BOREAS
Experiment Plan

Chapter 3
Staff Support

May 1994 Version 3.0

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BOREAS EXPERIMENT PLAN

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3.0 STAFF SUPPORT

3.1 Overview of Staff Support

BOREAS staff oversee the components of the project that require significant logistical effort, extended and/or routine monitoring work, or work that requires the particular expertise and resources of one of the participating agencies. Some of the contributing tasks to the staff support program will be done by investigators. The allocation of project resources to each of the staff activities is to be done by BEX in consultation with the SSG and, when appropriate, the BCC.

The U.S. and Canadian staff activities initiated by BEX are executed via the U.S. Project Office (NASA/GSFC, Greenbelt, MD) and the Canadian Secretariat (CCRS, Ottawa, Ontario), respectively. U.S. and Canadian staff responsibilities are shown in Figures 3.1a and 3.1b. Note that approximately parallel organizations exist within each country.

3.2 Staff Monitoring Program

The staff monitoring program includes:

- Automatic Meteorological Station (AMS) network
- Upper Air (UA) Network
- Hydrology, Snow and Soil Moisture
- Auxiliary Site Work
- Biometry and Allometry
- Radiometric Calibration

3.2.1 Automatic Meteorological Stations (AMS)

This surface network, see figure 3.2.1a, is to provide researchers with a sufficient record of near-surface meteorological and radiation measurements in and around the two study areas, as well as over the region between the two study areas. A limiting constraint on the location of these sensors is that the sites chosen must be accessible by light aircraft, i.e., close to all-weather airports, for servicing and maintenance.

Parameters: A list of the parameters measured is given in Table 3.2.1a and shown schematically in Figure 3.2.1b, as well as the resolution and accuracy of these measurements and sensors used to collect the data. There are two sensor suites: a general meteorological/radiation package - sensor suite A, and a more specific (and more expensive) radiation package - sensor suite B. All the AMS sites are equipped with suite A; five AMS sites are augmented with suite B instruments.

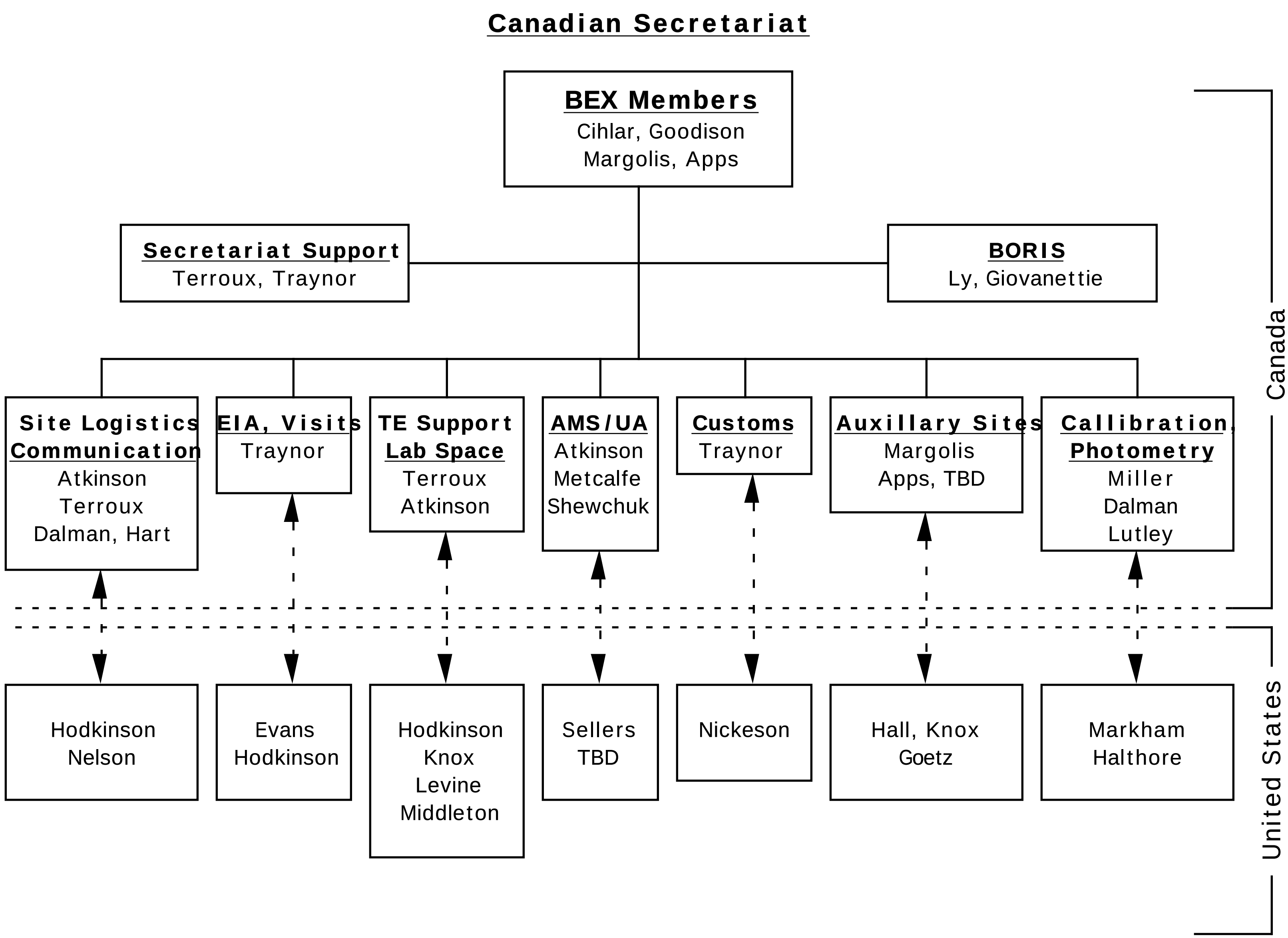

Figure 3.1.a: Canadian Secretariat, showing links to U.S. Project Staff.

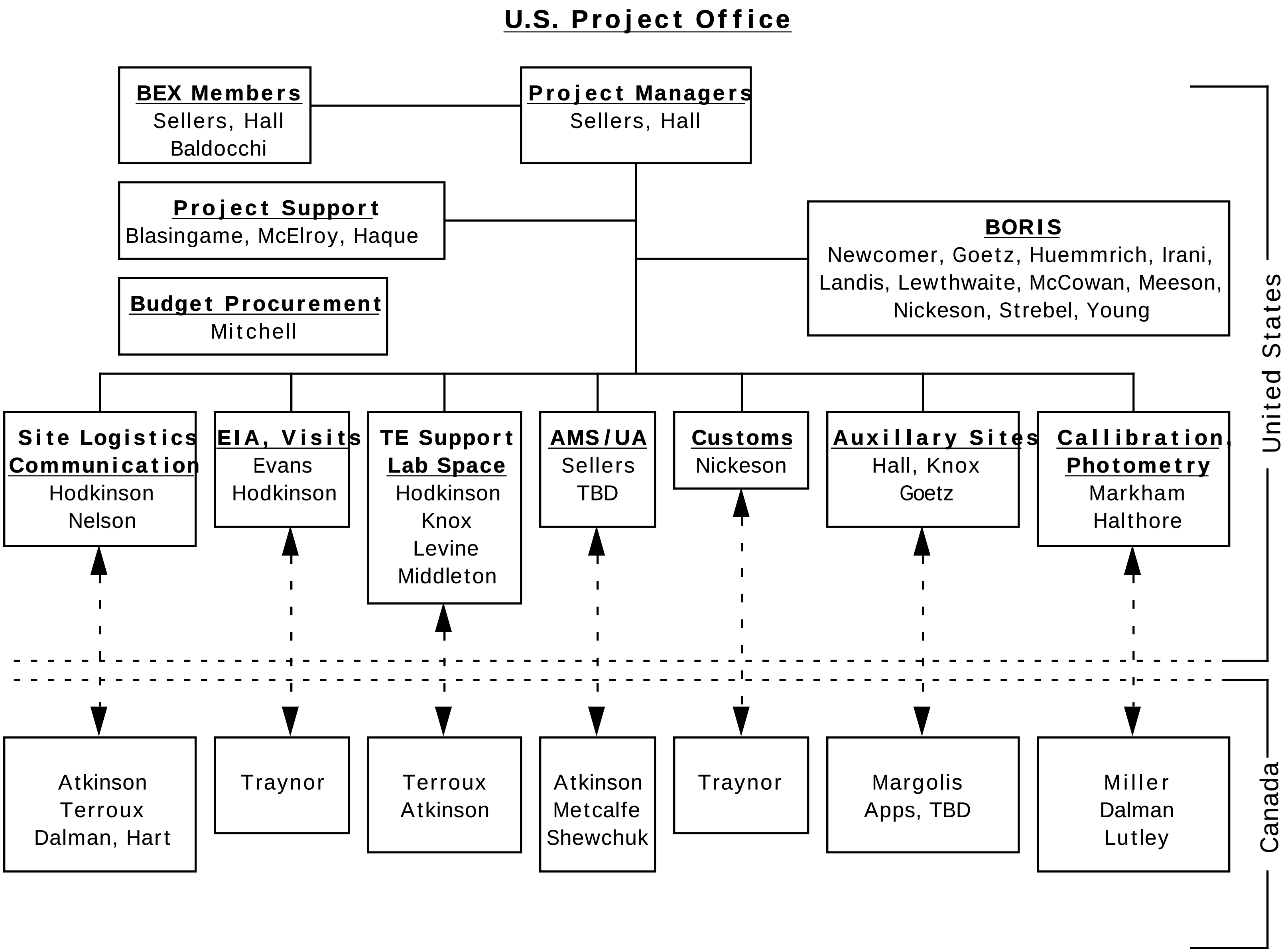

Figure 3.1.b: U.S. Project Office, showing links to Canadian Secretariat Staff.

Locations: The locations for the instruments of the mesoscale network are shown in Figure 3.2.1a. All suite A stations have been logging data from early 1994, and all suite B stations came on line by March, 1994. All stations are fully automatic and meet AES standards. Continuous measurements will be made through October 1995 (or longer). SRC has been contracted to buy, install and maintain these stations (see AFM-7). Table 3.2.1b lists the BOREAS AMS station locations and heights.

Sensors: All ten surface stations have sensor suite A. Three of the enhanced radiation packages (suite B) are employed at the primary sites : NSA-Fen, SSA-OA and SSA-OJP. A fourth suite B radiation package is placed at Flin Flon. SRC is also providing data from its Climatological Reference Station (CRS) located at Saskatoon to the BOREAS mesonet. This is considered the fifth suite B sensor package.

Variables and frequency: The statistics for all variables are collected every 15 minutes and ending at 0, 15, 30, 45 past each hour, consistent with TF group data products. For each variable and each reporting period the statistics reported are the mean and the standard deviation. In addition, the winds are reported as four variables: direction, speed, U (westerly component), and V (southerly component). All data collected by the surface network are transferred and archived within BORIS.

Abbreviated surface meteorological datasets, formatted in WMO standards, are transmitted via the Global Telecommunications Systems (GTS) network, to the Canadian Meteorological Centre (CMC), the US National Meteorological Center (NMC), and it is hoped to the European Center for Medium Range Weather Forecasts (ECMWF), in near real time at the standard six hour intervals. These transmissions will have begun before March 1, 1994 and will continue through to at least the end of the last field campaign. The variables transmitted to GTS are: air pressure, dew point temperature (from relative humidity sensor), air temperature (above canopy temperature), wind direction, wind speed and precipitation. The transmission is in the form of bulletins within the continental GTS network, which is sent to selected individuals or groups. For transmission to Europe, the data can be transmitted on the GTS network to Bracknell, England. SRC is responsible for collecting the data and putting it in into these specific formats (with AES guidance). This enables AES to simply broadcast (or load) the data into the GTS network for transmission to the continental network and for transmission to Europe. As of 4/1/94, CMC and NMC are receiving and decoding this surface data, but ECMWF is not because of conflicts between North American data coding protocols and international standards. AFM-8 is working on this.

Location of BOREAS Upper Air and
Surface Meteorological Stations

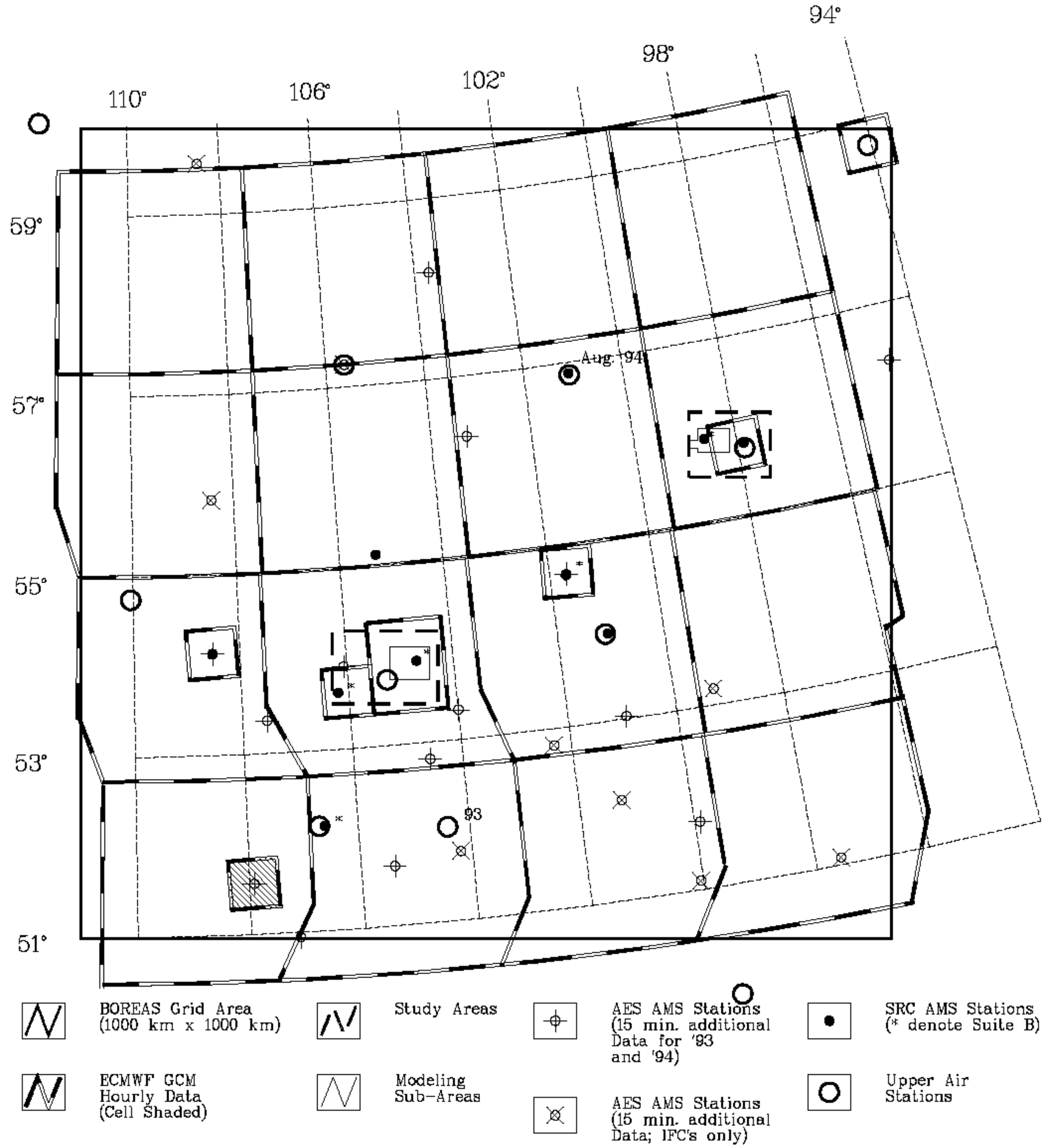

Figure 3.2.1a Location of BOREAS Upper Air and Surface Meteorological Stations within the BOREAS Region. The ECMWF model grid is overlaid; hourly GCM products will be saved for each grid area from 4/1/94 onwards, see also AFM-8.

Table 3.2.1a
Parameters to be Measured by the BOREAS AMS Network (AFM-7)

Parameters measured	**Resolution**	**Accuracy**	**Typical sensor/supplier**
Sensor suite A			
Above-canopy temperature	0.1deg C	+/- 0.25deg C	Vaisala HMP35C
Within-canopy temperature	0.1deg C	+/-0.25degC	Same as air temperature (without humidity sensor)
Air temperature (2m)	0.1degC	+/-0.25degC	Campbell 107
Soil moisture	1 percent	2 percent	Soiltronics transducers probes
Air Pressure	0.01kPa	+/-0.05kPa	Setra
Humidity	1 percent	+/-5 percent	Vaisala HMP35C (same as air temperature)
Wind speed	.1m/s,1deg	5percent,2deg	RM Young Wind Monitor
Precipitation *	1mm	5percent	AES Tipping Bucket Rain Gauge, Belfort Gauge
Snow depth	2.0cm	+/-2.0cm	Campbell Scien. UDG 1 ultrasonic depth sensor
Incident Shortwave	1percent	5percent	Eppley (PSP)
Incident PAR	1percent	2percent	Skye-Probetech (SKE510) PAR sensor
Reflected Shortwave	1percent	2percent	Eppley (PSP)
Net radiation	1percent	5percent	Fritschen type net radiometer
TIR Surface Temp	<1degC	+/-0.5°C	Everest (4000 AL)
Parameters measured	**Resolution**	**Accuracy**	**Typical sensor/supplier**
Sensor suite B			
Diffuse Shortwave down	1percent	5percent	Eppley (PIR)
Longwave down	1percent	3percent	Eppley (PSP) plus shadow band

*It was recommended by the AFM group that each Belfort-type precipitation gauge should be placed in clearings within cable distance of the station. In addition, the field of view from the top of the gauge to the nearest obstruction should not be greater than 45 degrees.

Table 3.2.1b
(a) SRC BOREAS AMS Station Locations and Heights
(b) AES AMS Stations (15-minute reporting)

4/19/94

SRC BOREAS AMS Stations

Name	Identifier	BORIS X	BORIS Y	Longitude West	Latitude North	UTM Easting	UTM Northing	Elevation (meters)
LaRonge, SK	ZBG	363.18	474.10	-105.29	55.13	481341	6108549	381
Meadow Lake, SK	ZBH	161.78	350.54	-108.52	54.12	661952	5999980	480
SSA-OA	ZBI	317.22	303.43	-106.20	53.63	420841	5942707	587
SSA-OJP	ZBJ	413.62	343.24	-104.69	53.92	520354	5974041	511
Saskatoon, SK	ZBK	300.74	138.88	-106.60	52.16	390374	5780254	480
Lynn Lake, SK	ZBL	601.23	698.37	-101.09	56.89	372523	6306433	366
The Pas, SK	ZBN	649.84	376.77	-101.05	53.97	365264	5981730	267
NSA-OJP	ZBO	768.61	617.22	-98.62	55.93	523623	6197911	282
Thompson, MB	ZBQ	817.16	612.10	-97.87	55.80	570623	6184571	221
Flin Flon, MB	ZBR	598.12	448.64	-101.69	54.67	326559	6061293	305

AES Surface Wether Stations collecting 15 minute Data for BOREAS

Name	Identifier	BORIS X	BORIS Y	Longitude West	Latitude North	UTM Easting	UTM Northing	Elevation (meters)
15 minute data for '93 and '94								
Collins Bay	WWC	428.55	822.58	-103.70	58.18	576449	6449648	492
Lucky Lake	WLE	270.85	1.93	-107.15	50.95	348976	5646247	665
Meadow Lake	WLJ	162.12	351.54	-108.52	54.13	270258	6003857	480
Melfort	WFF	430.78	221.83	-104.60	52.82	526959	5851734	490
Nipawin (AES)	WBU	465.26	282.95	-104.00	53.33	566594	5909601	373
Rosetown East	WRJ	213.92	67.70	-107.92	51.57	297855	5716657	586
Southend	WJH	475.72	620.28	-103.28	56.33	606139	6244290	344
Spiritwood West	WSR	229.42	268.93	-107.55	53.37	330332	5915874	590
Waskesiu Lake	WLV	323.57	335.98	-106.07	53.92	429940	5974561	569
Watrous East	WIW	387.34	89.67	-105.40	51.67	472335	5723822	526
Bachelors Island Marine	WBL	763.86	144.37	-99.90	51.75	437869	5733398	256
Flin Flon	WFO	598.36	450.04	-101.68	54.68	327017	6062645	304
Gillam	WGX	996.90	714.85	-94.70	56.37	765550	6254979	145
Hunters Point	WHH	672.70	274.86	-100.93	53.03	370356	5877509	256
15 min. Data during IFC's only (hourly otherwise)								
Buffalo Narrows	WVT	160.57	541.11	-108.43	55.83	284990	6192649	431
Uranium City	WDC	142.41	956.70	-108.48	59.57	303224	6608106	318
Wynyard Lake	WOY	469.01	108.13	-104.20	51.77	555207	5735171	561
Fisher Branch	WSZ	937.96	100.15	-97.55	51.08	601565	5659873	253
Grand Rapids	WJD	780.29	308.75	-99.27	53.18	482179	5892481	223
Swan River	WEQ	667.05	170.99	-101.23	52.12	347084	5776149	335
Hudson Bay	YHB	583.77	238.47	-102.32	52.82	680830	5855034	358
Key Lake	YKJ	324.33	708.63	-105.62	57.25	462789	6345172	511
Dauphin	YDN	764.91	71.39	-100.05	51.10	426479	5661251	305

A complete set of AES Surface Weather and Climate Stations in the region are in an appendix.

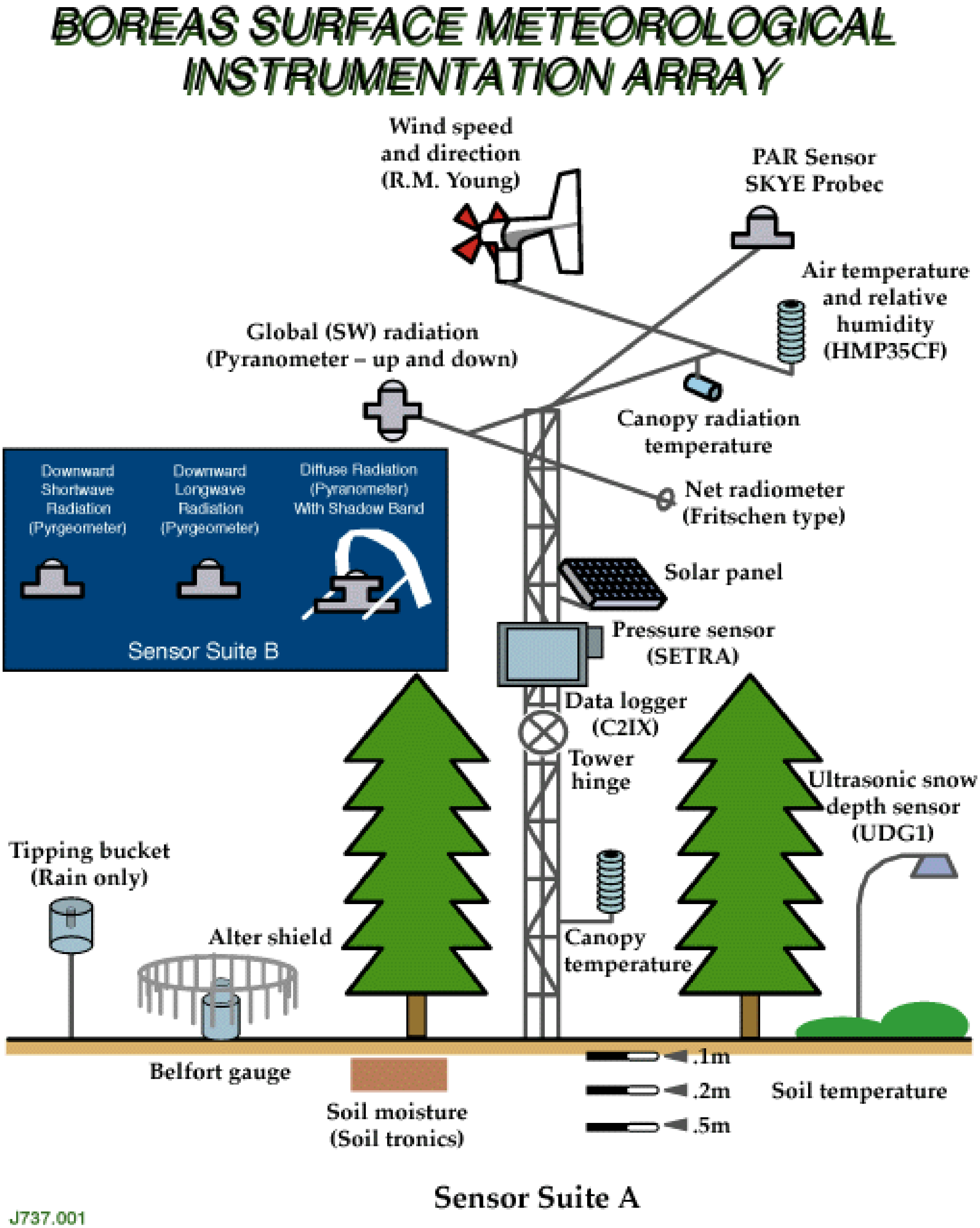

Figure 3.2.1.b Schematic of AMS Sensor Suites corresponding to Table 3.2.1a

3.2.1.1 AES Surface

Appendix L lists all the AES surface weather and climate stations: their locations, elevations, and record history. Some collect daily data, some hourly data. Of the hourly weather data stations, a subset of autostations will archive 15 min data for BOREAS, some during 1993 and 1994; some only during IFC's. These surface stations are listed in Table 3.2.1.b and shown in figure 3.2.1a.

