital replacement to be factored in

Quality Control
- range of accuracy and precision for existing sites; expected for new sites
- filter for obvious technical problems to be performed by researchers initially, but also checks at submission level
- classify sites according to quality of data

Data Reporting / Submission / Access
- annual or less frequent (depending on parameter, depth) summary data, based on a calendar year; web accessible
- any material or financial support contingent on data submission
- acknowledge individuals and organizations contributions in the archive
- no interagency charge for data

Archiving
- maintenance of database / archive should be integral part of monitoring infrastructure; serious long term issue; unsure of quantity of data
- link to "A State of the Cryosphere in Canada" meeting every few 3-5 years

Expertise / Capacity
- impressive infrastructure of existing sites already exists; lots of resources invested (need to assess the total real value); provides the foundation and framework for packaging and proposing a national plan
- success to date due largely to long term personal commitment of researchers; need shift to stable long term national institutional commitment
- collaboration is essential, involvement of communities (requires sustained effort)

- logistics support of NRCan's PCSP (Polar Continental Shelf Project) is critical to maintain and expand monitoring in the Arctic.

Funding requirements

- consensus that initial national network cost proposals for low level observation were an order of magnitude too low (was estimated at <$1M/yr); post-workshop follow-up survey will be undertaken to solicit estimated cost of existing activities, both real and in-kind support, in order to more accurately prepare network cost estimates
- first priority for new funding for the national network is to set-up coordination and management aspects (personnel and financial resources)
- long term requirements of monitoring network at odds with current "short term" program funding mode
- Kyoto has opened a window of opportunity to lobby for funding for monitoring, since the government has committed itself to do something.

Steps in the establishment of a Canadian Permafrost Network

In summary the key steps for the successful establishment and operation of a National Permafrost Monitoring Network contributing to the Global Climate Observing System are, in order of priority:

1. Secure long-term federal institutional commitment and funding for coordination and operation of a national network. The GSC, a branch of Natural Resources Canada, has been identified as the likely lead agency to undertake the coordination and management.

2. Provide this national coordination with the necessary human and financial resources to: i) establish the national data compilation and distribution centre (web based), ii) support existing government, university and other agency observatories of active layer and permafrost thermal state (where support includes site selection, equipment, personnel and logistics)

3. Support Canadian involvement in international GCOS programs: develop and maintain the GTN-P web site, maintain international metadata and annual summary observations.

4. Restore key inactive Canadian sites where possible.

5. Augment the network by establishing sites to fill critical thematic and regional gaps (e.g. regional gaps in south-eastern N.W.T., Nunavut west of Hudson Bay, and much of the discontinuous permafrost zone), working in partnership with communities, national parks and industry.

6. Support complementary monitoring of active geomorphic processes (eg. slope and coastal stability) to assess and detect long-term climate change.

7. Support research into development and implementation of remote sensing techniques to extend point source permafrost monitoring to broader spatial domain.