3.2.2 Upper Air Network

BOREAS has two overall objectives for the upper air network: to establish a large and fine enough mesh (areal coverage) to satisfy the requirements of the mesoscale modelers, and to operate on a time schedule (frequency) that would allow diurnally varying processes to be accurately resolved. See Figure 3.2.2, Table 3.2.2a and AFM-5.

Locations: Figure 3.2.2 shows that there are presently eleven upper-air (UA) stations being run by the Atmospheric Environment Service (AES) and the National Weather Service (NWS) within and adjacent to the BOREAS region. These stations normally take UA flights at 0000Z and 1200Z daily. BOREAS intends to augment the program of two of these stations (Churchill, MB and The Pas, MB) with a flight at 1800Z during the IFCs. (Figure 3.2.1a also shows the locations of these stations within and close to the BOREAS study area).

Included in the eleven is an AES station which is summer only (Saskatoon, SK) which operates for a severe weather monitoring program. This summer-only station normally takes a flight at 1200Z only, but on selected days may make additional flights. BOREAS intends to augment the program at Saskatoon with flights at 0000Z and 1800Z during IFCs in 1994.

Two Canadian Military stations (Primrose Lake, AB, (a part of CFB Cold Lake), AB and Shilo, MB) are also in or adjacent to the BOREAS region. These stations usually make flights in connection with military exercises only, but in the past have made regular flights when requested to do so. The Department of National Defense (DND) has been requested to provide flights at 1200Z and 1800Z during IFCs in 1994.

Also within the BOREAS region are two research programs which normally make UA flights for their own purposes. NASA launches stratospheric balloons from Lynn Lake, MB and for this they need to know the high altitude conditions. They have been asked to make flights at 0000Z, 1200Z and 1800Z during IFCs in 1994. Lynn Lake will operate only during the later part of IFC-2 and the early part of IFC-3. The Hydrological Process Division (part of AES) of the National Hydrological Research Center (HPD-NHRC) in

Saskatoon has an experimental site at Quill Lake, SK where they made up to 5 flights per day for the study of the boundary layer in 1993. Unfortunately, no flights are planned at Quill Lake during 1994.

In addition to the above, BOREAS intends to install three additional stations at Candle Lake, SK, Key Lake, SK and Thompson, MB to complement the existing coverage. Table 3.2.2a summarizes the Upper Air Station locations and elevations. These stations will take flights at 1200Z and 1800Z during the Thaw FFC, and at 0000Z, 1200Z and 1800Z during IFCs. In addition Candle Lake and Thompson, on selected days during the IFCs, will take seven flights per day at 0000Z, 1200Z, 1400Z, 1600Z, 1800Z, 2000Z, and 2200Z. When there are three flights per day, a relaunch will be made if the flight does not reach 200 mb. When there are seven flights per day, a relaunch will be made if the flight does not reach 500 mb (if time allows). This applies only to the "BOREAS" sites.

A decision on whether or not a day is selected for intensive observation would normally be made the preceding evening by BOREAS Operations, but a final "go/no go" decision may be made as late as 1245Z on that day. The decision to 'go' must be communicated to the AES observer at the Thompson Zoo (204-677-7078) and to the AES observer at the Candle Lake Operations Center (306-929-2669) by the mission manager.

Frequency: Table 3.2.2b provides the details for the number of releases planned for each station (regular, co-operative, or BOREAS established) during 1994. Five time periods are considered: a 21 day FFC-T, 24 day IFC-1, 21 day IFC-2, 21 day IFC-3, and all other times outside these field campaigns. No additional upper-air flights were made during the FFC-W. Of the 66 days during the IFCs, approximately 40 will be chosen as 'intensive' data gathering days. On each of these days, 7 releases per day will be made from Candle Lake and Thompson.

A total of 3563 radiosondes will be released during FFC-T and IFCs 1, 2, and 3. Of these, 1785 will be regularly scheduled flights, and 1778 will be additional flights sponsored by BOREAS. Many of the new flights will be obtained simply for the cost of the expendables, with no charge for the labour or the facilities. In addition, if some of the co-operating agencies make flights for their own purposes, BOREAS will be able to obtain that data as well.

Processing: It is planned that all flights sponsored by BOREAS will be processed for mandatory and significant levels and sent to the Global Telecommunications System (GTS) via AES communications (NCCS) in real time for the benefit of modelers and operational meteorology. These messages will be archived in BORIS. In addition, all raw data files (or hardcopy, where necessary) from the stations in Table 3.2.2b will be accumulated at HPD-NHRC in Saskatoon. There, some of them will be analyzed into a more detailed form that will be more useful to the meso-scale meteorological-modelling community. This refined post-processed data will be available in BORIS approximately six months after observation time.

3.2.2.1 ECMWF Operational products for BOREAS

ECMWF will provide faxed forecasts for BOREAS for 55.9˚N, 99˚W (WIN) and 53.6˚N 105.9˚W (WIP) as "Metgrams" for the NSA and SSA to the AES forecast offices in Saskatoon and Winnipeg. ECMWF will archive for research purposes two types of hourly column model diagnostics out to 72 hours for every forecast, starting at 12Z and 00Z from their operational model starting approximately 4/15/94 (with the intent of accumulating a one-year archive).

The first product will be an archive of model data from five single grid-points and one double grid-point (averaged): these are marked as small squares, roughly 50 x 50 km in size, on Figures 3.2.1a and 3.2.2. These form a SW-NE cross-section across the BOREAS region. They are intended for direct comparison with time-series data collected at Rosetown, PA Park, Nipawin Park (this is an average of 2 adjacent grid points straddling the area), Flin Flon, Thompson/Nelson House, and Churchill.

The second archive will be a 4 x 4 array of cells of hourly model data (each cell averaged over 4 x 4 model grid points) to define the large-scale spatial structure across the BOREAS Region, while resolving the diurnal cycle. Figures 3.2.1a and 3.2.2 also show this array. A higher spatial resolution than this (of approximately 240 x 240 km) of this full diagnostic product every hour at full vertical resolution (31 levels) cannot be archived from the operational model because of memory limitations. (Standard high spatial resolution products of basic meteorological fields every six hours at the surface (including surface fluxes) and at standard levels in the vertical will of course still be available from ECMWF and NMC.)

3.2.2.2 Products for BOREAS

NMC has two main model products: one global form the MRF (medium range forecast) model (currently T-126), and one regional, from the 'ETA' model (gridpoint; currently 80 km horizontal resolution, L38 in the vertical. The plan is for this to drop to 30 km resolution, at L50 by mid-1994, when their new computer becomes operational. The exact status of these models' land surface/hydrology parameterizations during BOREAS is not yet clear. A new 2-layer soil and plant canopy model is being tested for the MRF and the associated GDAS/Global data assimilation system. It may be implemented by spring 1994. There are plans to put the same sub-model into the ETA model and its analysis (EDAS), but it is unlikely this will occur for BOREAS. The present ETA model will be updated however (by a Penman-Monteith

Location of BOREAS Upper Air Stations

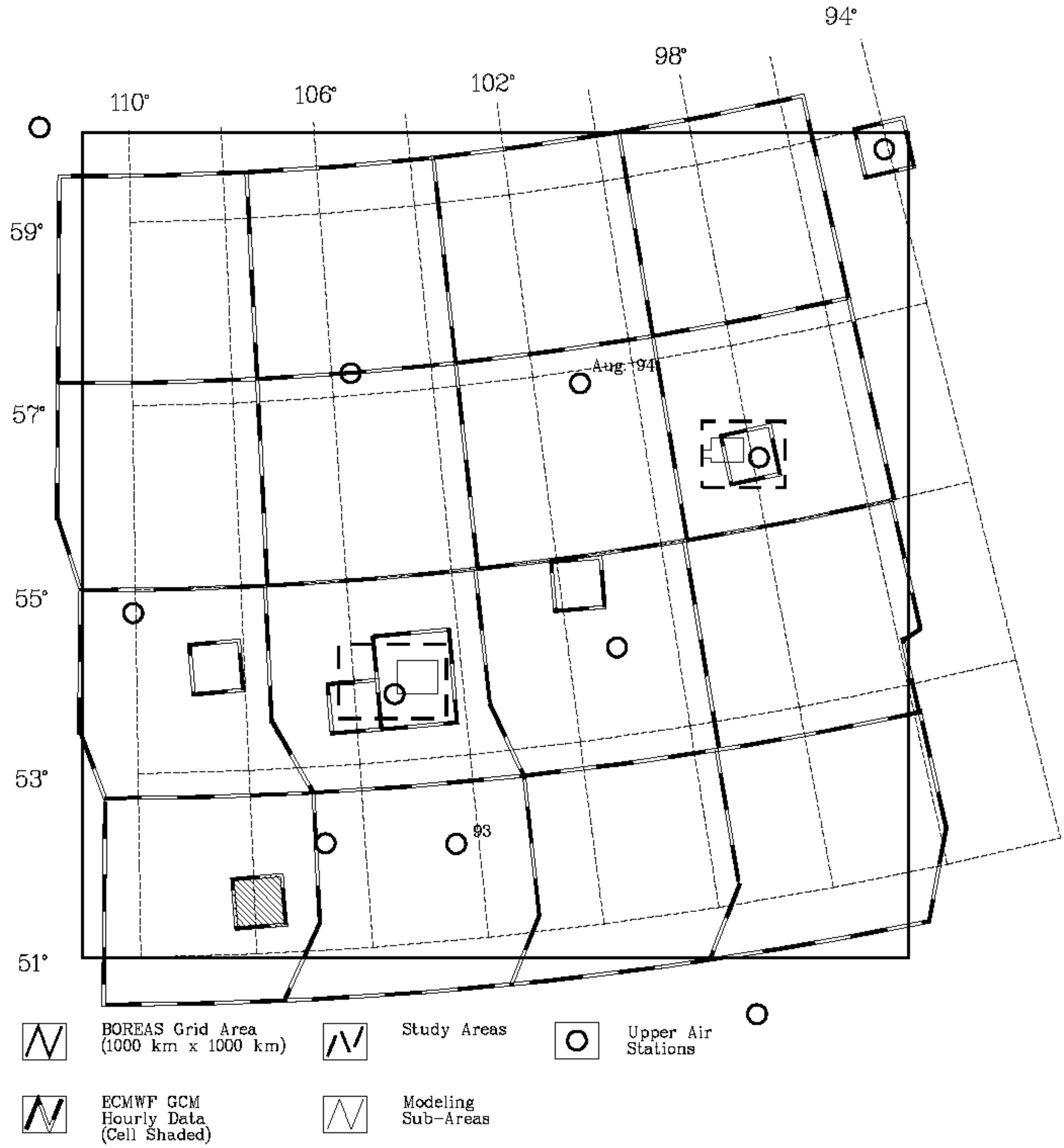

Figure 3.2.2 Schematic of BOREAS Upper Air Network. Note that some existing radiosonde stations are augmented with additional launches and some new stations are to be put in place for the experiment. The ECMWF model grid is overlaid; hourly GCM products will be saved for each grid area from 4/1/94 onwards, see also AFM-8.

Table 3.2.2a
BOREAS Locations of Upper Air Stations

Name	Notes	BORIS X	BORIS Y	West Longitude	North Latitude	UTM Easting	UTM Northing	UTM Zone	Elevation (meters)	Source of Location
Existing Regular										
Baker Lake UA, NWT	YBK	730.0	1559.0	-96.000	64.317	645,032	7,135,725	14	50	Catalogue
Fort Smith UA, NWT	YSM	-52.1	1006.4	-111,933	60.033	447,994	6,655,490	12	204	Catalogue
Churchill UA, MB	YYQ	970.4	979.9	-94.083	58.733	437,281	6,510,866	15	29	Catalogue
The Pas UA, MB	YQD	646.9	376.2	-101.100	53.967	362,245	5,981,855	14	274	Catalogue
Edmonton-Stony Plain, AB	WSE	-205.2	288.2	-114.100	53,550	692,114	5,937,369	11	766	Catalogue
Saskatoon, SK	YXE	294.1	138.8	-106.700	52.167	383,732	5,780,938	13	504	Catalogue
Pcikle Lake, ON	YPL	1424.9	264.3	-90.217	51.450	693,393	5,703,543	15	386	Catalogue
Great Falls, MT	GTF	-27.8	-389.4	-111.367	47.483	472,437	5,258,947	12	1115	Catalogue
Glasgow, MT	GGW	327.4	-298.2	-106.617	48.217	379,956	5,341,643	13	700	Catalogue
Bismark, ND	BIS	786.8	-410.5	-100.750	46.767	366,409	5,180,722	14	506	Catalogue
International Falls, MN	INL	1292.9	-105.3	-93.383	48.567	471,731	5,379,364	15	359	Catalogue
Existing DND										
Primrose Lake, AB	WIQ	61.1	417.8	-110.050	54.750	561,146	6,067,386	12	702	Catalogue
Shilo, MB	WLO	816.4	-68.3	-99.650	49.783	453,234	5,514,744	14	373	Catalogue
BOREAS Sites										
Thompson Zoo, MB	YTH	818.7	606.3	-97.867	55.750	571,137	6,178,837	14	206	Map
Candle Lake, SK	WLZ	377.6	319.7	-105.267	53,733	482,409	5,593,885	13	503	Map
Key Lake, SK	YKJ	324.3	708.6	-105.617	57,250	462,791	6,345,383	13	511	Map
Cooperative Sites										
Quill Lake, SK ('93)	WQH	452.3	138.2	-104.400	52.050	541,144	5,766,769	13		Catalogue
Lynn Lake, MB (Aug. '94)	YYL	602.1	696.3	-101.083	56.867	373,001	6,304,477	14	357	Catalogue

Table 3.2.2.b
BOREAS Upper Air Network Design

Field Campaigns	Winter FFC		Thaw FFC		Non IFC		During IFCs		During IFCs		Total
	Feb 1994		April 1994		May 3-Sep 30		non-intensive		intensive		(new)
Length (days)	20		30		90		15		48		
	reg	new	reg	new	reg	new	reg	new	reg	new	new
Existing regular (AES and NWS)											
Baker Lake,NWT	2	0	2	0	2	0	2	0	2	0	0
Fort Smith,NWT	2	0	2	0	2	0	2	0	2	0	0
Churchill,MB	2	0	2	0	2	0	2	1	2	1	63
The Pas,MB	2	0	2	0	2	0	2	1	2	1	63
Edmonton,AB	2	0	2	0	2	0	2	0	2	0	0
Pickle Lake,ON	2	0	2	0	2	0	2	0	2	0	0
Int.Falls,MN	2	0	2	0	2	0	2	0	2	0	0
Great Falls,MT	2	0	2	0	2	0	2	0	2	0	0
Glasglow,MT	2	0	2	0	2	0	2	0	2	0	0
Bismark,ND	2	0	2	0	2	0	2	0	2	0	0
Saskatoon,SK (summer only)	0	0	0	2	1	0	1	2	1	2	186
Existing DND											
Cold Lake, AB	0	0	0	2	0	0	0	3	0	3	249
Shilo, MB	0	0	0	2	0	0	0	3	0	3	126

Table 3.2.2.b
BOREAS Upper Air Network Design (Continued)

Field Campaigns	**Winter FFC**		**Thaw FFC**		**Non IFC**		**During IFCs**		**During IFCs**		**Total**
	Feb 1994		April 1994		5/3-9/30		non-intensive		intensive		(new)
BOREAS sites											
Thompson,MB	0	0	0	2	0	0	0	3	0	7	441
Candle Lake,SK	0	0	0	2	0	0	0	3	0	7	411
Key Lake,Sk	0	0	0	2	0	0	0	3	0	3	
Cooperative sites								4 days		16 days	
Quill Lake,SK	0	0	0	0	0	0	0	0	0	0	0
Lynn Lake, MB	0	0	0	0	0	0	0	3	0	3	
Totals	20	0	20	10	21	0	21	20	21	29	1874
	reg	new	reg	new	reg	new	reg	new	reg	new	
Regular (scheduled) sondes	400		600		1890		315		1008		4213
New sondes per FC		0		300		0		278		1296	1874
Total sondes per FC	400 sndes		900 sndes		1890 sndes		593 sndes		2304 sndes		6087

formulation and a monthly climatology of soil moisture). A GCIP archive from the ETA model is planned for April - September 1994 at a 6-hourly time resolution. Hourly soundings will be available at the 2 main BOREAS sites. Ken Mitchell (301) 763-8161 in the NMC Development Division has more details.

3.2.3 Hydrology, Snow and Soil Properties

3.2.3.1 Hydrology

Core hydrology measurements are summarized in this section. The field work is being coordinated by HYD-9 and details of the data collection program are described in Section 4.5.3. Most of the work will be funded by HYD-9 and will rely heavily on borrowed instrumentation.

Stream Gauges

The White Gull Creek above Highway 106 (drainage area approximately 574 sq km, total relief approximately 150 m) will be the largest gauged watershed in the SSA (figure 3.2.3.1a). The creek flows in a southeasterly direction. There is little evidence of overland drainage at any of the locations; streams originate only in extensive wetland areas. The Old Black Spruce, Old Jack Pine and Young Jack Pine tower sites are located within the White Gull watershed boundaries and the Fen site is located just to the southeast of the watershed.

The primary gauge is SW1 (SSA Water Level Recorder 1), which drains the entire basin. Water Survey of Canada installed an all-season gauge at this location in the fall of 1993. This gauge will be operated by WSC for at least two years. Three smaller subcatchments are suitable for summer flow measurement from the point of view of hydraulics and access (streamgauges SW2, SW3 and SW4). Gauge SW2 is at a culvert crossing on Harding Road and will gauge a tributary that includes the Old Jack Pine tower location. Gauge SW3 is on White Gull Creek at Hwy 120 and gauges the area that drains White Gull Lake and the Old Black Spruce tower site. Gauge SW4 is at a culvert crossing on Lorenz Lake Road and will gauge the northwesterly part of the watershed. Substantial flow was noted at each location during the field visit in late May, 1993 and during IFC-93.

In the NSA, the primary gauge will be NW1 (NSA Water Level Recorder 1) on the Sapochi River at the Highway 391 Bridge (drainage area 436 sq km), shown in Figure 3.2.3.1b. This is an all-season gauge installed and operated by Water Survey of Canada. However, because the southern part of the watershed is too inaccessible and too far away for extensive rainfall

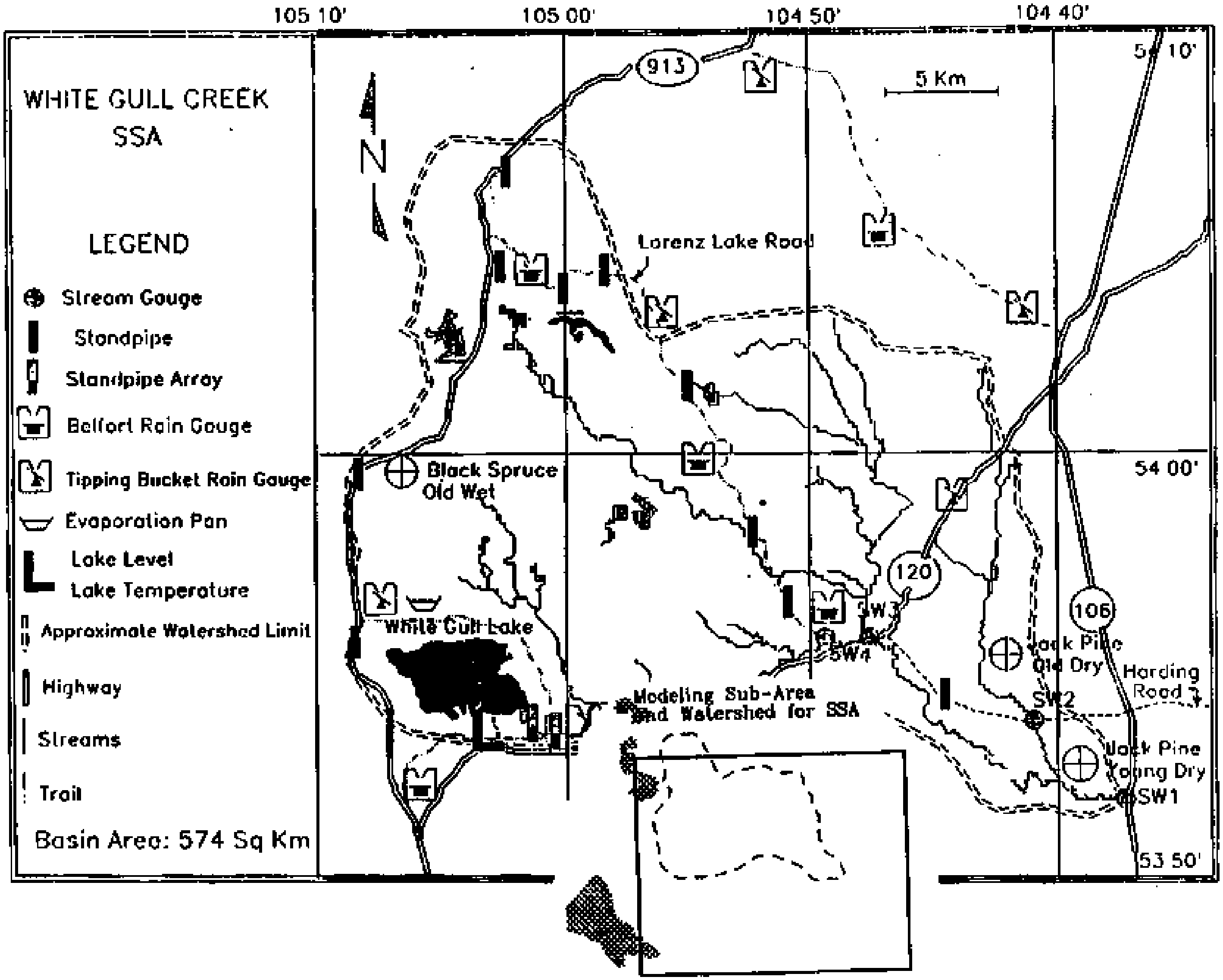

Figure 3.2.3.1a Map showing gauged catchment area of White Gull Creek in the SSA

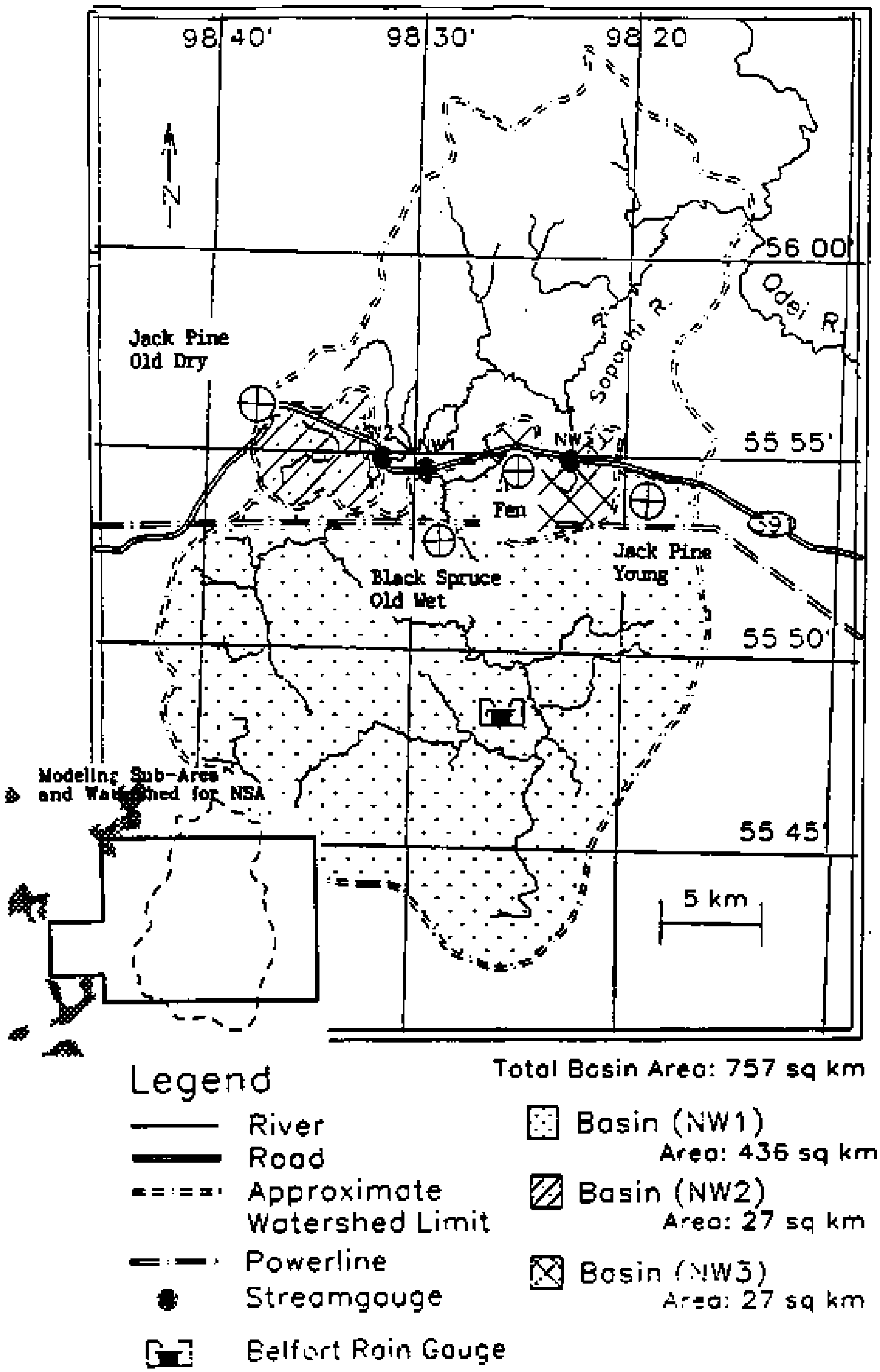

Figure 3.2.3.1b Map showing gauged catchment area of the Sapochi River in the NSA.

measurements, the entire basin is not suitable for detailed hydrological studies.

Detailed hydrologic activities at the NSA will focus within two small watersheds that are tributary to the Sapochi (Figure 3.2.3.1c). They will be referred to as the West Basin and the East Basin. Both were chosen because there was a substantial (measurable) flow during the site visit in late May, 1993 through conveniently located highway culverts and the basins are located near the towers. The gauging sites are shown as streamgauge NW2 for the West Basin and streamgauge NW3 for the East Basin on Figure 3.2.3.1c. Crest gauges have been installed on one small tributary in each basin.

The East Basin has the Fen tower site within its boundary and has a drainage area of roughly 27 sq km. The Young Jack Pine tower is 5 km east of the watershed while the Old Black Spruce is 4 km to the west. The main drainage system in the East Basin is an extensive interconnected series of fens. The West Basin is located between the Old Jack Pine and the Old Black Spruce tower sites and also has a drainage area of approximately 27 sq km. The West Basin has somewhat steeper creeks and fewer bogs than the East Basin. In addition to gages NW2 and NW3 for the West and East Basins, respectively, three additional gauges, NW4-NW6, will be installed and maintained by TF-10 in a small (drainage area approximately 3 square km) within the East Basin. Gauge NW4 will be located upstream of the Highway 391 culvert crossing, immediately north of the Fen tower site. Three additional weirs have been installed to gage small tributaries upstream of NW4 in the fen catchment. In addition, two neutron probe tube transects, and water table monitoring wells, have been installed within the small fen tributary to the East Basin.

<u>Precipitation Gage Network</u>

Precipitation (and other surface meteorological) measurements will be taken at most of the tower sites starting with the winter FFC and continuing through the final summer IFC. In addition, at one tower site, each in the northern and southern sites, precipitation (and other surface meteorological) measurements will be initiated with the summer, 1993 IFC and will continue through the winter of 1993-94. Summer precipitation measurements will be supplemented with several recording (Belfort and tipping bucket) rain gauges in each watershed (see Figures 3.2.3.1a, a portion of the Sapochi basin. In addition, AES Type B manual gauges will be deployed at the northern and southern sites in conjunction with the piezometer transects.

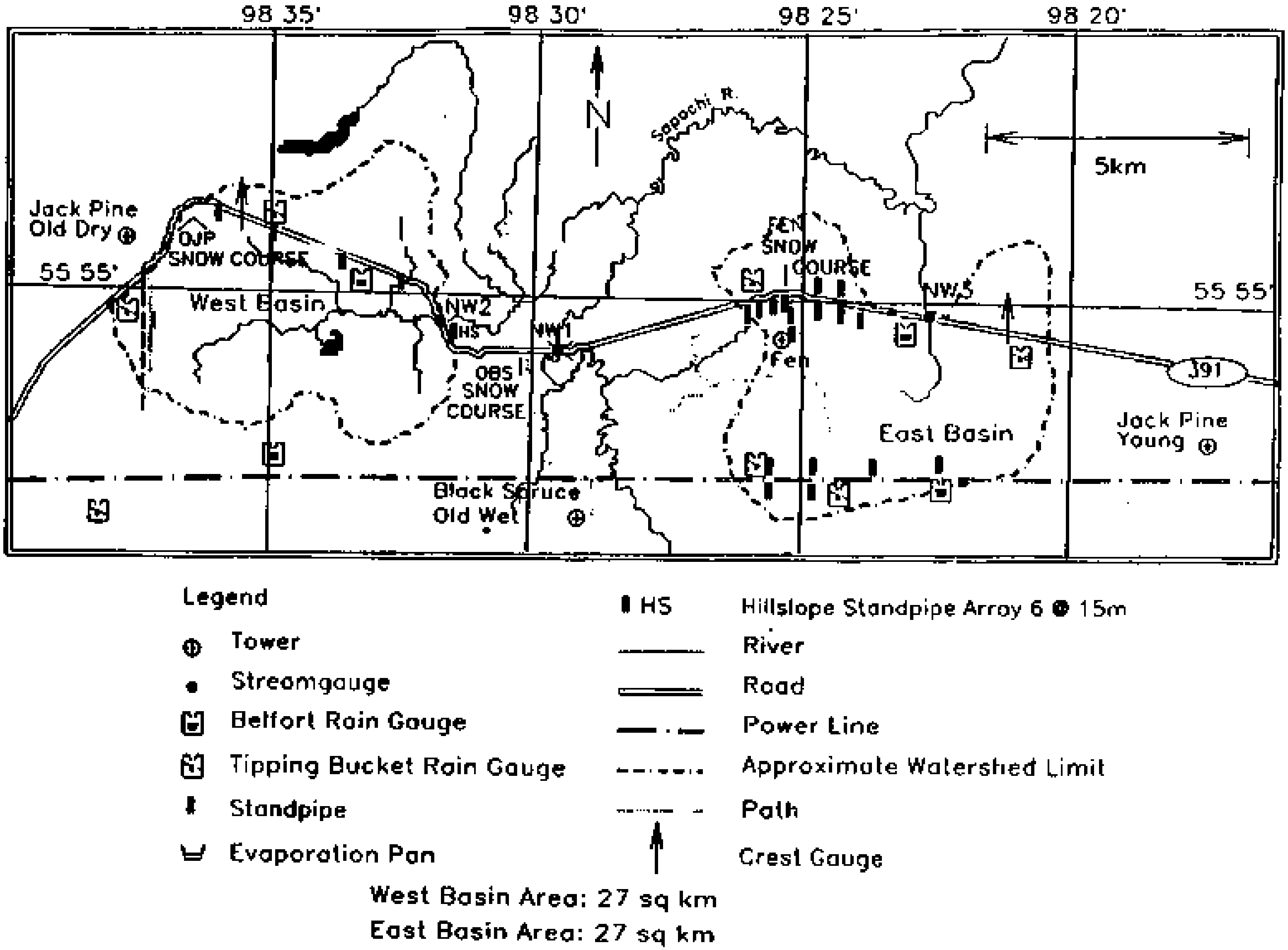

Figure 3.2.3.1c Map showing gauged sub-basins of the Sapochi River to be used for hydrologic modelling studies.

Table 3.2.3.1
Stream Gauge Summary Characterization

Area	Gage No.	Type	Location	Draw Area (Um2)	Operator[a]	Operating Period	Comments
SSA	SW1	primary	White Gull @ Hwy 106	576	WSC	10/93-10/95	year around
SSA	SW2	auxiliary	Old Jack Pine Cr at Harding Rd. Calvert	TBD	HYD-9	4/15-9/30/94	recording dial float gage (may have backmeter effects), to be checked weekly
SSA	SW3	auxiliary	White Gull Cr @ Hwy 120	TBD	HYD-9	4/15-9/30/94	recording float gage, to be checked weekly
SSA	SW4	auxiliary	White Gull Cr at Lorenz Lake Rd. off Hwy 120	TBD	HYD-9	4/15-9/30/94	recording float gage, to be checked weekly
NSA	NW1	primary	Sapochi River @ Hwy 391	436	WSC	Summer 93	year around
NSA	NW2	auxiliary	West Basin @ Hwy 391	27	HYD-9	5/15-9/30/94	recording float gage, to be checked weekly
NSA	NW3	auxiliary	East Basin @ Hwy 391	27	HYD-9	5/15-9/30/94	recording dial float gage to be checked weekly (will have backmeter effects)
NSA	NW4	auxiliary	East Basin from tributary @ HWY 391	χ3	TF-10	5/15-9/30/94	small tributary ≈ 1/2 km N of Fen tower
NSA	NW5	auxiliary	East Basin from subtributary	TBD	TBD	5/15-9/30/94	small subtributary to NW4
NSA	NW6	auxiliary	East Basin from subtributary	TBD	TBD	5/15-9/30/94	small subtributary to NW4
NSA	NW7	auxiliary	East Basin from subtributary	TBD	TBD	5/15-9/30/94	small subtributary to NW4

Core precipitation measurement will include, in addition to the White Gull and Sapochi Basin measurements, precipitation gages at each of the tower fluxes, etc., and additional precipitation gages in the vicinity of the NSA for tower in the small catchment immediately to the south of Highway 391 (to be operated by TF-10). All precipitation gages will be operated only from the thaw at least through IFC-3.

<u>SSA Precipitation Radar</u>

A major gap in the core data collection program is that areal precipitation coverage will be inadequate. Due to accessibility problems, deployment of an intensive rain gauge network for the entire SSA appears infeasible. Spatial variability of summer precipitation will make extrapolation of point measurements (e.g., from rain gauges in the vicinity of the tower sites) highly problematic. Therefore, a C-band truck mounted radar will be operated in the SSA (see map) for the period May 5 - September 20. AES in Saskatoon will produce radar precipitation estimates at a one hour time interval and a 2 km spatial resolution. A 12 km ground clutter zone and an obstructed sector will have no rain data. In the NSA, the spatial distribution of precipitation will be characterized entirely on the basis of precipitation gauges.

White Gull Lake Measurements

An evaporation pan will be placed near the northwest corner of White Gull Lake in the SSA. Access to the lake is possible using a existing trail from old Hwy 120 to the southern shore of the Lake (Figure 3.2.3.1a). Lake level and temperature will be recorded manually semi-weekly near the end of the trail. A piezometer transect will be installed in the fen that drains the Lake.

Water Table Measurements

Piezometer transects will be used to monitor near-surface water tables in order to provide indices of basin storage. In the SSA, the standpipes will be placed in bogs and fens 1-2 km apart along the Lorenz Lake Road and Hwy 913 (Figure 3.2.3.1a). In the NSA (Figure 3.2.3.1c), a West Basin transect will be placed south of Hwy 391 and along a N-S trail at the western edge of the Basin. The East Basin transects will be south of the highway and in low areas along the Manitoba Hydro power line.

A closely spaced downslope transect will be used in the West Basin near NW2 to study near-surface basin hydraulics. Transects will also be established north of Hwy 391 in the East Basin in order to assess through-road-embankment flow. All piezometers will be read on at least a semi-weekly basis from May to September.

3.2.3.2 Snow Measurements

The objective of the snow program is to provide a basic level of snowpack monitoring during the winter of 1993/94 to supplement the bi-weekly snow course measurements in the region. Snow course data will be collected by Environment Canada during the 1993/94 winter season at Hudson Bay, Nipawin, and Prince Albert in Saskatchewan, and at Churchill, Gillam, The Pas, and Thompson in Manitoba. Daily snow depth observations are available from each principal and climate station in the region. Six-hourly precipitation and snowfall data are available for synoptic and principal stations and daily measurements from climate stations.

Fixed 5-point snow courses (points 100m apart) were established in September 1993 - 5 in the SSA (mature aspen, mature jackpine, black spruce, open/regeneration, and young jack pine) and 3 in the NSA (old jackpine, black spruce, fen). Measurements of depth and water equivalent (and hence density) will be made bi-weekly beginning mid-November and ending after the thaw campaign, or when there is no snow. Extra depth observations will be made taken between points and selected depth profiles between and under individual tree canopies.

These data will provide background information for the detailed snow hydrology investigations and for others who require depth and water equivalent information to supplement available data. Detailed snow pack profile data are not currently planned to be collected as part of this program. These observations will be supplemented during the FFCs by individual investigations on snow hydrology and remote sensing.

One objective of HYD-3 is to classify the boreal biome into land cover classes of similar tree, understory, and soil characteristics. Presumably, these will have high spatial correlation with zones of similar net potential radiation and therefore, similar snow processes. Associated with this goal is the sampling of detailed snow profile measurements in each of the land cover classes, and the determination of the relationships between these data and the basic snow measurement program. (see above). Specific measurements include density programs, measured radially away from tree stems and in clearings, electromagnetic extinction properties throughout the spectrum (coordinated with RSS-16), calculated from microstructure and wetness, and transmission coefficients for non-reactive gases (coordinated with TGB-12). FFC-W and FFC-T write-ups in Chapter 5 for more details.

3.2.3.3 Soil Survey and Characterization

A soil survey at the soil series level of the 9 sites will be conducted. The area to be surveyed will encompass a 1 km region surrounding the location where the tower is placed, and will be mapped at a scale of approximately 1:5000.

The five tower sites within the southern region sites will be mapped and characterized by Darwin Anderson and assistants.

The four tower sites within the northern (Thompson/Nelson House) region will be mapped and characterized by Hugo Veldhuis (Agriculture Canada) and an assistant.

It is hoped that the survey can be completed by the end of the 1994 summer season.

A characterization pit will be dug for each of the major soil series identified in the soil survey. A detailed field description will be made to describe the morphological properties of the soil profile (including horizon identification and description, munsell color (including mottling), soil structure, estimate of root distribution, taxonomic and drainage classification, and site description (slope, aspect, cover, vegetation type)). Laboratory analyses to be performed on samples from these sites include bulk density, particle size distribution, moisture retention (.01,.033, and 1.5 MPa), estimate of hysteresis, hydraulic conductivity, total and inorganic carbon, total nitrogen, pH, cation exchange capacity, exchangeable acidity, and exchangeable cations. Organic samples from the Fen sites will include analysis of carbon content, total nitrogen, bulk density, pH, and other chemical characteristics.

Archive samples will be maintained for possible future analysis of other soil properties. It is desirable that all laboratory analyses be performed at the same lab for consistency of results and to minimize inter-laboratory errors. Thus, it is planned that samples taken from these pits will be sent to the Soil Survey Laboratory, Saskatchewan Institute of Pedology for laboratory analysis.

Additional surveying will be carried out at the northern site. This will include a map at a scale of 1:125,000 of the area within the modeling sub area boundary, which will be comparable to the soil map of the SSA. This map will be prepared by Agriculture Canada, based on standard soil mapping procedures used in Canada.

Soil characterization will also be required at the additional auxiliary sites outside the NSA along Gillam Road and along Route 391 south of Thompson. This activity should be identical to the characterization at the tower sites. This activity will be performed based on available resources.

3.2.3.4 Soil Moisture, Temperature and Soil Properties

Plans for soil moisture and temperature monitoring within the BOREAS project are described within Section 4.5. Tables 3.2.3.4a and b describe the activities and responsibilities involved with soil survey, moisture monitoring, and other soil related activities, see also section 3.2.4.7.

Soil water constants necessary to determine the soil water retention function and hydraulic conductivity function for all soil textures in the experimental domain will be determined by analysis of a combination of soil core and in situ data. Relationships for soils at the tower sites will be developed using the in situ data described in Table 3.2.3.4.b. Fitting constants for the van Genuchten (1980), Brooks and Corey (1964), Clapp and Hornberger (1978), as well as other retention and hydraulic conductivity functions will be determined using the combined soil core and in situ data.

Table 3.2.3.4a
Activities, responsibility for BOREAS soils survey, soil moisture monitoring and other soil-related activities

Southern Study Area (SSA)

Location	Survey Staff	Character-ization	Profile IFC	Soil Inter-IFC	Moisture Contin.	Tensio-meter	Infiltra-tion	Temp. Profile	Frost Tubes	Grav. Surfa
YJP	Anderson, Staff	Anderson, Staff	Cuenca	Anderson		Cuenca	Cuenca	Anderson	Davis**	Peck*
OJP	Anderson, Staff	Anderson, Staff	Cuenca	Anderson		Cuenca	Cuenca	Baldocch	Davis**	Peck*
OBS	Anderson, Staff	Anderson, Staff	Cuenca*	Anderson				Jarvis	Davis**	Peck*
OA	Anderson, Staff	Anderson, Staff	Anderson	Anderson	Voroney		Cuenca	Voroney	Davis**	Peck*
Fen	Anderson, Staff	Anderson, Staff	Cuenca*					LaFleur	Davis**	Peck*

Anderson	TE-1	Voroney	TF-1	Roulet	TGB-4
Cuenca	HYD-1	Davis	HYD-3	Wofsy	TF-3
Baldocchi	TF-5	Peck	HYD-6	Goulden	TF-3
Jarvis	TF-9	LaFleur	TF-10	McCaughey	TF-10

* TDR will be shared
** Davis will install. TF crews to read.
*** See Section 4.5.3.2.1

Northern Study Area (NSA)

Location	Survey Staff	Character-ization	Profile IFC	Soil Inter-IFC	Moisture Contin.	Tensio-meter	Infiltra-tion	Temp. Profile	Frost Tubes	Grav. Surfa
YJP	Staff	Staff	Cuenca	LaFleur	Need	Cuenca	Cuenca	LaFleur	Davis**	Peck*
OJP	Staff	Staff	Cuenca	Cuenca	Roulet	Cuenca	Cuenca	Roulet	Davis**	Peck*
OBS	Staff	Staff	Goulden		Wofsy			Wofsy	Need	Peck*
Fen	Staff	Staff	McCaughey	McCaughey	McCaughey					

** Davis will install. TF crews to read.
*** See Section 4.5.3.2.1

Table 3.2.3.4b
BOREAS TOWER SITE MEASUREMENTS

Southern Study Area - HYD-1 and TE-1

Young Jack Pine (HYD-1)

Variable	Device	Depth (cm)	Sites	Frequency (h)
Soil water content	Neutron probe	100	6	48
Soil water tension	Resistance blocks	100	2	48
Infiltration/Sorptivity	Tension infiltrometer		4	2/IFC

Old Jack Pine (HYD-1)

Variable	Device	Depth (cm)	Sites	Frequency (h)
Soil water content	Neutron probe	170	5	48
Soil water tension	Resistance blocks	170	2	48
Infiltration/Sorptivity	Tension infiltrometer		4	2/IFC

Aspen (TE-1)

Variable	Device	Depth (cm)	Sites	Frequency (h)
Soil water content	Neutron probe	130	5	48
Soil water tension	Theoretical retention function			
Infiltration/Sorptivity	Tension infiltrometer		4	2/IFC

Fen (HYD-1)

Variable	Device	Depth (cm)	Sites	Frequency (h)
Soil water content	TDR profiler	120	3	48
Soil water tension	Theoretical retention function			

Black Spruce (HYD-1)

Variable	Device	Depth (cm)	Sites	Frequency (h)
Soil water content	TDR profiler	120	3	48
Soil water tension	Theoretical retention function			

Table 3.2.3.4b (Continued)

Northern Study Area - HYD-1

Young Jack Pine (HYD-1)

Variable	Device	Depth (cm)	Sites	Frequency (h)
Soil water content	Neutron probe	60	5	48
Soil water tension	Resistance blocks	60	2	48
Infiltration/Sorptivity	Tension infiltrometer		4	2/IFC

Old Jack Pine (HYD-1)

Variable	Device	Depth (cm)	Sites	Frequency (h)
Soil water content	Neutron probe	160	5	48
Soil water tension	Resistance blocks	160	2	48
Infiltration/Sorptivity	Tension infiltrometer		4	2/IFC

Fen

Soil water retention function - Core data set
Hydraulic conductivity function - Core data set
No measurements planned

Black Spruce

Soil water retention function - Core data set
Hydraulic conductivity function - Core data set
No measurements planned

3.2.4 Auxiliary Site Work

3.2.4.1 Approach

Several kinds of field sites, beyond the tower flux sites, are needed for BOREAS. For example, it is anticipated that intensive biometric investigations for carbon budgets will be concentrated at six sites, representing the major forest types at the two study areas. Similarly, destructive sampling required for some terrestrial ecology studies will be carried out in conjunction with tower flux studies, but outside of the towers' wind aligned blobs or WABs. In addition to these special cases, many BOREAS investigations will require ground data from areas distinct from the tower flux sites, to spatially and conceptually extend the coverage those sites provide. Because there is substantial overlap in data required from auxiliary sites by various studies, a common network of about 70 coordinated auxiliary sites, with a set of basic staff science measurements, has been chosen. This is the plan for the design of that network.

The auxiliary sites can be grouped into six general classes with different measurement requirements and different aircraft acquisition priorities. The classes are (in rough priority order): (i) Tower flux annex sites, (ii) Carbon budget sites, (iii) Radiative transfer sites, (iv) Carbon model evaluation sites, (v) Allometry extension sites and (vi) Remote sensing/modeling study sites.

All auxiliary sites are at least 100 m on a side and consist of homogeneous vegetation cover. This minimum size requirement guarantees that at least one 30 m satellite remote sensing pixel can be reliably extracted within the site, given $\pm$ 1 pixel misregistration. The vegetation cover is homogeneous in the sense that the cover type can be represented by one spectral "signature" and can be characterized by a common set of mean values for its biophysical parameter (LAI, Biomass etc.). Each auxiliary site will be characterized by in situ measurements from sample plots (3 to 5) within the site, and by helicopter-acquired spectral measurements from above over a 30 x 30 m plot centered within the 100 x 100 m site.

Data acquisition priorities

The auxiliary site classes have been assigned priorities in terms of resource allocation for airborne and ground measurements. Of most concern to resource allocation are the site-specific airborne experiments requiring extensive fixed-wing or helicopter aircraft time to cover a single site, or labor-intensive ground measurements. Priorities will be used to allocate these limited resources to insure complete seasonal coverage of the highest priority sites. Category I sites consist of site classes (i), (ii) and (iii) since it is absolutely essential to acquire both detailed airborne and ground data at these sites. Category II sites consist of site classes (iv) and (v). The remainder, site class (vi) fall into category III. These are discussed in more detail below and are summarized by category in Tables 3.2.4.4a-d.

Category I Sites

(i) Tower flux annex sites: There are ten such sites, one such site near each TF tower, located on the lee side of the flux towers (based on prevailing winds) to represent as nearly as possible the vegetation characteristics of the WAB (wind-aligned blob) at the TF site. A large suite of measurements are being made at these sites by various teams and are described below under "measurements".

(ii) Carbon budget sites: These sites are for the purpose of obtaining detailed measurements of overstory, understory, and below-ground net primary productivity and annual carbon flux for model development. There are six such sites in BOREAS, five located at TF sites, and one, an aspen site in the NSA.

(iii) Radiative transfer sites: Sites with instrumented tramways are located at three SSA TF sites; mature aspen, pine and spruce. The tramways will be used to characterize the radiation levels above, below and within the canopies. Detailed optical properties, dielectric properties, canopy morphology and architecture measurements, as well as BRDF measurements will be made at these sites to develop and evaluate radiative transfer models. In addition, transect sites within the SE boundary of some TF site WABs, will be intensively characterized from ground and by aircraft spectral measurements.

Category II Sites

(iv) Carbon model evaluation sites: Measurements at these 10 sites (3 in the NSA, 7 in the SSA) provide data for independent evaluation of carbon flux models (Section 3.2.4.5.4). The carbon model evaluation sites will be at locations different from the carbon study sites for obvious reasons. Measurements of overstory, understory and below-ground NPP and carbon flux will be obtained at these sites, but with less labor-intensive methods than used at the carbon budget study sites.

(v) Intensive allometry sites: These sites will consist of 11 sites (4 in the NSA, 5 in the SSA and 2 outside the study area) at locations different than the TF sites (Section 3.2.4.5.5). Tree sacrifices will be conducted at these sites to evaluate and extend the allometric relations developed at the TF sites. Six of the intensive allometry sites are also carbon model evaluation sites. The sacrifices will not occur within the 30 x 30 m helicopter acquisition area.

Category III Sites

(vi) Remote sensing/modeling study sites: These sites will be used primarily to develop and evaluate remote sensing algorithms and for further evaluation of TE models. All other classes of sites will also be remote sensing/modeling study sites. Measurements of these sites related to remote sensing studies will consist of biometry measurements (DBH etc), and hemispherical photographs at multiple subplots to characterize stand-level biophysical characteristics such as LAI, Fpar, crown closure, etc. The primary variable for TE studies will be overstory NPP based on tree-increment cores (Section 3.2.4.5.6).

3.2.4.2 Requirements

There are two distinct issues in selecting auxiliary sites: (1) defining the objectives of the auxiliary site sample, and (2) defining the population to be sampled. The primary objectives for a site network were defined by the needs of BOREAS process modeling studies, of remote sensing algorithm development and testing, and for spatial extrapolation of ecological and biophysical measurements. However ambitious these needs might be, we are clearly not using auxiliary sites to estimate aggregate biome characteristics, i.e., biome-level carbon flux, biomass, average leaf areas, etc. Rather, we will attempt to understand the magnitude (bias and variance) of errors associated with process models and remote sensing algorithms, as a function of their most important dependent and independent variables. To do this, we need to make sure that our sample represents the range values for major independent variables. Then remote sensing products and geographical information systems could be used to perform spatial extrapolations and to scale up predictions to included unsampled areas. (A distinct effort by Forestry Canada will provide field verification of provincial forest cover maps, using a standard forest cruise with some supplementary data). The fiscal and logistical constraints on a site network should be obvious when one considers that simultaneous stratification on a modest number of categories of (i) dominant plant species, (ii) stand age, (iii) soil moisture and fertility, (iv) climate, (v) density or crown closure, (vi) disturbance type, and (vii) successional stage, would result in thousands of sample points, even with little or no replication. If more than cursory data are to be collected, a feasible design must have much less ambitious goals than full factorial sampling.

The initial plan was to stratify the area by species composition, stand development age, and site productivity, to assure that we get at least one sample within each of several ranges for the most important dependent model variables and independent algorithm variables. Out of a large number of cover types in the study areas, it was suggested that resources be concentrated on three major pure-stand forest cover types, and on a range of site productivities for mature stands, supplemented with three earlier age classes for each principal cover type. Non-forested wetlands must also be represented in the site network. For the development of remote sensing algorithms, sites need to represent spectrally homogeneous patches large enough so that effects of errors in registering data and locating stands on the ground can be controlled to modest levels. "Sites should at least be homogeneously heterogeneous." For process modeling and scaling up, it is important that sites represent samples of some defined sampling universe, rather than purely subjective selections. Finally, again for logistical reasons, site locations have to be constrained to be accessible to field crews for repeat sampling, with vehicle access nearby via roads or trails passable during the growing season. Clustering of contrasting sites would simplify flight plans of aircraft carrying remote sensing instruments (e.g., SAR acquisitions and helicopter borne radiometers). A form of spatially restricted stratified sampling is proposed, from among spectrally homogeneous patches. Assuming that more than one candidate site can be found within each stratum (which may not always be the case given the kinds of constraints we are imposing) we propose to select randomly among these candidates.

3.2.4.3 Stratification

Within the northern and southern study areas, the primary strata are: forested sites dominated by one of black spruce, jack pine, and quaking aspen, and fen wetlands (see Tables 3.2.4-a,b)

At the May 1993 workshop, this design was modified to add up to 6 mixed aspen/white spruce stands (a type of particular theoretical and economic importance) in the SSA. The network would also include low productivity jack pine "treed rock" among Forestry Canada allometry sites near Flin Flon. (Forested rock is of particular interest because of its widespread occurrence on exposed parent material of the Canadian Shield.)

Mature or stable fen vegetation would be stratified into two primary cover types, those with and without a high cover of tamarack (eastern larch), with 2 replicate sites identified in each class. Unstable fen vegetation types of greatest interest are not the same in northern and southern study areas. Fens with high tamarac density were eliminated in May because of resource limitations. Other fen sites (4) in the NSA will be closely tied to process studies in TGB and TE groups.

To facilitate inter-comparisons, similar sampling designs were used in each of the two BOREAS study areas. Finally, tower flux sites were counted as one occurrence of whatever category they occupy.

3.2.4.4 Site Selection

Site age or history was be identified using forest cover maps of the two study areas. For example, Manitoba cutting classes 0 and 1 are nominally recently disturbed, with canopies less than 3 m average height. Classes 2 and 3 represent intermediate ages. Classes 4 and 5 are mature or “overmature,” near or past typical rotation ages for that forest type. Site productivity for mature stands was assessed using a combination of data from "site potential" assessments associated with soil and forest cover maps and from spectral vegetation indices--indicating differential crown closure or canopy density. Relevant low productivity classes of forest cover included black spruce treed muskeg, jack pine treed rock, and hardwood treed rock. Recently established or intermediate age forest sites were assigned to one of the dominant forest cover types, thus evenly mixed or severely understocked stands were excluded from consideration. In areas with a history of repeated disturbance, those with some residual stems were acceptable but the bulk of the population represented establishment subsequent to a single dateable disturbance such as fire or loggings. Areas within 250 m of motorized access by road or trail were eligible, with the search area expanded to 500 m for uncommon strata.

Listed in Tables 3.2.4.4-a,b are the auxiliary sites selected to date in each of the BOREAS study areas that satisfy the requirements described above. They are further stratified into aircraft allocation priority categories in Tables 3.2.4.4-c,d. It should be noted that these sites are not final selections. Whereas they meet the criteria identified for suitable auxiliary sites their characterization into productivity classes is incomplete. In addition, not all those sites listed will be used, depending on redundancy and suitability as replicates. Eight candidates identified along the transect are not included in these tables. The geographic coordinates of most sites identified to date are included in Table 3.5.3.6 (in section 3.5.4 - BORIS Grid). This same table also includes the original site identifiers based on forest cover maps, which have since been superseded by the BORIS Grid identifiers used here. The most recent map of the sites in provided in Figures 5.1.5a, b.

Auxiliary site identification and selection is an ongoing process at the time of this writing. Descriptions of access to the sites selected to date is given in Tables 3.2.6-a,b. The distances listed to access the tie-in point on the road are not precise - they will be updated as soon as possible with more reliable distances and distributed to investigators. Access to the sites from the tie-in point can be considered reliable, but describes a transect through a stratification of the site - not the location of plot centers (which have not been established as of this printing).

3.2.4.5 Measurements

Measurements at the auxiliary sites will comprise a wide variety of data types. Some measurements will be made by science teams, other by staff science. In the following sections, we will detail the parameters being measured and the responsible teams. Where possible, we will refer to existing tables and descriptions within the experiment plan.

3.2.4.5.1 Tower flux annex sites (N=9)

Because the TF annex sites are selected to be as representative of the TF WABs as possible, the TF measurements from the WAB should be applicable to the corresponding annex sites. The suite of measurements from the TF towers are described in Table 4.2.3.2.

Table 3.2.4.4a
Auxiliary site strata and site allocation numbers (NSA).

Northern Study Area	Black Spruce	Jack Pine	Quaking Aspen	Mixed (Aspen/ J.Pine/ B.Spruce)	Fens	Totals
Productivity	**High Med Low**	**High Med Low**	**High Med Low**	**High Med Low**	**Treed Open**	
Mature and Late Intermediate	(Tower) T5Q7S, T0P8S S8W0S, T0W1S T7T3S, T0P7S	Q3V3P Tower, O9P	T2Q6A, P7V1A R8V8A Q3Z2A	T0P5M -- Q1V2M	(Tower)	**16**
Early Intermediate	**T6R5S** T4U8S, T4U9S T6T6S, T3U9S	-- T8Q9P, T7S9P T9Q8P	-- S9P3A **W0Y5A**, T4U5A, V5X7A	N/A	N/A	**12**
Recently Disturbed	-- U5W5S, U6W5S **T8S4S**, T7R9S	(Tower) -- T8S9P, T8T1P	-- T8S4A --	N/A	N/A	**8**
Totals	**16**	**9**	**8**	**2**	**1**	**36**

1) N/A indicates "not applicable" for those sites where no sites are desired, identified and/ or available.
2) Sites in bold print are suggested carbon-model evaluation sites.

Table 3.2.4.4b
Auxiliary site strata and site allocation numbers (SSA).

Southern Study Area	**Black Spruce**	**Jack Pine**	**Quaking Aspen**	**Mixed (Aspen/ W.Spruce)**	**Fens**	**Totals**
Productivity	**High Med Low**	**High, Med Low**	**High Med Low**	**High Med Low**	**Treed Open**	
Mature and Late Intermediate	Tower**, G6K8S**; H2D1S; **G9I4S**, D0H6S, G2L7S;	Tower**,** F7J0P; **G9L0P**, G1K9P, F7J1P; G4K8P, G7K8P;	Tower **D9G4A,** E7C3A; -- Batoche	G4I3M, F1N0M; H3D1M --	Tower	**21**
Early Intermediate	G2I4S -- --	-- -- **I2I8P**, F5I6P	**--** **B9B7A** --	**D9I1M**	N/A	**5**
Recently Disturbed	-- (+1) -- H1E4S --	Tower G8L6P --	D6H4A, (+1) D6L9A D0H4T --	-- H2D1M --	N/A	**8**
Totals	**9**	**11**	**8**	**5**	**1**	**34**

1) N/A indicates "not applicable" for those sites where no sites are desired, identified and/ or available.
2) Sites in bold print are suggested carbon-model evaluation sites.

Table 3.2.4.4c
Auxiliary sites organized by aircraft allocation category (NSA).

Northern Study Area		Black Spruce Grid-ID	Black Spruce Type (Age/NPP)	Jack Pine Grid-Id	Jack Pine Type (Age/NPP)
Category I	i	T3R8T	OBS Tower	T7Q8T T7S1T	OJP Tower YJP Tower
	ii	T3R8T	OBS Annex	T7Q8T	OJP Annex YJP Annex
	iii				
Category II	iv	T6R5S T8S4S	Intermed High NPP Young, Low NPP		
	v	T6R5S T8S4S	Intermed High NPP Young, Low NPP	T7S1T	YJP Tower site area
Category III	vi	T5Q7S T0P8S S8W0S T0W1S T0P7S T7T3S U6W5S T4U8S T4U9S T3U9S T6T6S T7R9S U5W5S	Mature, High NPP Mature, High NPP Mature, Mod NPP Mature, Mod NPP Mature, Low NPP Mature, Low NPP Young, Mod NPP Intermed, Mod NPP Intermed, Low NPP Intermed, Low NPP Intermed, Low NPP Young, Low NPP Young, Mod NPP (TF12)	Q3V3P O9P T8Q9P T7S9P T8Q9P T8S9P T8T1P	Mature, High NPP Mature, Low NPP Intermed, Mod NPP Intermed, Mod NPP Intermed, Low NPP Young, Low NPP Young, Low NPP

Northern Study Area		Quaking Aspen Grid-ID	Quaking Aspen Type (Age/NPP)	Mixed Grid-ID	Mixed Type (Age/NPP)	Fen Grid-ID	Fen Type
Category I	i					T8S9T	Tower
	ii						
	iii						
Category II	iv	W0Y5A	Intermed Low NPP				
	v	W0Y5A	Intermed, Low NPP				
Category III	vi	P7V1A R8V8A S9P3A V5X7A T4U5A T8S4A	Mature, High NPP Mature, Mod NPP Intermed, Mod NPP Intermed, Low NPP Intermed, Mod NPP Young, Mod NPP	T0P5M Q1V2M	Mature, High NPP Mature, Low NPP		

Table 3.2.4.4d
Auxiliary sites organized by aircraft allocation category (SSA).

Southern Study Area		Black Spruce	Black Spruce	Jack Pine	Jack Pine
		Grid-ID	Type (Age/NPP)	Grid-ID	Type (Age/NPP)
Category I	**i**	G8I4T	OBS Tower	G2L3T F8L6T	OJP Tower YJP Tower
	ii	G8I4T	OBS Annex	G2L3T F8L6T	OJP Annex YJP Annex
	iii	G8I4T	OBS Radiative Transfer	G2L3T	OJP Radiative Transfer
Category II	**iv**	G6K8S G9I4S	Mature, High NPP Mature, Mod NPP	G9L0P I2I8P	Mature, Mod NPP Intermed, Low NPP
	v	G6K8S G9I4S	Mature, High NPP Mature, Mod NPP Flin Flon Site, Low NPP	Tower	Young, High NPP
Category III	**vi**	D0H6S H2D1S H1E4S G2L7S G2I4S	Mature, High NPP Mature, Mod NPP Young, Mod NPP Mature, Mod NPP Intermed, High NPP	F7J0P G1K9P F7J1P G4K8P G7K8P F5I6P G8L6P	Mature, High NPP Mature, Mod NPP Mature, Mod NPP Mature, Low NPP Mature, Low NPP Intermed, Low NPP Young, Mod NPP

Southern Study Area		Quaking Aspen	Quaking Aspen	Mixed	Mixed	Fen	Fen
		Grid-ID	Type (Age/NPP)	Grid-ID	Type (Age/NPP)	Grid-ID	Type
Category I	**i**	C3B7T D0H4T	OA Tower YA Tower			F0L9T	Tower
	ii	C3B7T D0H4T	OA Annex YA Tower				
	iii	C3B7T	OA Radiative Transfer				
Category II	**iv**	D6H4A D9G4A B9B7A	Young, High NPP Mature, High NPP Intermed, Mod NPP	D9I1M	Intermed, Mod NPP		
	v	B9B7A	Intermed, Mod NPP Batoche, Low NPP	D9I1M	Intermed, Mod NPP		
Category III	**vi**	E7C3A D6L9A	Mature, High NPP Young, Mod NPP	G4I3M F1N0M H3D1M H2D1M	Mature, High NPP Mature, Mod NPP Mature, Low NPP Young, Mod NPP		

In addition to the TF tower measurements, the TE, TGB and RSS teams are cooperating to measure:

Stand-level structural parameters (except for YJP-NSA, see Table 4.3.3.1a),
Tree dimension data on 10 overstory canopies at each site (Table 4.3.3.1b)
Canopy optical properties at some sites (none at the SSA or NSA fen, and questions about NSA-OBS and NSA-YJP, see Table 4.3.3.1c) and
Soil CO_2 flux (Table 4.3.4.1)

The TGB teams, as shown in Table 4.4.3.1-a,b, will obtain measurements of vegetation and soil fluxes of various biogenic gases using cuvettes, flask, soil flux chambers and soil gas probes. Table 4.4.3.1-c,d shows which teams are measuring which gases at the TF annex sites. The few pages following these tables give additional detail describing these measurements.

The HYD teams will work at the TF annex sites as indicated in Table 4.5.3.1-a,b. These teams will measure soil moisture, snowpack properties, snow cover, canopy precipitation interception and rainfall at the TF annex sites. The rain gauge locations are shown in Table 3.2.3.1.

The RSS teams are measuring a large number of variables at the TF annex sites as shown in Table 4.6.3c through 4.6.3.1, which give the variables to be measured for each IFC. The variables include canopy architecture, dielectric constant, surface roughness, vegetation temperature, albedo, and biophysical parameters such as leaf area index, absorbed photosynthetically active radiation etc.

3.2.4.5.2 Carbon budget sites: (N=9) These sites include the TF annex sites, but have a mixed white spruce/aspen site in the SSA, an aspen site (Batoche) at the southern ecotone. At these sites, the TE group will conduct detailed measurements of organic matter and nutrient distribution (Table 4.3.3A), leaf-level measurements of carbon and water flux (Table 4.3.3 B) and miscellaneous data such as isotopic fractions, maximum photosynthesis, etc. (Table 4.3.3 C). The SSA mixedwood site may have incomplete closure of the carbon budget due to insufficient flux measurements.

3.2.4.5.3 Radiative transfer study sites: (N=3+) The radiative transfer study sites consist of 100 m long transects and the annex sites within the SSA OA, SSA OBS and SSA OJP. These three sites will be equipped with a 100 m long tramway above and below the canopy on which radiation sensors will be shuttled back and forth to measure multispectral bidirectional reflectance and within-canopy radiation levels. In addition, a number of detailed parameters will be measured that relate to the development of remote sensing models and algorithms as well as the relationships between canopy biophysical variables, processes and radiative properties. See Tables 4.6.3 for which variables are being measured at these locations during the various

IFCs. Transect sites within each of the TF Conifer site WABs will be intensively characterized See Section 4.6.3.1 TF Site WAB Transects for additional details

3.2.4.5.4 Carbon model evaluation sites: (N=10) The preliminary measurement requirements from the modeling groups include:

Hemispherical Photos
Leaf area index
Biomass (Foliage, Branch, Stem)
Fpar
Above ground NPP
Litter fall & chemistry
Foliar Nitrogen
Sapwood nitrogen
Sapwood thickness
Forest floor mass
Soil Chemistry (carbon and nitrogen)
specific leaf area
Leaf extension/expansion
Soil respiration

Our selection criteria were based on identifying sites that resembled the TF sites in age but span a range of productivities (low, high). Of the 12 possible sets, 10 candidates were selected. Three are in the NSA and seven are in the SSA.

We selected potential carbon-flux model evaluation sites by examining the range of measured tree age, DBH and heights from field surveys done by GSFC personnel in May and August of 1993. The field survey data of FC, done in the late Summer and Fall of 1993 were not yet available for inclusion in our selection, but many of the sites were visited by both GSFC and FC (in the following list, if no grid-id is given that site was not visited by FC field crews).

Northern Study Area

T6R5S	(BIH-9) Mature, relatively high productivity spruce. Location: South of Rt.391 between access to black spruce tower and Sapochi river. BIH-11 (no grid-id yet) is a possible alternate.
U6W5S	(BIL-21) Mature, low productivity spruce. Location: Trumbore (TGB-12) site on Gillam Road.
W0Y5A	(AIM-20) Intermediate age aspen. Location: West of Gillam Road 2km north of Odei river, 250 West of road (after Alder stand).

Southern Study Area

G6K8S	(BMH-9) Mature, relatively high productivity spruce. Location: East of Rt. 120, just after Harding road splits off to east.
G9I4S	BDL-20 Mature, low productivity spruce. Location: East of access trail to OBS tower.
G9L0P	(JHM-10) Mature, higher productivity jack pine. Location: East of Rt. 120, few km after Harding roads splits off to east.
I2I8P	(JIH-7) Intermediate age jack pine, lower productivity. Location: North of junction of Rt. 913 and Rt. 912, about 10km N of OBS tower.
D9G4A	Mature, high productivity aspen. Location: Just west of Candle Lake.
B9B7A	(AIM-13) Intermediate age aspen, high productivity. Location: Just south of aspen tower.
D9I1M	Mixedwood with TE canopy access Tower. Location: Near Candle Lake.

3.2.4.5.5 Intensive allometry sites: (N=11) There are 11 of these sites selected to overlap the carbon model evaluation sites where possible. As described earlier, the purpose of these sites is to extend the allometry in the TF annex sites to span a greater range of tree density and growth patterns than present in the TF sites. The stand-level structural and allometry measurements to be made at these sites are the same as those listed in Tables 4.3.3.1-a,b and will be made by the team indicated below.

Allometry site locations:

SSA:	Mixedwood (D9I1M) - FC Spruce (G6K8S) - FC Spruce (BDL-20) - FC Aspen (B9B7A) - FC Pine (YJP tower area) - Gower
NSA:	Spruce (T6R5S) - FC Spruce (BIL-21) - FC Aspen (W0Y5A) - Margolis Pine (YJP tower area) - Gower
Transect:	Spruce (Flin Flon) - FC Aspen (Batoche) - FC

3.2.4.5.6 Remote sensing/modeling study sites: ($N \cong 60$) These sites will serve primarily to develop and test remote sensing algorithms. All other auxiliary sites not previously described form this class. A reduced set of measurements will be made here as shown below.

Biomass	Forest floor mass
Leaf area index	% coarse fragment
Fpar	Litterfall & chemistry
NPP overstory	Foliar nitrogen
Stem density, basal fraction	Hemispherical photos
Species composition - overstory	
Species composition - understory	
Age of overstory	
Crown closure	
Shadow fraction from helicopter photography	
Sunlit canopy fraction from helicopter photography	
Sunlit background fraction from helicopter photography	
Tree height	
Crown diameter	
Crown depth	

There are 60 sites at which just the above measurements will be taken and are shown in tables 3.2.4.4a-d.

3.2.4.6 Hemispherical Photography

Overview:

Hemispherical (fisheye) photography will be used to (1) measure the angular distribution of canopy openings, (2) estimate fPAR, and (3) estimate LAI and leaf inclination for the BOREAS project study sites (tower flux, auxiliary, and mixed boreal forest sites). Field measurements and analyses will be coordinated with BOREAS staff efforts and Canadian contributions to biometric measurements. Estimates of fPAR (direct, diffuse, and total) from photographs will be validated using PAR sensor measurements, while LAI and leaf inclination estimates will be validated using both direct and indirect methods.

Photograph Acquisition

Acquisition of arrays of hemispherical photographs will permit examination of horizontal variation within each site and vertical variation in the understory and throughout low canopies. Photographs taken from towers will permit examination of complete vertical profiles for TF and TE sites. Pairs of photographs will be taken on opposite sides of the tower for each height. Not only will this permit analysis of canopy in photo directions away from the towers, it will also allow assessment of the impact of the towers themselves. Photographs will be taken for as many sites as possible during the middle of the growing season for all sites and for a phenological sequence at the tower flux sites.

Priorities for Photograph Acquisition

Because acquisition of hemispherical photographs is dependent upon weather conditions, sites have been prioritized.

Photograph Analysis

Sets of hemispherical photographs will be digitized using the Kodak PhotoCD system, catalogued, and made available as raw data in CD ROM format (2K x 3K x 24 bits/image). Analysis performed using the CANOPY image analysis system will involve classifying images to distinguish foliage and canopy openings and then calculating indices of gap fraction, fPAR, and LAI: (1) angular distributions of openings (as function of zenith and azimuth angles); (2) indirect site factor (ISF), direct site factor (DSF), and total site factor (TSF), estimates of diffuse, direct, and total fPAR based on appropriate latitude and assuming clear sky conditions; estimated LAI and leaf inclination based on inversion models. Intermediate analyses, consisting of tables of the angular distributions of openings, and summary analyses, consisting of estimates of fPAR and LAI, will be provided to BORIS. A generic version of CANOPY will be made available to permit novel analyses using raw or intermediate data. This will enable calculation of fPAR for any specified time interval and sky conditions and investigation of alternative inversion models to calculate LAI and other architectural characteristics.

Coordination with Other BOREAS Efforts

Estimates of fPAR and LAI from hemispherical photographs will be essential for many other BOREAS efforts. For validation of fPAR measurements, it will be important to acquire photographs from locations where ongoing measurements are available for PAR sensors (TF sites). For validation of LAI measurements, it will be important to coordinate direct biometric measure of LAI (by TE6, TE9, TE13, RSS16, RSS19) and indirect measurements of LAI LAI-2000, sunfleck ceptometer, and "walkman" instruments (RSS8). hemispherical photographs will be acquired employing intensive sampling arrays for sites where detailed reconstruction of canopy architecture is made possible using stem maps (TE20, RSS19, Rich). Hemispherical photographs will be used for parabola study sites (RSS1) to gain insights into relations between canopy architecture and radiative transfer. In addition, vertical and horizontal variation in fPAR will be related to within-canopy gas exchange properties (TE9).

Schedule

Phase 1: July 1993 to May 1994

1. Test Kodak Photo CD System for digitizing and archiving of hemispherical photographs
2. Begin developing generic version of CANOPY analysis system using independent funds..

3. Analyze preliminary data set from 1993 Petawawa BRDF field experiment (using boreal forest tree species in plantation plots) from IFC-93.
4. Acquire equipment and construct field fisheye systems.
5. Plan intensive field sampling for 1994 IFCs.

Phase 2: May 1994 to April 1995
1. Conduct extensive and intensive field sampling at all BOREAS sites.
2. Complete generic version of CANOPY analysis system.
3. Perform initial analysis.
4. Provide catalog of imagery and analysis to BORIS.
5. Identify gaps in comprehensive set of hemispherical imagery.
6. Begin synthesis with other BOREAS efforts.
7. Complete analyses of all variables for a subset of sites identified by the BOREAS Operations Group - Dec 94.

Phase 3: May 1995 to April 1996
1. Fill gaps in field sampling for BOREAS sites.
2. Make generic version of CANOPY available to BOREAS investigators.
3. Complete analysis of hemispherical imagery.
4. Provide full set of final data for inclusion in BORIS.
5. Complete synthesis with other BOREAS efforts.

3.2.4.7 Soil sampling at the auxiliary sites.

In order to provide meaningful information for modeling and characterizing soils within the auxiliary sites, certain information must be obtained.

Soils will be surveyed at each site and the typifying pedon described and classified to the soil series level. Samples will be taken by horizon to determine field estimates of texture, structure, color, horizonation, and thickness of horizons. If funding is available, samples should be taken by horizon to the laboratory for analysis of bulk density, particle size distribution, moisture retention, and cation characteristics.

Organic soils require additional field characterization. Horizons should be identified based on the degree of decomposition specifying the O, Of, Om, and Oh horizons. Measurements of pH as well as thickness of these horizons over mineral soil should be noted. Characteristics of the mineral soil (i.e. color, mottling, texture, etc.) should be described. Depth to water table and frozen horizons or their absence should be noted. In addition, if funding permits, bulk density should be measured for each of the horizons within the profile.

3.2.4.8 Schedule

Structural measurements and measurements of pool sizes could be made in single visits to each auxiliary site, by field crews working throughout the 1994 field season. Any phenological measurements, litterfall collections, and soil CO_2 fluxes would require periodic visits to each site. Distributed destructive sampling for LAI will need to be coordinated with intensive biometric measurements, so that allometric models using sapwood area or basal area to estimate peak LAI can be adjusted for differences in site productivity. It will not be feasible to make direct measurements of daily integrated *f*PAR at a large number of sites. Estimates from allometry and from under canopy sensors, such as the LiCor LAI 2000, could be complemented by subcanopy measurements taken during helicopter overflights. Also any direct measurements of soil moisture or plant moisture stress would be highly time dependent, and would have to be closely coordinated with the timing of remote observations.

There are a series of tradeoffs between the number of auxiliary sites included, the number and kind of measurements performed at each site, and resources diverted from other potential BOREAS efforts. Some kind of auxiliary site program is essential to many remote sensing and modeling efforts. Although it may appear modest, the effort proposed here is large and may not be fully feasible. Also we cannot add strata, replication, better spatial coverage, or measurements without eliminating other elements. Which elements of this design are most and least important? Are there serious flaws in it? If there are critical missing pieces, what other aspects should be deleted to address them?

3.2.5 Radiometric Calibration

3.2.5.1 Aircraft and Remote Sensing Instrumentation

3.2.5.1.1 Radiometric Scale Realization

In March and April 1994, there will be a radiometric scale realization (calibration comparison) coordinated by Bruce Guenther, 925 NASA/GSFC. This is scheduled to occur at Ames Research Center the week of March 21 and at the Institute for Space and Terrestrial Science at York University the week of April 4, 1994, and at Moffett Field, California, and is expected to include sources at least from the Jet Propulsion Laboratory, Goddard Space Flight Center, Ames Research Center and York University. This calibration comparison will provide a common scale for pre-BOREAS instrument calibrations. This scale will be available during the BOREAS campaign at a "tertiary" calibration laboratory site. This approach has been used for the SeaWiFS data product validation instrumentation.

The primary calibration source in the comparison is expected to have an uncertainty of less than 5 percent, in comparison to SI units. This accuracy should be obtained between 400 and 2300 nanometers; calibrations of channels in water vapor absorbing regions of the spectrum are expected to have greater uncertainty in calibrations at this time. Investigators who wish to participate directly in this comparison should contact Brian Markham by telephone at 301-286-5240.

3.2.5.1.2 On Site Radiometric and Spectral Calibration Sources

A 76 cm hemispherical integrating source with a 25 cm aperture will be located at the Prince Albert Airport, or Thompson depending on the active study area, during each of the 1994 IFC's. This source will be on casters and will be rotatable to provide a vertical or horizontal aperture. The source will be radiometrically calibrated from 400 to 2400 nm at a minimum of four radiance levels in the expected range of brightness levels to be observed at the BOREAS sites. This source will be calibrated by the NASA/GSFC calibration facility (Bruce Guenther, 925, NASA/GSFC) prior to shipment to the site and the calibration validated on site by this facility during the first and third IFC's (perhaps before the first IFC and between the second and third IFC's). Personnel will be available for one week during each IFC to assist/train users in its operation. The 122 cm hemispherical source will be available on site on at the times of the on-site calibration.

A 10 cm by 10 cm low temperature ~5° to 50° C black body calibration source will be available as noted above by the Prince Albert or Thompson airport.

Low pressure pencil Hg and Ar lamps will be available on site as above. A small integrating sphere will be available for use with these lamps. This activity will be coordinated by Brian Markham, 923, NASA/GSFC.

3.2.5.1.3 Diffuse Reflectance Reference Panels

One calibration panel from each investigation employing them as diffuse reflectance standards (~4) will be characterized prior to and after the 1994 field campaigns using the and/or the University of Nebraska (UNEB) field goniometer code 925 GSFC laboratory goniometer . Those investigators who desire to have their panels measured at the GSFC Facility, and whose panels are larger than 1' x 1', should contact Bruce Guenther by telephone at 301-286-5205 for additional information on these measurements. The UNEB calibration exercise will occur during the month of April 1994.

3.2.5.1.4 In-Flight Calibration and Comparison of Aircraft Instrumentation (R. Green, NASA/JPL)

Relatively uniform sites at or near the southern study area will be selected for in-flight calibration and comparison of the aircraft instrumentation (see RSS-18).

During IFC-2 at SSA, three canvas standard reflectance panels will be deployed as part of RSS-19 field activities related to an evaluation of atmospheric correction approaches for optical sensors. These three calibration panels are 8 meters square, have measured BRDF characteristic with nadir reflectances in 3 steps-between 0 and 32%. The location of these panels will be determined at the beginning of IFC-2. For further information, contact RSS-19, Norman O'Neill or John Miller.

3.2.5.2 Satellite Sensors

The orbital parameters, calibration coefficients and the in-flight calibration behavior of critical satellite sensors (SPOT-HRV, Landsat-TM, NOAA-AVHRR) will be tracked by Brian Markham (923, NASA/GSFC). These will be analyzed to provide overpass times and view angles (prior to field campaigns), gains and offsets, spectral responses and conversion factors for operational BORIS processing.

3.2.6 Standard Gasses and Gas Calibration

A number of TGB, TE and TF investigator teams require compressed gas cylinders at the field site laboratories during the 1994 IFCs. The two BOREAS Field Laboratories will be located at Paddockwood School (SSA) and in Thompson (NSA). Gas cylinders must be provided to these laboratories in advance of the first 1994 IFC (second week in May 1994).

The investigator requirements fall into two categories: A) "Working Standards", defined here as gas cylinders for which the approximate gas concentration has been determined to an accuracy of ~95%; and B) "Calibration Standards", defined here as gas cylinders for which the gas concentration has been been determined by the supplier to an accuracy of 99%, with a further rigorous determination of gas concentration by a second calibration effort to be conducted by Atmospheric Environment Service of Canada (AES), before shipment to the Field Labs. For the working standards, the gas supplier will be PRAXAIR Canada Inc. (9501 34th St., Edmonton, Alberta, Canada, T6B 2X6). The contact person is Mr. Barry Mottershead (Phone: 403-449-0778; FAX: 403-467-3938). For the calibration standards, the supplier will be Medigas of Toronto.

Methane and carbon dioxide gases are balanced and analyzed in air and will be provided in aluminum cylinders; pure nitrogen will be provided in steel cylinders. Clean Regulators will only be provided by BOREAS for the Calibration Standards.

Brass regulators to be utilized are two-stage for high purity, noncorrosive gases: type CGA-590 for the methane & carbon dioxide cylinders; type CGA-580 for the pure nitrogen.

Since many of the project needs are similar, and since the logistical issues are difficult for individual investigators to handle, the Canada Centre for Remote Sensing (CCRS/Jing Chen) has agreed to:

1) Establish, manage, and handle payments for a general BOREAS account with a gas supplier, to which the Calibration Standards and their regulators will be charged; separately arrange for payment by BOREAS of the AES calibrations;

2) Establish and manage BOREAS sub-accounts for individual teams, to which the cost of orders placed by investigator teams for "Working Standard" cylinders, regulators, and appropriate deposits on cylinders will be charged;

3) Coordinate requests from BOREAS investigators wishing to place orders for Working Standard cylinders & regulators, etc.;

4) Arrange for 2 sets of 8 gas cylinders & appropriate regulators for use as "Calibration Standards" to be sent from the supplier to AES for further calibration, and then directly to the BOREAS field laboratories at Paddockwood School (near Prince Albert) and Thompson in mid May 1994;

5) Arrange for shipping of "Working Standards" & regulators [from investigator's requests for inclusion in the BOREAS bulk order] directly from the gas supplier to the BOREAS field laboratories at Paddockwood School and Thompson in mid May 1994; and

6) Arrange for return of all empty cylinders from the field laboratories to the supplier.

I. General TGB, TE and TF Gas Standard Needs

A Calibration Standards

Eight-nine cylinders are included in the Calibration Standard Set. Each set includes 3-4 cylinders with methane ($CH4$ in air) and 5 with Carbon Dioxide ($CO2$ in air), which will be kept at the field laboratories. The CGA-590 type regulator works on all of these. The concentrations requested are:

$CH4$ in air: 0.5, 0.8-1, 2, and 9 ppmv; $CO2$ in air: 300, 355, 400, 700, and 2000 pmv.

B. Working Standards

Working Standards will be available at the same concentrations as Calibrations Standards (accuracy is 95%). In addition, nitrogen tanks (for pressure bombs) and one additional standard- - $CO2$ in air at 5% (50,000 ppmv) will also be needed. For methane and carbon dioxide, the regulator type CGA-590 is required; for the nitrogen, CGA-580. The list of Working Standards is: CH_4 in air: 0.5, 0.8-1, 2, and 9 ppmv; CO_2 in air: 300, 355, 400, 700, 2000 ppmv, and 5% (50,000 ppmv); N_2 (99.95% pure)

In practice, investigators will take their Working Standard cylinders to the appropriate field labs to accomplish intercalibrations with the Calibration Standard Set.

BOREAS teams (TGB, TE, and TF) will specify the number and kind of Working Standards required and order them [including regulators] through CCRS. CCRS will place the orders with the supplier, who will charge the costs to the appropriate sub-BOREAS accounts by team (e.g. TE-10). Orders must be placed by the individual BOREAS teams with CCRS well in advance of the IFCs. These Working Standards/regulators will be sent directly to the field labs.

II. Specific Needs

A. Specialty Calibration Standards

The Tower Flux teams requiring additional standards should make special arrangements with CCRS to have these cylinders provided according to your specifications, shipped, billed to your sub-account, and returned with the rest of the cylinders to the supplier.

B. Fuel and Carrier gases

Some TGB teams have a need for ultra-high purity gases (He, H, N_2). These should be handled in the same manner as those in II.A above.

3.2.7 BOREAS Thermal Radiance Measurement Intercomparison Plan

There is a need to conduct an inter comparison of all satellite/ airborne/ helicopter instruments with thermal channels (from about 8 to 12 microns) by obtaining near-simultaneous acquisition of measurements over Candle Lake in the Southern Study Area (SSA). This effort will allow a detailed analysis of surface temperature retrieval from multi-sensor, multi-resolution instruments, facilitate the identification of inconsistencies between instruments, and allow corrective measures to be performed as early as possible in the course of the experiment.

For the surface measurements, a hand held, well calibrated Everest Infrared Thermometer - IRT - (+/- 0.5 deg C) will be used to measure the radiative temperatures over water. This instrument will be carried to the center of the lake (or a region of the lake that is identified as deep and horizontally uniform) on a small boat. About 6 measurements during each of the IFCs are contemplated, preferably during the times of satellite / aircraft /helicopter overpasses. Additional instruments to measure the lake temperature are being considered as for example, an automated system on a buoy that would measure the kinetic temperature at different heights in the lake.

Surface measurements will be targeted for all TM overpasses (see below for a schedule) and in all likelihood, weather permitting, C-130 overpasses as well. All other aircraft and helicopter should coordinate with C-130 optical missions thereby obtaining several good data sets for useful inter comparisons.

Thermal radiance measurements of Candle Lake will also be made from the NASA helicopter and the NASA C-130 aircraft at two different altitudes. The helicopter will acquire infrared thermometer measurements (collected at the same altitude as data collected at the flux-tower and auxiliary sites). The C-130 will collect thermal measurements with the NS001 Thematic Mapper Simulator (TMS - Section 3.3.2.2), and an infrared thermometer mounted on the underside of the aircraft. Thermal data over Candle Lake will also be collected from the MODIS Airborne Simulator (MAS - Section 3.3.2.12), the Airborne Ocean Color Imager (AOCI - Section 3.3.2.8), and the Compact Airborne Spectro graphic Imager (CASI - Section 3.3.2.9).

Thermal data will also be extracted from the Landsat-5 Thematic Mapper (Section 3.3.1.6). Current predictions of dates and times of Landsat-5 overpass in 1994 are:

IFC-1		IFC-2		IFC-3	
29-May-94	17:20	25-July-94	17:20	02-Sept-94	17:20
07-June-94	17:20	01-Aug-94	17:20	11-Sept-94	17:20
14-June-94	17:20			18-Sept-94	17:20

As part of an intercomparison of retrieved surface temperatures, local radiosonde data will be used in conjunction with an atmospheric radiance model to correct the radiometer data for atmospheric attenuation. Local radiosonde soundings are already planned coincident with the Landsat overpasses as part of BOREAS core measurements.

3.2.8 Global Positioning System (GPS)

Based on a poll of GPS users participating in BOREAS, X-Y accuracies of 2-10 m are desired. Reaching the 2-10m accuracy objective will require the use of differential GPS procedures. It is planned to use post-processing differential procedures as there have been no requests for real-time applications. Most applications will be static, with few kinematic requirements. Receiver INdependent EXchange (RINEX) format will be the recommended format for GPS raw data logging. Data processing details TBD.

Differential GPS Procedures: Wide Area Differential GPS Procedures, a newly developed procedure from the Geodetic Survey Division of the Canada Center for Surveying, will be used to achieve the desired accuracies. This procedure essentially corrects the timing information from the NAVSTAR satellites that is collected by base stations as far apart as several thousand Km. The corrections are calculated by the Geodetic Survey Division and then made available to users via Internet. Differential software, developed by the Geodetic Survey Division, is then used with the corrected timing information to process rover GPS measurements to the desired positional accuracies. This software is to be made available to BOREAS personnel, at a nominal cost, sometime during early summer of 1994. The Canadian Government has installed a network of survey-quality GPS stations throughout Canada that serve as the base stations for this procedure. The two closest stations are Prince Albert and Churchill. This procedure will provide differential accuracies at both the SSA and the NSA.

Base Station at the SSA: BOREAS personnel wishing to pursue traditional differential GPS applications utilizing a base station will be able to pursue this option at the SSA. Base station data is available from three GPS base stations at the SSA as well as from the Canadian Government station. The Saskatchewan Institute of Applied Science and Technology (SIAST) has a Trimble Pathfinder system that they log data from 24 hours/day at 5 s intervals. They have agreed to log the data from at 1s intervals during IFCs. The data is currently available via Internet and via a modem. The useable range for this system is 500Km from Prince Albert. They have confirmed 2-5m accuracy figures via field tests at selected locations.

Tim Crawford (NOAA; AFM-1, TF-5) will be deploying a base station during the IFCs in support of his airborne measurements. This data will be available to BOREAS personnel. Distribution details TBD. There is also a private company in Saskatoon (Tri-City Surveys Ltd.) that logs GPS base station with a Trimble system at 5s intervals. This data is available from them at a reasonable cost.

Base Station at the NSA: It is planned to hire a student from SIAST that has experience processing GPS data. This student will provide in-field GPS instruction to BOREAS personnel, will oversee GPS for the experiment, will be making GPS measurements of BOREAS study sites with a rover unit, will process some data and will function as a member of an auxiliary site team. Supervision and coordination of the student and the additional rover units will be by BOREAS Ops, J. Newcomer (U.S. Staff), C. Walthall (RSS-3), J.

Cihlar (Canadian Staff) and by a faculty/staff member of SIAST. Questions concerning GPS for BOREAS should be directed to these individuals.

There are plans to rent/purchase at least two other GPS rover units for use during IFCs. These units will be capable of logging raw data from the NAVSTAR satellites and will be distributed to other auxiliary site teams. If other BOREAS researchers are planning to purchase or rent GPS units, it is recommended that they acquire devices that are of sufficient quality to achieve 2-10m accuracy using differential procedures.

NOTE TO GPS USERS: GPS users are urged to insure that they log the raw data used for GPS calculations (not Latitude/Longitude provided by mobile units). RINEX is the suggested format.

3.3 Satellite and Airborne Remote Sensing

3.3.1 Satellite Image Data Plan

The BOREAS digital satellite image data products will include observations from AVHRR-HRPT, ERS-1 SAR, GOES VISSR, Landsat MSS (multispectral scanner) and TM (Thematic Mapper), and SPOT HRV. The details of each of these are given in the following sections. Table 3.3.1.1a gives the spatial, spectral, and temporal coverages associated with each image type. Digital data from the U.S. Defense Meteorological Satellite Program (DMSP) (OLS and SSM/I) can be obtained from the official archive at NSIDC and NGDC (Boulder). Satellite overpass times are listed in Appendix O.

3.3.1.1 Landsat and SPOT

Landsat and SPOT coverage is shown in Section 5.2.4.

CCRS will acquire and provide both Landsat and SPOT data to BOREAS. CCRS operates two satellite receiving antennas at Prince Albert which can record Landsat, SPOT 2 and SPOT 3 data. Landsat 5 is performing well and it may be expected to last through IFC-3. Landsat data is routinely acquired and archived over Canada during the time period 3/15-10/31. There is no upper limit on acquisitions, and any Landsat data received during BOREAS may be requested subsequently.

CCRS and GSFC will process the Landsat data to Level-1a format, using control points supplied by BORIS to provide the information necessary to determine the geographic location of image pixels. It is expected that the distribution of derived data products within BOREAS will not be affected by copyright provided that non-disclosure agreement is signed by the

Investigator. Selected images will be processed by BORIS staff to reduce atmospheric effects.

In addition to the real-time acquisition of Landsat data, BOREAS staff has searched the Landsat archives to obtain a retrospective data set over the BOREAS study areas and transect. The Landsat data available from BORIS is shown in Table 3.3.1.1.b.

We have yet to receive final confirmation from SPOT Image on the feasibility of our data acquisition plan, but the following explains what it is we would like to acquire.

Four to five SPOT scenes centers have been selected to best cover our study areas and modeling sub-areas. By programming the satellite, we can capture most of our area of interest with just two scenes per study area, and more importantly, we can capture the whole modeling sub-area (MSA) within one scene.

The SPOT HRV cameras operate in either nadir acquisition mode or can be programmed to point to specific points or areas. We have specified coordinates for a modeling sub-area scene and an auxiliary site scene(s) at each study area (Figures 3.3.1.1a, b). Transect data will be collected in nadir acquisition mode.

The strategy we have requested SPOT Image to implement for BOREAS data collection through 1994 is as follows:

<u>During IFCs</u>
Acquire MSA and Aux Site scenes
SPOT2 (HRV 1 & 2) and SPOT3 (HRV 1 & 2)
Ratio of priority 3:1 MSA:Aux Site

<u>Between IFCs</u>
Acquire MSA and Aux Site scenes
SPOT2 (one HRV), SPOT3 (one HRV)
Ratio of priority 1:1 MSA:Aux Site

and Transect scenes
SPOT 2 (one HRV in nadir acquisition mode)
SPOT 3 (one HRV in nadir acquisition mode)

In all cases, whether MSA, Aux Site, or Transect is specified, the acquisition is actually a pass over the BOREAS Grid (1000 km in length) containing the specific area of interest.

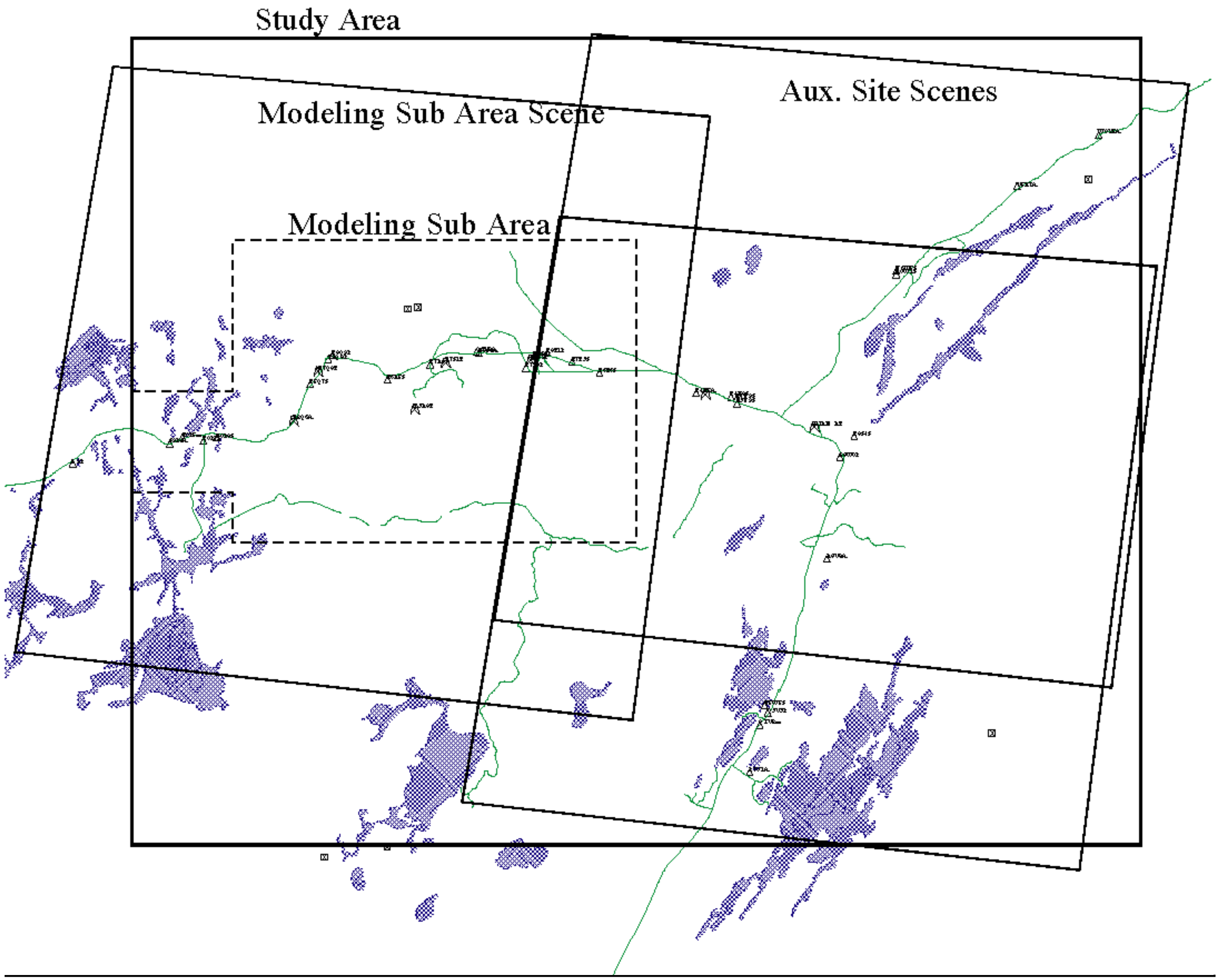

Figure 3.3.1.1a Northern Study Area SPOT Acquisition Plan

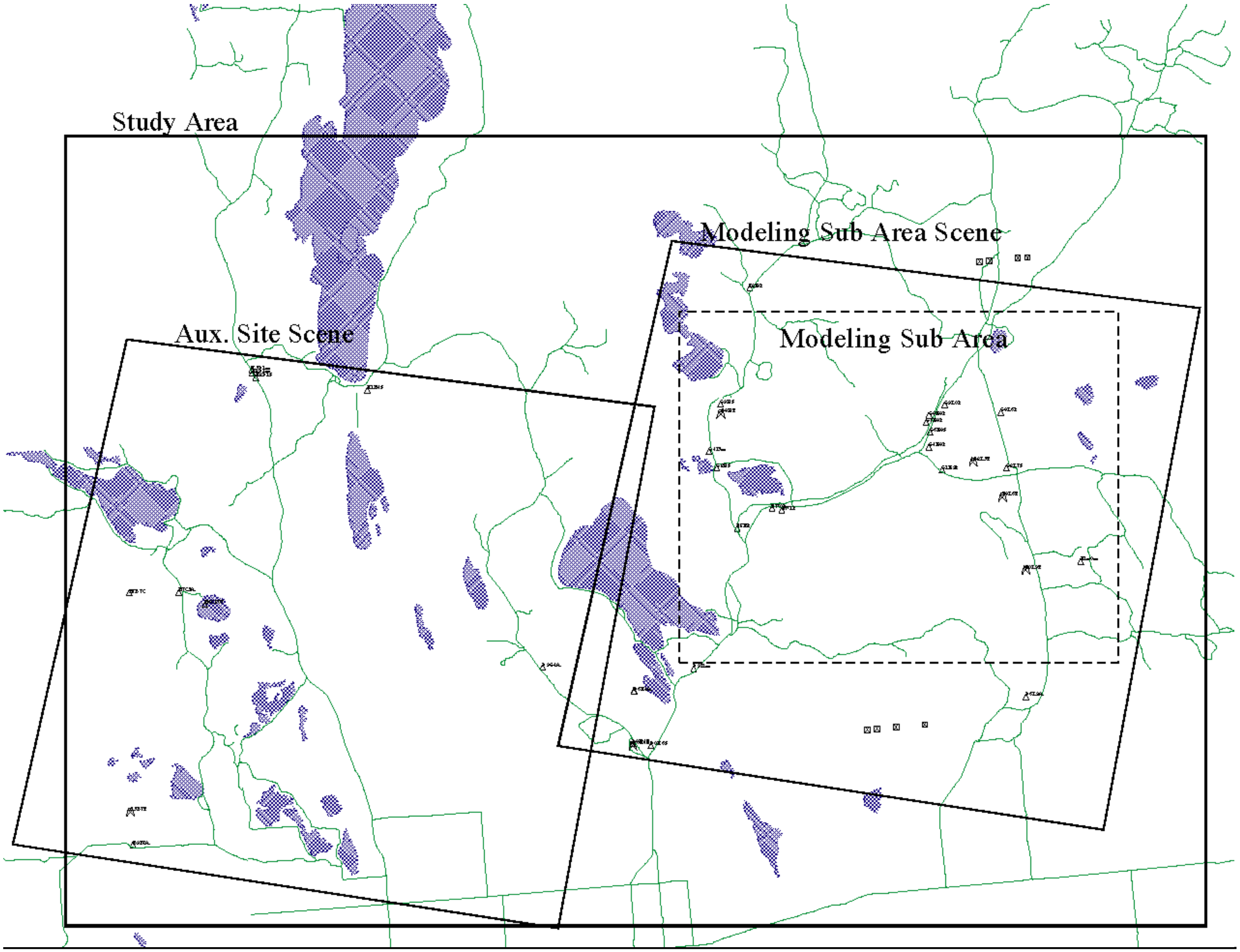

Figure 3.3.1.1b Southern Study Area SPOT Acquisition Plan

Table 3.3.1.1b Landsat Overpasses for 1994

	Southern Study Area (SSA)		Northern Study Area (SSA)		Transect from SSA to NSA	
Year	**Date**	**Scenes**	**Date**	**Scenes**	**Date**	**Scenes**
1972	2-Aug-72	40/21-22			21-Aug-72	37/22
					22-Aug-72	38/21
1973	1-Aug-73	40/21-22	15-Aug-73	36/21	30-Jul-73	38/21
			2-Sep-73	36/21		
1974						
1975			10-Jul-75	37/21		
1976	10-Jun-76	40/22	8-Aug-76	36/21	18-Jun-76	39/21-22
	25-Jul-76	40/22-23				
	16-Jul-76	40/21				
1977	21-Jul-77	41/22				
	8-Aug-77	40/22-23				
1978	15-Jul-78	40/22-23				
1979			7-Jul-79	37/21		
1980	22-Jul-80	40/22-23				
1981	18-Jul-81	41/22	13-Jul-81	36/21		
	22-Aug-81	40/22-23	1-Aug-81	37/21		
1982						
1983	27-Aug-83	37/22-23	5-Jul-83	34/21		
			31-Aug-83	33/21		
1984	11-Jul-84	?	22-Jun-84	33/21		
	12-Aug-84	?	1-Aug-84	33/21		
			17-Aug-84	33/21		
1985	7-Jul-85	37/22-23	17-Aug-85	34/21	2-Jul-85	34/21
1986	11-Aug-86	37/22-23	15-Aug-86	33/21		
	18-Aug-86	?				
1987	30-Aug-87	37/22-23				
1988	20-Jun-88	?	23-May-88	34/21		
	6-Jul-88	?	1-Jun-88	33/21		
	23-Aug-88	?	10-Jul-88	34/21		
			4-Aug-88	33/21		
			5-Sep-88	33/21		
			8-Jun-88	34/21		
			20-Aug-88	33/21		
1989	2-Jul-89	37/23				
	10-Aug-89	?				
	4-Sep-89	37/22-23				
1990	12-Jul-90	?				
	6-Aug-90	37/22-23				
1991	5-May-91	37/22-23				
	6-Jun-91	37/22-23				
	24-Jul-91	37/22-23				
	9-Aug-91	37/22-23				
	10-Sep-91	37/22-23				
1992						
1993	18-Jan-93	37/22-23	14-Feb-93	34/21		

3.3.1.2 AVHRR-LAC

CCRS will acquire AVHRR-HRPT data from NOAA-9 and NOAA-11 at its Prince Albert Satellite Station (PASS). These images will be processed and output by the Manitoba Remote Sensing Center using the CCRS GEOCOMP system and sent to BORIS for inventorying, reformatting, further processing, and distribution. Data for processing will be selected based on the assessment of cloud cover using quicklook images. The selection criteria will be more relaxed during the IFCs, but as a guideline, related images must be cloud-free for at least one SA and over 50% or more of the BOREAS region. Plans are for the AVHRR-LAC image products to cover the entire BOREAS region. The imagery will be gridded to match the established BOREAS grid. Potential derived image data products from AVHRR-LAC include regional vegetation index, visible and near IR reflectances, and surface temperature values. The planned temporal sampling of AVHRR-LAC is shown in Table 3.3.1.1c (subject to the above cloud cover limits).

3.3.1.3 ERS-1

ERS-1 data are available over the BOREAS sites and the majority of the ERS-1 coverage is collected and processed at the Alaska SAR Facility (ASF). The current plans for ERS-1 include having BOREAS personnel at JPL (JoBea Way) acquire the ERS-1 data through the ASF, perform subsequent processing, and deliver the image products to BORIS. Additional ERS-1 SAR coverage will be provided by CCRS to ensure that data are available for the entire BOREAS region. Both high and low resolution images will be acquired and made available. Table 3.3.1.2 summarizes the accessible data over the BOREAS sites for August 1991 - August 1993. This data set is planned for processing and distribution starting in 1994. Similar coverage and processing will occur for data collected in 1994.

3.3.1.4 GOES

BOREAS staff at GSFC are working with Dr. Eric Smith at Florida State University to arrange delivery of derived GOES image products over the BOREAS region. Current plans are for the data to include half-hourly images of insolation and PAR during the daylight hours and half-hourly images of of net radiation around the clock. Acquisition and processing of the GOES data will start as close to August 1, 1993 as possible and extend through October 1995 with hopes of later extending the coverage through October 1996. The planned 4 km resolution of the GOES pixels will result in image sizes of 256 by 256 pixels for covering the whole region.

Table 3.3.1
Definition of Image Data Processing Levels

Level	**Definition**
Level-0	Reconstructed, unprocessed instrument/payload data at full resolution.
Level-1a	Reconstructed, unprocessed instrument data at full resolution; time-referenced and annotated with ancillary information, including radiometric and geometric calibration coefficients and georeferencing parameters computed and appended, but not applied.
Level-1b	Level-1a data that has been processed to sensor units.
Level-2	Derived environmental/physical variables at the same resolution and location as the level-1 data.
Level-3	Variables mapped to uniform space-time grid scales.
Level-4	Model output or results from analyses of lower data (e.g., variables derived from multiple platform or temporal measurements)

Table 3.3.1.1a Satellite Instrument Information

Satellite	Bandpass Instrument/Band	(50% RSR)(μm)	Spatial Resolution	Repeat/Time
ERS-1	C-band (23° incidence)	NA	30 m (high)	Monthly
	VV polarization	NA	100 m (low)	Weekly
GOES	VISSR		4 km	48 per day
	Net radiation		4 km	48 per day
	Insolation and PAR			24 per day
Landsat-5	MSS/1	0.497 - 0.607	78 m	1 per 9 days
	MSS/2	0.603 - 0.615	78 m	
	MSS/3	0.704 - 0.814	78 m	
	MSS/4	0.809 - 1.036	78 m	
	TM/1	0.451 - .0521	30 m	
	TM/2	0.526 - 0.615	30 m	
	TM/3	0.622 - 0.699	30 m	
	TM/4	0.771 - 0.905	30 m	
	TM/5	1.564 - 1.790	30 m	
	TM/6	10.45 - 12.46	120 m	
	TM/7	2.083 - 2.351	30 m	
NOAA-9	AVHRR/1	0.570 - 0.699	1.1 km	2 per day
	AVHRR/2	0.714 - 0.983	1.1 km	
	AVHRR/3	3.525 - 3.931	1.1 km	
	AVHRR/4	10.33 - 11.25	1.1 km	
	AVHRR/5	11.39 - 12.34	1.1 km	
NOAA-11	AVHRR/1	0.570 - 0.699	1.1 km	2 per day
	AVHRR/2	0.714 - 0.983	1.1 km	
	AVHRR/3	3.525 - 3.931	1.1 km	
	AVHRR/4	10.33 - 11.25	1.1 km	
	AVHRR/5	11.39 - 12.34	1.1 km	
SPOT-1	HRV/1	0.500 - 0.588	20 m	
	HRV/2	0.615 - 0.658	20 m	
	HRV/3	0.773 - 0.865	20 m	
	HRV/PAN	0.516 - 0.715	10 m	
SPOT-2	HRV/1	0.506 - 0.591	20 m	
	HRV/2	0.627 - 0.670	20 m	
	HRV/3	0.792 - 0.884	20 m	
	HRV/PAN	0.525 - 0.706	10 m	
SPOT-3	HRV/1	0.506 - 0.591	20 m	
	HRV/2	0.627 - 0.670	20 m	
	HRV/3	0.792 - 0.884	20 m	
	HRV/PAN	0.525 - 0.706	10 m	
DMSP	OLS	0.4-1.1	0.6km or 2.4km	2 per day
		10.2-12.8	0.6km or 2.4km	
	SSM/I	19.35-V+HGHz	45x70 km	2 per day
		22.235-VGHz	40x60km	
		37.00-V+HGHz	30x38km	
		85.50 V+HHGHz	14x16km	

Table 3.3.1.1c
Planned acquisition of AVHRR HRPT data for BOREAS

Period	**Sampling Mode**	**Data Acquisition (expected maximum shown in all cases, actual acquisition to be based on cloud cover assessment)**
6/92 - 4/93	Monitoring	4 best daytime images/week Single best day/night pair per week
5/93 - 9/93	Intensive	All imagery (day and night)
10/93-10/94	Monitoring	4 best daytime images/week Single best day/night pair per week
5/94-10/94	Intensive	All imagery (day and night)

Table 3.3.1.2
ERS-1 Data Acquisition Opportunities for BOREAS

Site	**Resolution**	**Coverage Frequency**	**Transect/Scene Length**	**Number of Scenes /Year**
SSA	Low (100 M)	Daily transects of 1000 x 1000 km area	1000 km	4000*
		17-day maps of 1000 x 1000 km area	1000 km	
	High (30 m)	Weekly night transects of 1000 x 1000 km area	1000 km	
NSA	Low (100 m)	Daily transects of 1000 x 1000 km area	l00 km	72
		17-day maps of 1000 x 1000 km area	100 km	12
	High (30 m)	Weekly night transects of 1000 x 1000 km area	100 km	84*

*Subset will be selected for analysis

3.3.1.5 JERS-1

JERS-1 data have been requested from the JERS-1 Validation Project by JPL personnel. The planned data acquisitions are for one scene at each site for each FFC/IFC, giving only 12 total scenes. This limited data is based on the JERS-1 mission strategy of mapping the world as opposed to providing multitemporal data sets. CCRS will request JERS-1 data over the BOREAS SAs to be received at the Gatineau satellite receiving station. Josef Cihlar is the BOREAS contact on JERS-1.

3.3.1.6 SIR-C/X-SAR

The SIR-C/X-SAR mission currently includes the BOREAS sites as backup super sites (2nd highest priority). Both the Prince Albert and Thompson sites are included. Because of the geographic location of these sites in relation to SIR-C orbits, many acquisition opportunities will exist. There are many options for coverage scenarios. An initial plan is shown below. We are currently requesting L- and C-band quad polarization data and X-band VV. The approximate swath width is 10 km for mode 16 data (varies with incidence angle). Launch dates are currently scheduled for April 1994 and December 1994.

a. Sites

The following sites (center point and region) are listed in the SIR-C mission plan:

	Site	Latitude	Longitude
Prince Albert	Center	53.92	-106.69
	Box	50.00	-110.00
		50.00	-95.00
		60.00	-95.00
		60.00	-110.00
Thompson	Center	55.915	-98.43
	Box	50.00	-110.00
		50.00	-95.00
		60.00	-95.00
		60.00	-110.00

b. Coverage

The following coverage is currently available for the SIR-C mission. Current launch dates are April 1, 1994 and August 18, 1994; 8 to 10 day missions. This coverage will be repeated for the second mission.

Prince Albert

Data Take	Asc/Desc	MET	N/S	Look Angle	Mode
20.1	Asc	01/04:27:59	S	23.8	16x
36.3	Asc	02/04:9:21	S	28.4	16x
52.x	Asc	03/03:50:40	S	31.0	16x
68.3	Asc	04/03:31:10	S	35.5	16x
84.3	Asc	05/03:11:37	S	38.2	16x
100.3	Asc	06/02:51:46	S	40.4	16x
116.3	Asc	07/02:31:35	S	42.2	16x
132.4	Asc	08/02:11:04	S	43.7	16x
101.1	Desc	06/04:23:54	S	56.5	ScanSAR
117.1	Desc	07/04:03:42	S	56.4	ScanSAR
133.1	Desc	08/30:43:50	S	56.3	ScanSAR

Thompson

Data Take	Asc/Desc	MET	N/S	Look Angle	Mode
21.1	Desc	01/06:01:18	S	25.6	16x
37.1	Desc	02/05:42:38	S	24.1	16x
53.1	Desc	03/05:23:40	S	22.4	16x
69.1	Desc	04/05:04:25	S	20.6	16x
85.1	Desc	05/04:44:51	S	18.8	16x

c. Modes

Modes are currently set at mode 16 for the majority of the data acquisitions. Swath widths may be increased considerably on flight 2 if fewer L- and C-band channels are selected. ScanSAR coverage will be acquired on the last three descending passes over Prince Albert. The angles selected will be updated once the available swath options for ScanSAR are better known. The goal is to obtain a regional map of the BOREAS 1000 x 1000 km area. Funding for processing of the ScanSAR data is still uncertain.

d. Calibration

Calibration of the SIR-C/X-SAR data will be dependent on calibration done at the Raco site and applied to the BOREAS sites. Currently there is no funding available for BOREAS-specific calibration for SIR-C/X-SAR data; however, it may be possible to deploy up to 5 corner reflectors in the SSA in conjunction with IFC-T AIRSAR flights.

e. Minimum Surface Measurements if Non-IFC

If the SIR-C/X-SAR mission occurs between IFCs, some additional surface measurements will be required. These include soil and vegetation moisture, photosynthetic activity and water potential measurements. These measurements acquired by the Way (RSS-17) group will be focused at the Prince Albert black spruce and aspen stands.

f. Crew Observations

The astronauts will make dedicated observations of the SIR-C/X-SAR sites throughout the mission. For the BOREAS sites, observations will focus on weather, recent disturbances (fires, storm damage, clearcuts), leaf color, snow cover, cloud cover and type, and lake status (frozen, windy, calm). Observations all along data passes will be made. Documentation will be in the form of written notes and sketches and photographs. A stereo pair will be collected of each area (Prince Albert and Thompson) if a clear day is available.

3.3.2 **Airborne Sensor Data Plan**

Table 3.2.2 summarizes the aircraft and airborne instruments to be deployed in BOREAS. The data plans for each instrument are covered in the following subsections.

3.3.2.1 C-130/MAS; Staff (Ungar)

MODIS Airborne Simulator (MAS) data will be acquired only during IFC-2. MAS is a multispectral whisk-broom scanner. The MAS acquires digital radiometric data (at 12 bit resolution) for 50 spectral bands between 520 nm and 15 μm as shown in table 3.3.2.1.a. The instrument's instantaneous field-of-view (IFOV) is 2.5 milliradians. However, samples are obtained at increments of approximately 2 milliradians from 43 degrees on one side of the nadir to 43 degrees on the opposite side, producing approximately 700 (partially overlapped) pixels per scan line.

The altitude for data acquisition will tentatively be 7.5 km with a ground speed of 200 knots. The spatial resolution or ground field-of-view (GFOV) is 19 meters at nadir and the full scan swath-width is 14 km. At a scan rate of 6.25 rps, the MAS will be over-sampled in the along-track direction (providing scanline overlap) as well as in the along-scan direction. Although the MAS will be the principal instrument for obtaining wide area coverage, it will always be flown in conjunction with the ASAS and NS001-TMS.

There will be a concerted effort to produce highly calibrated data, based on pre- and post-flight measurements made with an integrating hemisphere. The MAS has provision for internal (on-board) thermal calibration with the

Table 3.3.2 Airborne Remote Sensing Instruments in BOREAS

Aircraft	**Sensor**	**Team**	**Investigator**
C-130	ASAS	RSS-2	Irons
	NS001/TMS	Staff	Angelici
	POLDER	RSS-20	Vanderbilt, Breon
	MAS	Staff,Modland	Ungar,Modland
	ATSP	RSS-12	Wrigley
CV-580	SAR	TE-16	Hawkins
DC-8	AIRSAR	RSS-16	Saatchi
Twin Otter	AMMR	HYD-2	Chang
ER-2	AVIRIS	RSS-18	Green
	MAS,AOCI	Staff,Modland	Ungar,Modland
Piper Chieftain	CASI	RSS-19	Miller
DC-3	MEIS	Staff	Chen/Gauthier
Aerocommander	©-ray	HYD-6	Peck
Helicopter	C-Band Scatt	Staff	Gogenini
	ATSP	Staff,RSS-3	Hall/Walthall
	SE-590, MMR	RSS-3	Walthall

presence of two black body temperature sources. It is anticipated that one of these sources will be operated at a fixed temperature of 30 degrees K while the other will "float" at ambient temperature. The temperatures of both sources will be monitored. Additional external thermal calibration will be attained by flying over Candle Lake while measurements of surface temperature are being made.

Although it is anticipated that 12 bit data will be available on all 50 MAS channels during IFC-2, provision is being made for a back-up mode of observation, as indicated in Table 3.3.2.b, in the event of failure of modifications currently being made to the MAS instrument. Navigation and instrument data will be interleaved real-time and recorded on 8 mm EXABYTE tapes. The data collected will be viewed immediately after each flight through a quick-look capability available on a SUN SPARC Workstation at the site. The EXABYTE tapes will be duplicated, one copy being sent to GSFC for special processing, the other retained by AMES for their normal processing and data screening. At GSFC, the data will be radiometrically corrected and geometric distortions removed through a joint effort of the MODIS Science Data Support Team (SDST) and the BORIS.

Table 3.3.2.1a MODIS Airborne Simulator (MAS) Spectral Characteristics

Spectral Band	Center (μm)	Width (μm)	Spectral Range (μm)
1	0.547	0.043	0.529-0.572
2	0.664	0.055	0.635-0.688
3	0.707	0.042	0.688-0.729
4	0.745	0.040	0.729-0.769
5	0.786	0.040	0.770-0.810
6	0.834	0.042	0.810-0.852
7	0.875	0.041	0.852-0.893
8	0.910	0.031	0.896-0.927
9	0.945	0.043	0.926-0.969
10	1.623	0.057	1.395-1.652
11	1.680	0.050	1.655-1.705
12	1.730	0.050	1.705-1.755
13	1.780	0.050	1.755-1.805
14	1.830	0.050	1.805-1.855
15	1.880	0.050	1.855-1.905
16	1.930	0.050	1.905-1.955
17	1.980	0.050	1.955-2.005
18	2.030	0.050	2.005-2.055
19	2.080	0.050	2.055-2.105
20	2.142	0.047	2.126-2.173
21	2.180	0.050	2.155-2.205
22	2.230	0.050	2.205-2.255
23	2.280	0.050	2.255-2.305
24	2.330	0.050	2.305-2.355
25	2.380	0.050	2.355-2.405
26	3.000	0.150	2.925-3.075
27	3.150	0.150	3.075-3.225
28	3.300	0.150	3.225-3.375
29	3.450	0.150	3.375-3.525
30	3.600	0.150	3.525-3.675
31	3.725	0.151	3.659-3.810
32	3.900	0.150	3.825-3.975
33	4.050	0.150	3.975-4.125
34	4.200	0.150	4.125-4.275
35	4.350	0.150	4.275-4.325
36	4.503	0.142	4.436-4.578
37	4.651	0.150	4.582-4.732
38	4.800	0.150	4.725-4.875
39	4.950	0.150	4.875-5.025
40	5.100	0.150	5.025-5.175
41	5.250	0.150	5.175-5.325
42	8.563	0.396	8.342-8.738
43	9.642	0.426	9.451-9.877
44	10.438	0.466	10.259-10.725
45	11.002	0.448	10.791-11.239
46	12.032	0.447	11.799-12.246
47	12.775	0.447	12.539-12.986
48	13.186	0.352	13.023-13.375
49	13.952	0.517	13.630-14.147
50	14.302	0.358	14.163-14.521

Table 3.3.2.1b
Fall-back selection of MAS Bands for
IFC-2 (Summer 1994 Campaign)

Center (μm)	Width (μm)	Radiometry (bits)	Feature
0.547	0.043	8	green peak
0.664	0.055	8	chlorophyll
0.745	0.040	8	NIR plateau
0.786	0.040	8	NIR plateau
0.834	0.042	8	NIR plateau
0.875	0.041	8	aerosols
0.945	0.043	8	water vapor
1.623	0.057	8	pollutants
2.142	0.047	8	mid-IR water
4.050	0.150	8	
11.002	0.448	8	surf temp
12.032	0.447	8	surf temp

Distribution to BOREAS investigators will be made through the BORIS while the data will be made available to the wider EOS community through the SDST MAS distribution system.

3.3.2.2 C-130/ASAS; RSS-2 (Irons)

ASAS data will be acquired during the three IFC's for investigation RSS-2, and in FFC-T for HYD-3. ASAS is an airborne, off-nadir tilting, imaging spectroradiometer. The ASAS dataset will consist of multi-angle digital images of selected 1 km^2 sites.

ASAS acquires digital image data for 62 spectral bands between 420 nm and 1030 nm. The spectral resolution is approximately 11 nm and the spectral sampling increment is approximately 10 nm between band centers. The sensor is rigorously calibrated and the data will be provided in units of absolute at-sensor spectral radiance. An ASAS scene will typically contain over 200 Mbytes of data.

An ASAS scene of a particular site will consist of a sequence of up to 10 sub-images where each sub-image will be acquired from a different tilt angle (i.e., view zenith angle). The tilt angles will range from 70° forward to 55° aft. The sub-images will be acquired by initially tilting the sensor field of view forward as its platform aircraft approaches a target site. The target will then be tracked through a discrete sequence of fore-to-aft tilt angles as the aircraft flies over and then past the site.

The altitude for data acquisition will be approximately 17,500 feet (5334 m) above ground level. At nadir, the spatial resolution is 3.7 m and the swath width is 1870 m from this altitude. The altitude is flexible depending on requirements from other investigators.

Target sites for the FFC-T will be all tower flux sites at the NSA, and if snow conditions are met, three tower flux sites in the SSA (Old Aspen, Old Black Spruce, and Old Jack Pine). The required conditions for a Thaw C-130 mission in either the NSA or the SSA have been set by the HYD-3 team at a minimum of 25 mm snow water equivalent. During the IFCs, ASAS will acquire data over all five tower flux sites in the SSA, and all four tower flux sites in the NSA.

Flights may be repeated over some target sites during each IFC if time permits. The strategy will be to acquire ASAS data for a range of solar zenith angles and from multiple view zenith angles, in up to three azimuthal planes: parallel to the solar principal plane, perpendicular to the solar principal plane, and oblique to the solar principal plane. A priority will be placed on flying along the solar principal plane over each target site.

Raw ASAS data will be processed and radiometrically calibrated, with a final standard archive product of at-sensor spectral radiances. Signal to noise ratios for each spectral channel will be provided in ASCII headers. ASAS images delivered to BORIS will have been screened for site coverage, clouds, excessive aircraft motion, and data quality, however the standard product for all ASAS datasets will not include geometric registration or atmospheric correction. Ongoing ASAS research and development into efficient/successful geometric registration and atmospheric correction of multiple angle data may result in a limited number of datasets which will be processed to these levels, however it must be stressed that these datasets will be beyond the standard processing.

3.3.2.3 C-130/NS001-TMS, Staff (Angelici)

NASA's NS001 is a wide-angle scanner referred to as a Thematic Mapper Simulator (TMS). It has 7 channels similar to the Landsat Thematic Mapper, plus an additional channel in the 1.13 - 1.35 mm waveband. It has a 2.5 milliradian instantaneous field of view (IFOV) and a scan angle of 50 degrees either side of nadir. The NS001 IFOV provides a footprint of 12.2 meters at nadir at an altitude of 4877 meters (16000 feet), or 20.2 meters at an altitude of 8077 meters (26500 feet). There are 700 pixels in each NS001 image record. The number of records per flight line varies with the aircraft altitude and flight line length. The pixel values of the images can range from 0 to 255 and are stored in a single byte.

Beginning with Level-0 processing, NS001 image data obtained in grid coverage overflights will be screened. Notes as to cloud cover and data quality will be recorded, and subset areas encompassing tower and flux sites will be selected for acceptable flight lines. It will be ensured that selected areas will include overlap between flight lines.

A Level-1a data product consisting of several components will be generated for areas previously selected for subsetting. Separate files of instrument counts and of housekeeping data for each channel will be written to erasable optical disk. In addition, calibration coefficients obtained from the staff science calibration effort will be used to calculate instrument gains and offsets. General summary and calibration information will be written to an ASCII header summary file, which will be used as the leaf file on all Level-1a products.

Navigation data with sufficiently high temporal resolution and geo-locational accuracy should be available in time for the BOREAS overflights. GPS (global positioning system) readings, obtained at ground stations near the study areas, will be used after the flight to differentially-correct GPS readings obtained on the C-130. These capabilities will allow "automatic" geo-rectification of NS001 data, assigning a latitude and longitude value to each pixel in each scan line. Files of latitudes and longitudes will be written to disk. Files of view zeniths and view azimuths will be calculated from the geotagged files. Should the geometric rectification prove inaccurate, techniques of control point selection and location triangulation (rubber sheeting) will be employed. Summary information of viewing and solar geometry will be added to the ASCII header file. All Level-1a files will be copied to 8mm data grade magnetic tape and delivered to BORIS.

At-sensor radiance will be calculated from Level-1a images and summary information, such as instrument gains and offsets, for all pixels. These Level-1b data products will be stored on optical disk and made available to BOREAS investigators upon request.

Level-1b visible and near infrared channel data will be atmospherically corrected using optical thickness data cross-referenced with the imagery and interpolated to the sensor band centers using log-log fits of wavelength and optical thickness. This effort will be coordinated with Wrigley (RSS-12). Default values derived from standard continental atmospheres will be used for gases that are uniformly mixed in the atmosphere (CO_2,O_2) and for O_3. Water vapor will be estimated from radiosonde profiles (see thermal channel corrections, below). The 6S atmospheric radiance model will be used to derive atmospheric correction coefficients (path radiance, scattering, transmission, path transmission, spherical albedo) across variable scan angles / path lengths for correcting the imagery.

Thermal channel data will be atmospherically corrected using radiosonde profiles, cross-referenced with the imagery. The radiosonde data will be resampled to the maximum number of levels allowed as input to the Lowtran 7 atmospheric radiance model, with disproportionate sampling in the atmospheric boundary layer. Correction coefficients (transmission and path emission) will be derived and used to correct the imagery, interpolating across variable scan angles / path lengths.

The Level-2 products of surface reflectances and temperatures for each pixel in the subset images will be quality checked and saved on optical disk. The values will be written to 8mm data grade tape, which will be sent to BORIS where they will be loaded into the on-line system for data requests.

From the Level-2 images, geometrically-corrected data products will be created. Using the latitude and longitude files generated during Level-1a product generation, the pixels of each image will be re-mapped to a latitude and longitude grid at the resolution of the instrument at the time of data acquisition. The accuracy of the rectification will be verified with tie points selected throughout the image. The image will be converted to Albers Equal Area conic projection and sent to BORIS on 8mm data grade magnetic tape as Level-3 data products.

The possibility of producing mosaicked images of the grid coverages may be required and will be investigated. Images will be selected at the outset such that mosaicking can be performed if necessary. The MAXMIN function or other image processing package routines will be used to determine the selection of pixels between adjacent overlapping Level-3 images. The mosaicked products will be stored on 8mm data grade tape and delivered to BORIS.

Based on the results from FIFE, it is expected that approximately 120 to 140 NS001 acquisitions will be processed to Level-1a status (60 to 70 at each study area; approximately 10 dates with 6 flight lines per date). About half of the Level-1a acquisitions will be processed to Level-2 status (30 to 35 at each study area; approximately 10 dates with 3 flight lines per date). An as-yet-undetermined number of Level-3 products will be created and possibly mosaicked. In addition, flux tower and auxiliary sites will be located and data for these sites will be extracted from processed Level-1a and Level-2 data products. Images and calibrated radiances will be loaded into BORIS. All of these site radiances will be corrected to surface reflectance or temperature as described above.

3.3.2.4 C-130/ATSP; RSS-12 (Wrigley)

The Airborne Tracking Sun Photometer (ATSP) is mounted on top of the C-130 aircraft and measures atmospheric transmission between the sun and the aircraft in six spectral bands, 380, 451, 526, 860, 940, and 1060 nm. The instrument is mounted outside the aircraft skin to avoid looking through any window which might affect the instrument's calibration. The detectors are temperature stabilized at 45 degrees Celsius so neither cold ambient air at altitude nor warm surface temperatures would influence the calibration. The ATSP tracks the sun continuously and acquires data in all six bands every 2 seconds and records them on a hard disk drive in a dedicated, PC-based, data acquisition system. Housekeeping data as well as data from the aircraft data system (altitude, pressure, latitude, longitude) are recorded at the same time also. Real-time display of the data is possible for all six raw detector voltages simultaneously; real-time display of preliminary optical depths derived from the raw voltages and pre-mission calibration coefficients are also possible. (Final aerosol optical depth values await acquisition of post-mission calibration coefficients and subtraction of calculated optical depths due to molecular scattering, ozone absorption, and NO_2 absorption.)

For a BOREAS flight, a typical data acquisition sequence would be:

a) Five minutes of data prior to takeoff when the sun is unobscured,

b) Approximately one minute of data at the lowest altitude permitted over a lake near the site prior to ascent,

c) Five to thirty minutes of data during ascent,

d) Two to ten minutes of data along each C130 flightline,

e) Five to thirty minutes of data during descent,

f) Approximately one minute of data at the lowest altitude permitted over a lake near the site prior to landing, and

g) Five minutes of data after landing when the sun is unobscured.

Due to the large separation of the BOREAS sites from the base airports, it is appropriate to acquire ATSP data at the lowest altitude permitted near each of the two major sites (PA and NH) but operational considerations (including NS001 fogging) limit such acquisitions to periods prior to ascent and after remote sensing data collection. Such a BOREAS flight would generate 60-120 minutes of data or 1,800-3,600 data records. Processed data records are normally constrained to 128 bytes for convenient lineprinter output. Hence, a typical single flight output from the ATSP would be in the neighborhood of

200-500 kilobytes. During FIFE, an occasional flight would generate up to 9,000 records or 1,000 kilobytes. It is anticipated that there would be 10-20 flights per IFC.

The ATSP will be calibrated before and after the principal IFCs at Mauna Loa Observatory in Hawaii where high altitude and stable air in the early morning usually provide 2-4 good Langley plots in a 10-14 day period. Good Langley plots can be extrapolated to provide "zero airmass voltage intercepts" for each band. These intercepts will be interpolated to values appropriate for each IFC.

Processing ATSP data into aerosol optical depths involves calculating the airmass from position information (lat /long /altitude /time /solar position), calculating total optical depths using "zero airmass voltage intercepts" derived as above, and subtracting optical depths due to Rayleigh scattering, ozone absorption, and NO_2 absorption. Although preliminary aerosol optical depths will be submitted to BORIS within 60 days of the end of an IFC, these values will be based only on the pre-BOREAS sun photometer calibration. The final values will have to await the post-BOREAS sun photometer calibration at Mauna Loa.

Selected sun photometer data sets corresponding to a number of remote sensing data sets considered to be important to BOREAS will be processed further to calculate additional aerosol optical properties such as aerosol size distribution, scattering phase function and single scattering albedo. These calculations will utilize Mie theory and assumptions about the aerosol shape (spherical) and index of refraction.

The aerosol optical depths and other optical properties will be used in a simplified radiative transfer model to provide atmospheric corrections to the corresponding remote sensing image data sets (Wrigley et al., 1992). Level 1 data from Thematic Mapper, the NS001 Thematic Mapper Simulator, SPOT, and ASAS will be required for input to the simplified radiative transfer model. Ancillary information for each data set will be required from BORIS: calibration coefficients, the relative spectral response of each band, aircraft parameters (heading, altitude, time), geographic location, solar elevation and azimuth angles, and surface pressure. Any information about the index of refraction of atmospheric aerosols found at the BOREAS sites would be welcome. Since the simplified radiative transfer model does not account for water vapor absorption, bands significantly affected by water vapor absorption (i.e., TM 5, 6, and 7) will not be atmospherically corrected and the parameters associated with those bands will not be required.

Atmospheric correction efforts will begin after the final aerosol optical depths have been derived from the post-BOREAS ATSP calibration and the other required aerosol optical properties have also been derived. It is anticipated that the data sets submitted for atmospheric correction by the simplified radiative transfer model would be limited to data from the "golden days": perhaps 3-5 TM or SPOT scenes, 8-12 NS001 flightlines, and a few ASAS scenes. This work should be completed in FY '95. As in the atmospherically corrected data submitted to the FIFE Information System on magnetic tape, header files would document them and list the parameters used in the atmospheric correction program. For BORIS, the new information would be added to the original BORIS summary file.

3.3.2.5 CV-580/SAR; RSS-15 (Ranson); Staff-CCRS (Cihlar/Hawkins)

Since its commissioning in 1986 (C-band; Livingstone et al., 1987) and X-band (Livingstone et al., 1988) the system was upgraded by including: polarimetric and interferometric C-band capabilities; multichannel real-time processing; more flexible geometries; improved navigation, motion compensation and recording systems; and system changes required to support the new operational modes (Hawkins et al., 1992). Interferometric mode makes use of a dual-antenna installation; in late 1993, a new double-antenna designed to allow along-track interferometry is also expected for delivery. In the polarimetric (C-band) mode, both like and cross polarizations are received simultaneously for each pulse. A new switching network developed for the polarimetric mode also permits simultaneous HH and VV full swath real-time processing at C-band, and doubling of PRF recording with no polarization switching to increase azimuth bandwidth.

The initial configuration allowed three imaging geometry modes; nadir, narrow swath, and wide-swath (with geometries beginning at incidence angles of 45, 0, and 45 degrees respectively). Narrow swath and nadir modes had 6m slant range resolution and wide swath 20 m. In 1991, the concept of variable range gate delay was introduced to allow placing the near edge of the swath in a flexible manner (and move the far edge accordingly).

Radiometric calibration has been emphasized through antenna pattern measurements, empirical testing, analysis of calibration methodology, and tracking of system upgrades (Hawkins, 1990; Ulander et al., 1991).

The system records real-time processed imagery for one receive channel (like- or cross-polarization) or half-swath data from both receive channels (see table below). The data are recorded on EXABYTE using CEOS compatible format.

In addition to the real-time processing, all recorded data may be processed using a generalized ground SAR processor. While real-time processing is routine, the more advanced operating modes (quad-pol, interferometry) are experimental in nature and therefore require the involvement of CCRS radar scientists to ensure that high quality data sets are produced.

Polarization Mode	Band	Transmit Pol	Subswath	Real Time Proces. Pols/Signal recorded Pols
Normal	X and/or C	H	Full Near or Far	HH or HV HH and HV
Normal	X and/or C	V	Full Near or Far	VV or VH VV and VH
Quad-pol	C only	H and V	Full Near or Far	(HH or HV) and/or (VV or VH) (HH and HV) and/or (VV and VH)
Insar	C only	H	Near only	CHH main antenna CHH side antenna

3.3.2.6 DC-8/AIRSAR; RSS-16 (Saatchi)

The AIRSAR system is an airborne synthetic aperture radar (SAR) which operates simultaneously in a fully polarimetric mode at three frequencies (P-, L-, C-band). JPL operates the radar aboard the NASA/Ames Research Center DC-8 aircraft.

The data collected by the DC-8 AIRSAR system will be processed to polarimetric imagery at JPL and provided to the BORIS in digital and photographic forms. The AIRSAR system provides several output products. This includes real time imagery and the final processed digital products. Two of the most common digital products are the Frame products and the Synoptic products.

The real time imagery is provided to the investigators for a SAR pass. This is a low resolution black and white single frequency/polarization (typically LHH) image of the entire pass. No digital data of this type is provided. Annotation of the image allows the investigators to select areas for further processing. The information on the data includes: run name (name assigned to the data acquisition pass, typically the site name), GMT time (day of year followed by GMT time), A/C Lat-Lon, frame count, and frequency/ polarization. In order to get the data processed by the AIRSAR ground processor, investigators must fill out a processing request form and submit this to JPL.

The standard AIRSAR Frame product consists of a sixteen-look (20 MHz) or eight-look (40 MHz) "polarization compressed" digital file on tape for each frequency (for input to polarization synthesize software provided by JPL) and a color photo product. The frame product corresponds to about 12 km along track of imagery by 10-15 km across track. The Synoptic product consists of a floating-point digital image file for each channel and color photo products. The synoptic images are 62 km along track with 10-15 km across track swath. As part of the standard products, the data sets are calibrated by the ground SAR processor. The data requested by the investigators will be in one of these forms. All the data sets processed for the investigators will be part of BORIS as well.

Digital products are normally delivered on 9-track 6250 BPI computer tapes or 8 mm tapes. JPL can write tapes in default format of the model EXB-8500 from the Exabyte Corporation ("5 Gigabyte format") or the model EXB-8200 ("2 Gigabyte format"). Standard AIRSAR data tapes are known as CM tapes (compression tapes) for the frame products and SY tapes (Synoptic tapes) for the synoptic processor. The CM tapes typically contain three data files corresponding to SAR imagery. Each file contains the complete Stokes matrix data at a particular frequency (P, L or C), plus some ancillary header information. The order of these files is always P, L, and C. The SY tapes also contain three files, one for each channel being a particular frequency or polarization channel. The order of these files on the tapes is the order which is shown in the photo product. There are six navigational text files following the three files in each of the tapes. There are also CS tapes (compressed scattering matrix) which do not include the navigational information. Furthermore, the raw data sets are usually not provided to the investigators. The size of the raw data set is 1.92 GBytes per frame. The compression technique introduced in the processor reduces the data volume to 37.5 MBytes per scene.

The header structure for the data files contains important information. The first few records of each data file contain the new header information. The new header contains 20 fields, 15 of which are currently defined for the data file specifications. Each field is 50 bytes in length and contains ASCII characters. Following the new header is the old header which contains information concerning the radar parameters concerning the data take as well as some processing parameters used to process the data. There is also a parameter header which can be found in all new CM data sets produced using the AIRSAR processor version 3.5 or greater.

3.3.2.7 Twin Otter/AMMR; HYD-2 (Chang)

Three microwave radiometers (18, 37 and 92 GHz V and H polarizations) were mounted on the Canadian Twin Otter (NRC/NAE). NASA/GSFC Code 975 made these radiometers available for the BOREAS FFC-W. Installation will be handled by the Canadian group. They were installed to look out the side windows at 45^{o} incidence angle of the aircraft, so flight paths will be offset from target lines.

The Twin Otter deployed the first week of February to YPA. An instrument calibration was conducted inside the hanger before FFC-W.

Typical flight lines were about 10 km in length. Flight lines in the PA site and Thompson were flown on different days.

Microwave radiometer data was collected along the flight lines. The raw data was stored on the hard disk of the PC onboard the aircraft. Quick look of the data was displayed on PC monitor during the flight to ensure the quality of the data. Calibration and processing of the raw data will be conducted at GSFC after the mission. Navigation data collection will be part of the Twin Otter operation. INS information, perhaps the GPS location information will be recorded by the onboard computer system.

The standard microwave radiometer data will be the calibrated brightness temperature along the flight lines. Navigation data will be merged onto this data set. The foot print size of these data is about one tenth of the aircraft altitude. A video camera looking at the same direction of the microwave radiometers will provide actual view of the radiometer. Time will be used as a reference to pinpoint targets.

Data will be calibrated and processed by GSFC. Since the microwave radiometer has low data rate, the archival data set will reside on floppy disks. Detailed data distribution formats have not been defined.

3.3.2.8 ER-2/AVIRIS; RSS-18 (Green)

AVIRIS will provide uncalibrated, radiometrically calibrated and corrected surface reflectance spectra from 400 to 2500 nm at 10 nm spectral sampling for each 20 m by 20 m spatial element over the BOREAS region of AVIRIS acquisition. The fully resolved molecular absorption and particle scattering properties expressed in the corrected reflectance spectra will be used to derive vegetation characteristics: vegetation pigments, liquid water, chemistry structure, etc. Atmospheric water vapor and to the extent possible other atmospheric gas and aerosol properties will be derived from the AVIRIS measured spectra for the time of acquisition.

AVIRIS data distribution will be provided as requested to the BOREAS Information System or directly to the BOREAS investigators from the AVIRIS Data Facility which handles 200 gigabytes of AVIRIS data each year.

Level - 0 and Level - 1 are routinely provided. Level - 2 spectral reflectance data will be provided on a selected basis. Data will be provided in either 4 mm, 8 mm or 1/2 inch tapes in either Unix or VMS format. Each AVIRIS scene covering a 10 by 11 km region corresponds to 140 megabytes of digital data.

A) Level - 0 data

All data will be provided as requested as Level-0 digitized numbers with all appropriate spectral, radiometric and geometric calibration information. GPS and onboard gyro data are included as part of the geometric calibration data set. All data will be available in 4 weeks of acquisition. Data can be provided on 4 mm, 8 mm and 1/2inch tapes in Unix or VMS format.

B) Level - 1 data

All data will be provided as requested from the AVIRIS Data Facility as Level-1 radiometrically calibrated data with all appropriate spectral, radiometric and geometric calibration information. GPS and onboard gyro data are include as part of the geometric calibration data set. All data will be available within 4 weeks of acquisition.

C) Level - 2 data

A selected subset of the 1993 and 1994 data will be corrected to apparent surface reflectance using the JPL reflectance inversion algorithm. This algorithm is based on the MODTRAN_2A radiative transfer code. A summary of the main procedures and constraining parameters is given below. Selected data will be available within 12 weeks of acquisition.

The MODTRAN_2A-JPL reflectance inversion algorithm:

1) Radiometric calibration:	Laboratory & Inflight Calibration Experiment
2) Radiometric correction:	Onboard Calibrator
3) Latitude and Longitude:	AVIRIS sensor GPS
4) Solar time:	AVIRIS sensor
5) Surface pressure Altitude:	AVIRIS-JPL-O2 from 760 nm O_2 band
6) Water vapor:	AVIRIS-JPL-H2O non-linear least squares fitting with compensation surface and leaf water
7) Rayliegh scattering:	Surface pressure altitude
8) Well mixed gas absorption:	Surface pressure altitude
9) Ozone:	Seasonal or measured
10) Aerosol scattering:	Visibility estimate or measured

3.3.2.9 ER-2/Airborne Ocean Color Imager); TE-15 (Bukata)

The Airborne Ocean Color Imager (AOCI) was developed as an aircraft instrument to simulate the spectral and radiometric characteristics of the next generation of satellite ocean color instrumentation such as SeaWiFS which is scheduled for launch in early 1994. A number of improvements had been suggested based on the experience with the Coastal Zone Color Scanner and many of these were incorporated in the AOCI: more spectral bands (particularly in the near infrared for atmospheric correction), higher radiometric sensitivity, and 10-bit digitization. The spectral and radiometric characteristics of the AOCI are:

Band No.	Band Center, nm	Band Width, nm	Signal/Noise Ratio
1	444	23	450
2	490	20	1010
3	520	21	915
4	565	20	615
5	619	21	440
6	665	21	350
7	772	60	360
8	862	60	250
9	1012	60	120
10	11500	2000	--

The signal/noise ratio is calculated with respect to radiances expected at the top of the atmosphere. SeaWiFS added a band at 412 nm to measure dissolved organic carbon and deleted the band at 619 nm; the AOCI band at 1012 nm for atmospheric correction over turbid water does not exist in SeaWiFS. Except for these differences, the AOCI mimics the spectral and radiometric characteristics of SeaWiFS. With a 2.5 milliradian IFOV the AOCI has a spatial resolution of 50 meters from the ER-2 altitude of 20 km which is more appropriate for lakes than the 1.1 km spatial resolution of SeaWiFS. The AOCI field of view of 85 degrees provides a swath width of 35 km in 716 pixels. The AOCI spectrometer section mounts on the Deadalus AADS-1268 MultiSpectral Scanner System (in a manner similar to the Airborne Thematic Mapper and the MODIS Airborne Simulator) and can fly on the ER-2 in either of the wingpods or in the fuelage Q-bay. Since the AOCI does not have a tilt capability, sunglint avoidance over water is provided by operational constraints; the solar zenith angle should be greater than 40 degrees and the flight direction should be close to the principal plane of the sun.

Data processing software for the AOCI was developed at Ames Research Center for atmospheric correction using the approach that was applied to Coastal Zone Color Scanner data; one of the near infrared bands which had no light exiting the water was used to model aerosol scattering radiances in the visible bands. Additional Ames data processing software provides both bio-optical output products (such as total pigment concentration and the diffuse attenuation coefficient of the water) and georeferencing to a geographic data base using aircraft navigation data (Wrigley et al., 1992). The bio-optical algorithms were developed from the underwater spectroradiometer data base obtained for the Coastal Zone Color Scanner.

New bio-optical algorithms must be developed for BOREAS using the inherent optical properties of lakes within the BOREAS test sites due to the complexities of such waters. A new underwater spectroradiometer data base will be developed under BOREAS for this purpose by the TE-15 group. Inherent optical properties of the components of the water (chlorophyll, suspended mineral matter, and dissolved organic carbon) will be derived by the method of Bukata et al. (1985, 1991) and used to develop bio-optical algorithms for atmospherically corrected AOCI data."

The AOCI is calibrated on a periodic basis using the 76 cm, internally illuminated, integrating sphere at Ames which is traceable to NITS radiance standards. Typically, the AOCI is calibrated before and after each deployment. Each band of AOCI data contains 25 16-bit words of housekeeping data and 716 16-bit words of video data. All bands for a single scan line are placed in one physical record of 14320 bytes beginning with band one and proceeding through band ten. At 6.25 scans/sec and a typical ER-2 ground speed of 400 knots (205 m/s) a 20 km flight line would consist of 610 scans and take 100 seconds to complete. Such a scene consists of 8.7 megabytes. A typical mission might consist of 120 km of AOCI flightlines (or 10 minutes of data), 70 km of which would be primary. As noted above, sunglint avoidance requires operational constraints: solar zenith angle between 40 and 50 degrees with the heading of the aircraft within 30 degrees of the principal plane. One to two missions are anticipated in each IFC.

3.3.2.10 ER-2/MAS; Staff (Ungar, D.K. Hall), Modland

MAS data were collected by the ER-2 in FFC-W; the PI was Dorothy K. Hall. MAS data may also be collected during the IFCs by the ER-2; see Section 3.3.2.8. for operations details and 3.3.2.1 for details on the instrument.

3.3.2.11 Piper Chieftain/CASI; RSS-19 (Miller)

Compact Airborne Spectrographic Imager (CASI) Sensor Description.

CASI is a push-broom imaging spectrograph with a reflection grating and a two-dimensional CCD (charge coupled device) array detector. The imaging area of the array is 512x 288 pixels. The instrument operates by looking down in a fixed direction and imaging successive lines of the scene under the platform, building up a two-dimensional image as the platform moves forward (Anger et al. 1990).

The image consists of 512 pixels across the 35° swath or field of view (FOV), giving a 1.23 meter ground resolution (cross track) and 630 meter swath per 1 km AGL altitude. The along track spatial resolution is a function of the integration time and aircraft speed. The spectral range of the CASI is sensor-head dependent but is nominally 400 nm to 900nm. The spectral resolution is nominally 2.5 nm FWHM (full width at half maximum), with 288 pixels sampled at 1.8 nm intervals. More technical details on CASI are available from Miller (RSS-19).

The CASI sensor will be flown on a Piper Chieftain twin-engine aircraft by staff from the Ontario Remote Sensing Office, based in Toronto. The aircraft will be deployed from Prince Albert and Thompson for each of the campaigns. Most of the flight operations will be conducted at an altitude of approximately 2000 m yielding cross-track/along-track pixel dimensions of approximately 2.4/3.0 m in the imaging mode and 2.4/10 m in the imaging spectrometer mode. A manually-operated titling mount permits the CASI to view at angles between +/-45° which will be used to acquire limited multi-view imagery over selected sites. CASI missions flown on all FFCs and IFCs will produce (i) line image segments up to 20 km in length over auxiliary sites in both NSA and SSA, (ii) line image segments coinciding with snow gamma lines at NSA and SSA, along the transect between study areas, across lakes at SSA being sampled by TE-15 (Crean and Waskesiu), and (iii) multi-altitude and multi-view frame images over flux tower sites, calibration sites, and selected auxiliary sites at both NSA and SSA. The expected raw data volume is 7 megabytes/linear km, with each campaign mission expected to cover approximately 150 km.

Imagery Screening/ Previewing

Images will be viewed to ensure minimum acceptable values of noise, aircraft motion and cloud are maintained. Quick Look images will be produced to determine if the site is contained in an image. This imagery will be made available for viewing via the internet to project co-investigators.

Post-Flight Processing of Image Data

i) Calibration to radiance

The CASI data tapes are calibrated to radiance after flight. Data processing can be done on a PC type computer directly from the EXABYTE tapes. Calibration information and software have been supplied by the instrument manufacturer (ITRES) and will be supplemented by calibrations done by the Electro-Optics Laboratory (ISTS) (Harron et al., 1992) and software written by ISTS staff.

ii) Geometric Correction

Geometric correction is applied as a post-flight procedure using on-board gyro and GPS data collected simultaneously with the CASI image data. In order to achieve acceptable accuracies for overlaying multitemporal IFC data one control GPS base station must be operated at each of the supersites and data made available to be merged with the airborne GPS. Data will be calibrated to radiance using in-house and/or instrument manufacturers calibration coefficients and algorithms. Data will be corrected using an on-board gyro and GPS system.

iii) Image Correction to Reflectance

Images of direct scientific interest will be corrected to surface reflectances using one of the following methods: 1) On-board incident light sensor (ILS), 2) radiative transfer modelling using LOWTRAN-7 and available ground measurements of atmospheric optical parameters, and 3) pseudo-invariant ground targets. Media and Data Format: The imagery will be made available on Exabyte tapes. Data will provided as PCIDSK images in tar save-sets. Delivery Schedule: A possible schedule of delivery of CASI data processed to Level 0, 1, and 2 is presented in the table that follows. However, the process of defining BOREAS sites is still in progress and the number actually required by this project along with the co-investigators remains to be defined. The number defined may effect the delivery schedule.

Data Product Schedule

Product	**Time***	**Quantity**	**Level**	**Comment**
Quick look	1 week	600 Kb/Km	Level 0	Single channel view of BOREAS scenes
Radiance Images	4 weeks	7 Mb/Km	Level 1	
Reflectance Images	9 weeks	7 MB/Km	Level 2	Corrected to reflectance

Time assumes ancillary data available.
*Time from aircraft return to Toronto.
Would propose only sending Quick Look and Reflectance Images

3.3.2.12 DC-3/MEIS II; Staff-CCRS (Gauthier) RSS-7 (Chen)

The MEIS II sensor is a pushbroom CCD scanner with eight optical channels between 390 - 1100 nm (silicon detectors). Gain settings are operator-adjustable. The instrument IFOV is 0.70 mrad with a total swath width of 40 degrees. Image data are organized as 1024 pixels (bytes) per record for each channel. The highest spatial resolution is 0.4m when the aircraft is operated at the height of 540m.

The DC-3 is the present platform for MEIS II. It will participate in IFC-2 1994 based in YPA and YTH. It will be available for 7 days, 20-25 July for the SSA and 26-28 July for the NSA. These dates may change according to flight plans for CASI and ASAS. We would like to operate MEIS as close in time as possible with CASI and ASAS.

The total number of hours for the flights is 7.5, 5 h for the SSA and 2.5 h for the NSA.

The sites of interest include OJP, YJP, OBS and OA tower sites at the SSA and OJP, YJP and OBS tower sites at the NSA.

The time window for DC-3/MEIS overflights is approximately from 0900 to 1200 in order to cover transects in the SE direction in the principle solar plane. The aircraft will be flown at the heights of 1,800 and 12,000 ft., or 540 and 3,600 m.

The deployment of MEIS II in IFC-2 is subject to the resolution of platform (DC 3) availability, a programmatic and funding issue.

3.3.2.13 Helicopter/C-band Scat; Staff (Gogineni)

The objective of radar measurements is to provide quantitative backscatter data for different vegetation species of boreal forest. We will use helicopter-based multifrequency ranging radar to collect data at 1.5, 5.3 and 10 GHz over incidence angles from 0 to 60 degrees with all four linear polarizations. We will mount boresighted video camera to record target characteristics. We will calibrate the radar both internally and externally to obtain scattering coefficients from measured data. The important radar specifications are shown below. We will 300-MHz bandwidth for airborne measurements.

Table 3.3.2.13 Radar Specifications

	X band	**C band**	**L band**
Radar Type	FM-CW	FM-CW	FM-CW
Center Frequency (GHz)	10	5.3	1.5
Bandwidth (MHz)	300, 600, 1000	300, 600, 1000	300, 600, 1000
Power Output (mW)	10	10	100
Antenna beamwidths (deg)	3	5	17
Polarization	VV, VH, HV, HH	VV, VH, HV, HH	VV, VH, HV, HH
Calibration			
Internal	Injection	Injection	Injection
External	Luneburg lens	Luneburg lens	Luneburg lens
	Diplane	Diplane	Diplane

Data products:
Level-0: We will produce echograms of radar return at different frequencies and polarizations for each site. These will be obtained by Fourier-transforming and range-gating recorded data to select returns from ranges extending from tree tops to the soil surface. These data will be corrected for any power level variation using internal calibration data. We will submit

data on Exabyte tapes. We anticipate that it will take about three months to produce level-0 products.

Level -1: The level-0 data will be converted into absolute scattering coefficients using external calibration. We will submit these data in tabular form on Exabyte tapes. We anticipate that it will take about six months to produce level-1 products.

Level-2: The level-2 products will contain total backscatter coefficients for each type of vegetation, and relationships between measured radar data and vegetation parameters. We anticipate that it will take about 18 months to produce level-2 products and we will submit these data also on Exa-byte tapes.

3.3.2.14 Helicopter/SE-590; RSS-3 (Walthall), TE-18 (Hall)

The primary helicopter-based remote sensing system will consist of a spectroradiometer (0.4 to 2.5 um), a thermal infrared thermometer (IRT) and color video system. Data will be collected at the primary and as many of the secondary sites possible during each mission. There will also be a nadir-looking instrument package consisting of a pyranometer, a PAR sensor and a photographic camera loaded with color infrared film. Data from these systems will be collected at the highest priority sites. A sun tracking photometer will be deployed during the missions to provide measures of irradiance and data for atmospheric correction of the radiometer data.

The data collection methods and processing sequences are still under development for most of the devices. Since the GPS system is still in question at the time of this writing, it is difficult to say what resources will be required and how long this will take.

Primary Data: Nadir and off-nadir measurements will be made using a pointable mount while in a hover at the sites at an altitude of between 500 and 1000 feet AGL. A minimum of 8 and a maximum of 25 observations per look angle will be taken. We will fly slow flight transects to cover the WAB for nadir measurements also. Some multiple altitude data over the same site will be flown if time/weather conditions permit as a means of addressing calibration and variability.

The spectroradiometer processing sequence will be along the lines of the following:

1. Collect data with information on Lat./Long. (via GPS) and BOREAS grid site location, view zenith, view azimuth, altitude, site abbreviation.

2. Review the raw DN values using a customized quick plot and review package. This step will be a subjective, visual search for problems with gain settings, instrument malfunctions, observations of "non-target" materials, etc. Obviously bad scans will be deleted.

3. The DN values will be converted to absolute radiances using calibration data collected prior to and/or after the field season. Spectral calibration will also be applied, most likely in the form of a smoothing routine via a spline-fit.

4. The mean and standard deviation radiance for each channel will be calculated. THIS WILL SERVE AS THE LEVEL 0 DATA. This can be reported to BORIS with data on site number, view zenith, view azimuth, start and stop time for observations, number of observations used to calculate the mean, altitude above ground level, Lat./Long.

5. When optical depths from the helicopter-borne sun tracking photometer and surface-based photometer data are available, the mean radiances, optical depths will be input to the Second Simulation of the Satellite Signal in the Solar Spectrum (6S) radiative transfer model. This will provide reflectances of the sites, corrected for atmospheric effects. The SWIR data may be processed using LOWTRAN or some other algorithm. There is a great deal of uncertainty with this optical head and we plan to work with the device in the coming year to work out problems.

6. The corrected reflectances will be visually reviewed as a check. If the data appears useable at this point, it will be submitted to BORIS as LEVEL 2 DATA. It is expected that over 90% of the LEVEL 0 data will be processed to LEVEL 2. Further checks will be made during the course of reviewing the data following submittal via analysis of variance on the data.

There will be some in-field processing of data for feedback on how the vegetation is progressing through the season. The IRT data is available as degrees Celsius directly from the instrument. No further processing of this data is planned. Immediately-available documentation will be in the form of video tapes made during the missions. The video camera will be bore-sighted with the SE-590 and will feed to a VCR which will also be used to record cabin intercom conversations among the aircrew and an audible tone each time the instruments are triggered. A summary of the data collection with operator notes will be compiled following each IFC and reported to the Science Steering Group.

The nadir-looking only data will be reported as-is. Film will be developed by WFF. Data submittal will be via diskette or electronic mail.

3.3.2.15 Aerocommander/Gamma Radiation: HYD-6 (Peck), HYD-4 (Goodison)

The aerocommander airborne gamma radiation system is used to remotely collect measurements of soil moisture (SM) and water equivalent of the snow cover (WE) by HYD-4. The data collection methods for measurement of SM and WE for the operational data collection program of the NWS are well documented (Carroll and Allen, 1988).

The airborne measurements have a measurement width of approximately 300m. NWS operational flight lines average about 16 km in length and represents the average over an area of approximately 4.8 km^2. During FIFE, methods were developed to divide flight lines into sections representing areal measurements as small as 0.15 km^2. The airborne program conducted for FIFE is discussed by Peck, et al. (1992) and the method for obtaining values for short flight lines (sections) by Peck et al. (1990).

The NWS has conducted winter snow surveys for a few years using the airborne gamma system for flight lines in and near the SSA for AES of Canada. Some of these lines are in the immediate area of the SSA and are included in the BOREAS network. Additional lines have been established for BOREAS for measuring both WE and SM. Maps of the BOREAS flights lines selected are shown in Figure 5.2.1.4a for the NSA, Figure 5.2.1.4b for the lines on a transect between the SSA and NSA, and Figure 5.2.1.4c for the SSA. The AES standard flight lines are identified by CRxxx and those established for BOREAS by BPxxx.

Additional lines are being considered for support of other RSS and modeling projects.

a. Remote Measurements

Fluxes of gamma radiation at flight level are collected during each gamma radiation survey. These data, along with other radiation data and information to calculate the mass of the air between the aircraft and the ground, are stored each 5 seconds during a survey. For short flight lines, repeated surveys are required to obtain sufficient data for computing the SM or the WE. A video camera, in a nadir position, is used to photograph each flight line under snow and no snow conditions. If the flight line has been calibrated, an average SM or WE estimate for the flight line is automatically computed and available for immediate use.

The Moss/Humus layer is a significant part of the overall moisture conditions near the soil. During September 1993 a method was developed to measure the water content of the Moss/Humus layer above the mineral soil using the ESC snow tube (30 cm^2) to obtain cores of the moss/humus layer. Near the Black Spruce study tower north of Candle Lake 2.3 cm of water was measured in 15 to 20 cm of the moss/humus layer above the mineral soil. Near Flin Flon, Manitoba, a thick layer (75 cm) of Moss/Humus at a single location was found to contain over 32 cm of water. The ground information on the water content of the Moss/Humus layer will be used in the calibration of those flight lines where the layer is significant (i.e. for flight lines over Black Spruce areas) and provides a means of measuring the water content of the layer during all airborne surveys.

During the winter, measurements will be made (by HYD-4) of the WE of the snow, SM of the mineral soil, and where possible of the water content (WC) of the Moss/Humus layer along selected flight lines. These measurements, along with airborne measurement of the WE will be published in separate tables in BORIS.

b. <u>Ground Measurements</u>

Measurements of in-situ soil moisture (SM) of the mineral soil and the water content (WC) of the Moss/Humus layer, when present, along each flight are required for calibration of flight lines. The number of samples obtained is dependent upon the accessibility and the length of the flight line. Sufficient samples of the SM of the mineral soil (and of the WC of the Moss/Humus layer) for the area measured by the airborne gamma radiation survey. For dividing the flight line into sections of smaller areas, SM (and WC) samples need to be distributed along the flight line with sufficient samples to represent the average for each section selected.

The soil and Moss/Humus layer samples are placed in plastic sample cups and processed by the gravimetric method by drying the samples out in ovens for 24 hours at 105^{o}C. The SM is percent be weight compared with the weight of the dry sample of the mineral soil. The WC of the Moss/Humus layer is the mass of the moisture in cm (similar to the water equivalent of the snow cover in cm).

c. <u>BORIS Files</u>

Three major data fields will be placed in BORIS.

Locations of airborne flight lines - information on the beginning, end, and for each turning point along a flight line for each flight line section.

Ground In-Situ measurements - for each in-situ sampling point the following data are recorded:

Flight line - Sample Point	Date	Time
Latitude	Longitude	Sample Wet Wgt (grams)
Dry Wgt (grams)	Water (grams)	Soil Wgt (grams)
Soil Moisture (percent)	Slope (terrain slope in degrees)	

Aspect (direction of downslope in 16 points of the compass)

Soil Type - depth of sample (type of soil, information on condition of soil, i.e. rocky, and depth of soil sample in cm)

Vegetation (type of vegetation. For forest areas, includes information on undercover and on conditions in immediate area)

Remarks (information on type of moss and on humus layer)

Depth of Moss/Humus layer (cm)

Average depth of Moss/Humus layer at sampling point

Water content of Moss/Humus layer

Depths of Moss/Humus layer at 5 meters locations from sampling point (4 measurements, cm)

Depth of snow cover, cm, at sampling point

Water equivalent of snow cover, cm

Depths of snow cover, cm, at four points

NOTE: Measurements during snow cover do not include information on slope, aspect, soil type, and vegetation.

Airborne SM measurements of mineral soil (and in some cases of the WC of the Moss/Humus layer) for each survey flight line will be placed first in BORIS. As flight line sections are determined values for each flight line section will be included. Airborne WE flight line and sections of flight line measurements will be entered into BORIS by HYD-4.

d. <u>Research Analyses</u>

Comparison studies with all available ground measurements will be conducted as part of the quality control for the airborne SM measurements. Other comparison studies will be completed as was done during FIFE with other remotely sensed estimates (Peck and Carroll 1991) and with results of modeling studies (Peck and Carroll 1992).

If sufficient data and resources are available, isoline maps and gridded values of average SM for each 0.5 km^2 area for the SSA will be prepared as has been done for the FIFE area (Peck and Hope 1993).

Other BOREAS scientists are invited to work with HYD-6 to obtain special SM measurements or information.

3.4 Site Logistics and Infrastructure

3.4.1 Infrastructure for Tower Flux Sites

Nine tower flux sites, five in the Prince Albert area and four in the Thompson/Nelson House area, are outfitted with towers, huts, boardwalks, walking trails, a main power supply, site electrics, outhouses, platforms for storage tents and, at Nelson House, fuel storage areas. Two ATV's should be available at each study area.

All sites are supplied, either by line power (SSA) or by diesel generator (NSA), with 220-240 volt, 60 cycle, single phase power. The wiring plans for each site are somewhat generic, though individual modifications have been made to suit specific tower flux scientists. Power availability is detailed in Table 3.4a. All sites will have standard house outlets supplying 110-120 volt, 60 cycle single phase alternating current. 220-240 volt current will be available at selected sites according to the wishes of the individual TF site captains. In general, however, these 220 lines are dedicated to the specific needs of the tower fluxer, and scientists visiting any given site should not expect that 220 volt power will be available to them. No direct-current power drops (e.g., 12 volt, 24 volt D.C.) will be available. Scientists needing direct current must work from their own batteries and/or must bring their own inverters to the sites.

The infrastructure is relatively spartan at the nine tower flux sites. BOREAS has supplied one or two 12'x20' huts in the immediate vicinity of the towers. All huts on all sites are insulated and heated. Electric heat is provided at the sites to keep the scientific equipment in the huts above freezing (5-10 degrees C). The heaters are not sized to provide a cozy working environment in very cold weather. (i.e., dress warmly if you'll be working during the non-summer months.) No site will be air-conditioned unless the air-conditioning unit is supplied by the tower flux scientist. All huts have screened windows and a screen door and should be relatively well ventilated.

A large floored tent will be erected at each TF site for storage. The tents are provided as a nonsecure area where instrument crates and bulky experimental equipment may be stored out of the weather. No power will be provided to the tents, though an extension cord may be run from the main hut to the tent for a temporary power drop.

Northern Study Area, near Thompson/Nelson House, Manitoba

Tower

The four communications towers will receive routine maintenance. Guy wire tensions and tower stability will be checked by a tower contractor twice yearly, once in the spring (after ground thaw) and once in the fall, to insure safety. All towers are rigged with climbing safety systems that all tower climbers are required to use when climbing. A training and safety course or proven experience is required for anyone climbing the communications towers.

Power

All four NSA sites are powered by diesel generators. A 12 KW Onan generator powers the Old Black Spruce (TF-3) site. Six KW Kohler generators power the remaining three sites (one generator per site). The four diesel generating systems are housed in ventilated all-weather huts supplied by the generator contractor. A common key, available from the TF site captains or from the site manager, will open all four generator huts. Since the four NSA sites are powered by generators, power is limited. It is the responsibility of the site captain to apportion power appropriately, given that the tower flux measurements are a primary focus of this experiment. Anyone needing electrical power at any of the four NSA sites should contact the respective site captains to ascertain availability.

Once every two weeks the generators will be shut down for at least half a day for periodic maintenance. Maintenance items include an engine oil change, oil and fuel filter change, and topping off the oil level maintenance reservoir. In the event of a catastrophic generator failure, a stand-by generator stored at the Keewatin Air Hangar will be swapped for the disabled engine. Down time should not exceed 48 hours.

Table 3.4a
Electrical outlets installed at the tower flux sites.
GFI indicates a ground fault interrupt outlet or circuit.

		Huts			Tower		
		Interior		Exterior			
Study Site		**120V 15A**	**240V 15A**	**120V 15A-GFI**	**120V 15A-GFI**	**240V 15A-GFI**	**Comments**
SSA: Old Aspen	Hut A	7	3	2			
	Hut B	7	0	0	6+	0	Outlet heights on tower: 0, 15, 25, 55, 85, 115 ft.
Old Jack Pine		7	0	2	5	0	Outlet heights on tower: 0, 40, 50, 70, 85 ft.
Young Jack Pine		7	2	2	4	0	All tower outlets at base.
Old Black Spruce		3	4	2	1	4	Tower 120V outlet at base. Tower 240V outlets: 0, 30, 50, 75 ft.
Fen	Hut A	11++	0	2			All tower outlets at base
	Hut B	2	0	0	3	4	All 240V tower outlets dedicated to TF equipment
NSA: Old Black Spruce	Hut A	5	0	2			
	Hut B	7	0	0	2	0	Outlet heights on tower: 2, 80 ft.
Old Jack Pine		8	0	2	2	0	Both tower outlets at base.
Young Jack Pine		6	0	2	2	0	Both tower outlets at base.
Fen		6	0	2	2	0	Both tower outlets at base.

\+ tower outlets are 120V, 20A GFI.

++ One outlet dedicated to refrigerator.
One outlet is actually 120V, 20A, dedicated to a gas chromatograph.

Huts

The five huts on the four NSA sites were essentially completed by mid August, 1993. Nelson House First Nation carpenters built the dry site huts, private contractors completed the three huts on the two wet sites. The huts have been outfitted with tables, chairs, electrical fixtures, heaters, fire extinguishers, and first aid kits. The huts have locks on the doors; keys are available from the TF site captains or from the site managers. At the NSA sites, hut keys are unique, the hut for one site will not open huts on other sites.

Southern Study Area, near Prince Albert, Saskatchewan

Tower

Eight tower foundations, eight towers and three tram systems (linking six of the eight towers) were erected/installed by the tower contractor. The work was completed by mid September, 1993. Guy wire tensions and tower stability will be checked by a tower contractor twice yearly, spring and fall, to insure safety. Anyone climbing the communications towers or the outside of the double scaffold towers is required to take a tower climbing and safety course or have proven experience and also to use the provided climbing gear.

Power

Five sites in the SSA have line power. Saskatchewan Power cut a 15 - 20 foot right-of-way into each of the sites in order to bury the 14.4 KV feeder. Stepdown transformers have been placed approximately 200 feet from the main hut and 220 -240 v, single phase, 60 cycle service has been provided to each hut.

Huts

All huts are accessible by, at a minimum, foot and ATV. All SSA huts can be opened with a common key available from the site manager, TF site captain or SAHQ. Road gates have been installed at the Fen, YJP, and OBS sites. A Canadian Park Service gate blocks access to the Fish Lake to the OA site. Gate keys are available from the site manager or the SAHQ.

Questions concerning site access and infrastructure should be directed to Dan Hodkinson (301-286-3621) or Ross Nelson (301-286-9925) at NASA/GSFC (FAX 301/286-1757). Questions concerning access to the Old Aspen site should be directed to Mary Dalman at PANP (306)663-5322.

Requests for site infrastructure support should be handled as shown in Figure 3.4.1.

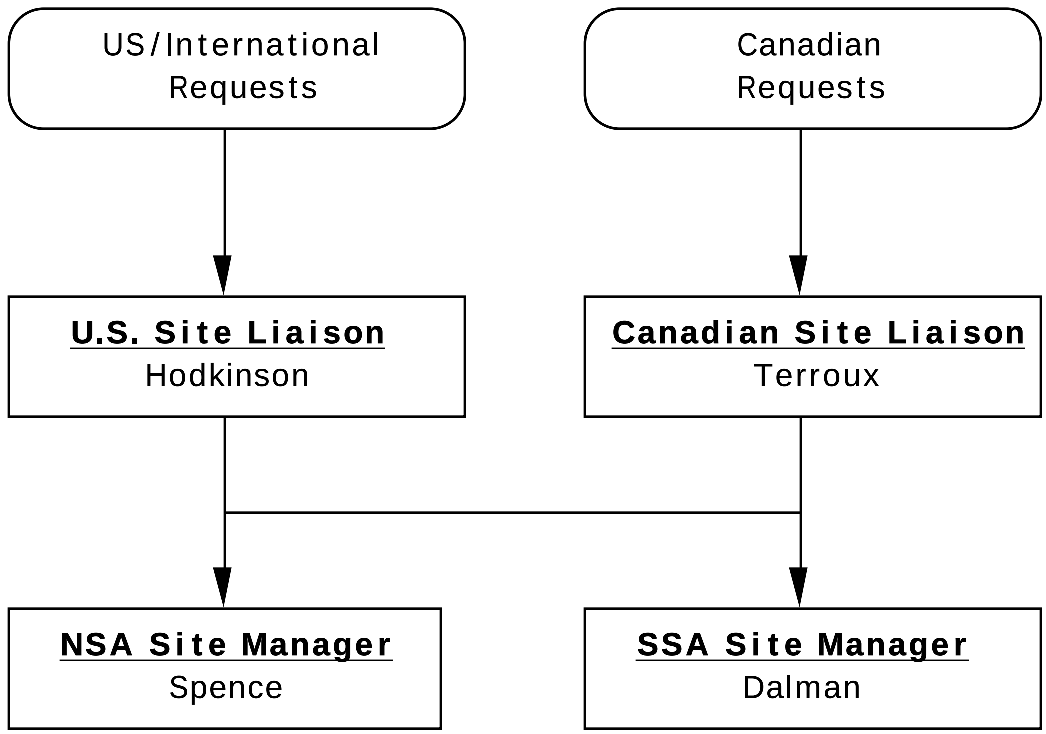

Figure 3.4.1 Procedure for handling staff requests or initiating significant activities in the study areas

3.4.2 **Laboratory Facilities**

Some limited off-site laboratory facilities will be provided by the project, to permit analyses of samples that need to be performed within a few hours to sample collection of which would be impractical to perform at investigators home institution. These facilities will be operated during the 1994 IFC's, and at a reduced level during the Thaw campaign and between IFC's. These same areas will be used for equipment receiving and storage between IFCs. The project will be providing space, power, running water, and a few items of equipment for shared use, as well as helping coordinate investigator access to consumables such as gas cylinders. The project will not be directly purchasing expensive laboratory instruments or other capital equipment which is expected to have a useful life well beyond the duration of the BOREAS experiment. It is vital that investigator teams and groups who require such equipment arrange for it to be available and shared as appropriate.

192 Hayes Road (NSA)

This warehouse has been modified to meet the lab space requirements of all investigators in the NSA. The lab is divided into three main areas (see figures 3.4.2a and 3.4.2b). The clean lab section has a tile floor, two sinks, and a small area designated for electronics calibration. One high precision balance will be provided by the project in the clean lab. The general lab area is a larger area with a concrete floor and a double utility sink with a solids intercepter. A high capacity balance will be provided by the project in this space. The dirty lab area is equipped with a pit drain, an equipment staging area, and 2 medium sized drying ovens. Two refrigerators and an upright freezer are also provided by the project, to be spread out over the three areas. In addition to three main lab areas, there is a loft storage over the clean lab space. Benches and tables have been added to all sections for sample preparation, computer stations, and work space. The building has been rewired with ample 110v outlets.

Paddockwood School (SSA)

This modern elementary school is no longer used for classes and has been leased by the project. Each classroom is equipped with some bench space and a sink. Each investigator group that requested space has been assigned a room for their group (see figure 3.4.2c). It is important that investigators understand that these designations may be subject to change depending on how well they actually suit the group. In addition to these rooms there are some common areas. The dirty lab is located adjacent to large exterior doors for bringing in rough field samples. Two medium sized drying ovens and a dual range balance will be located in the dirty lab. The general purpose non-lab area is located next to the kitchen and showers and is designed as a storage and general use area. The general purpose measurement area is a place for

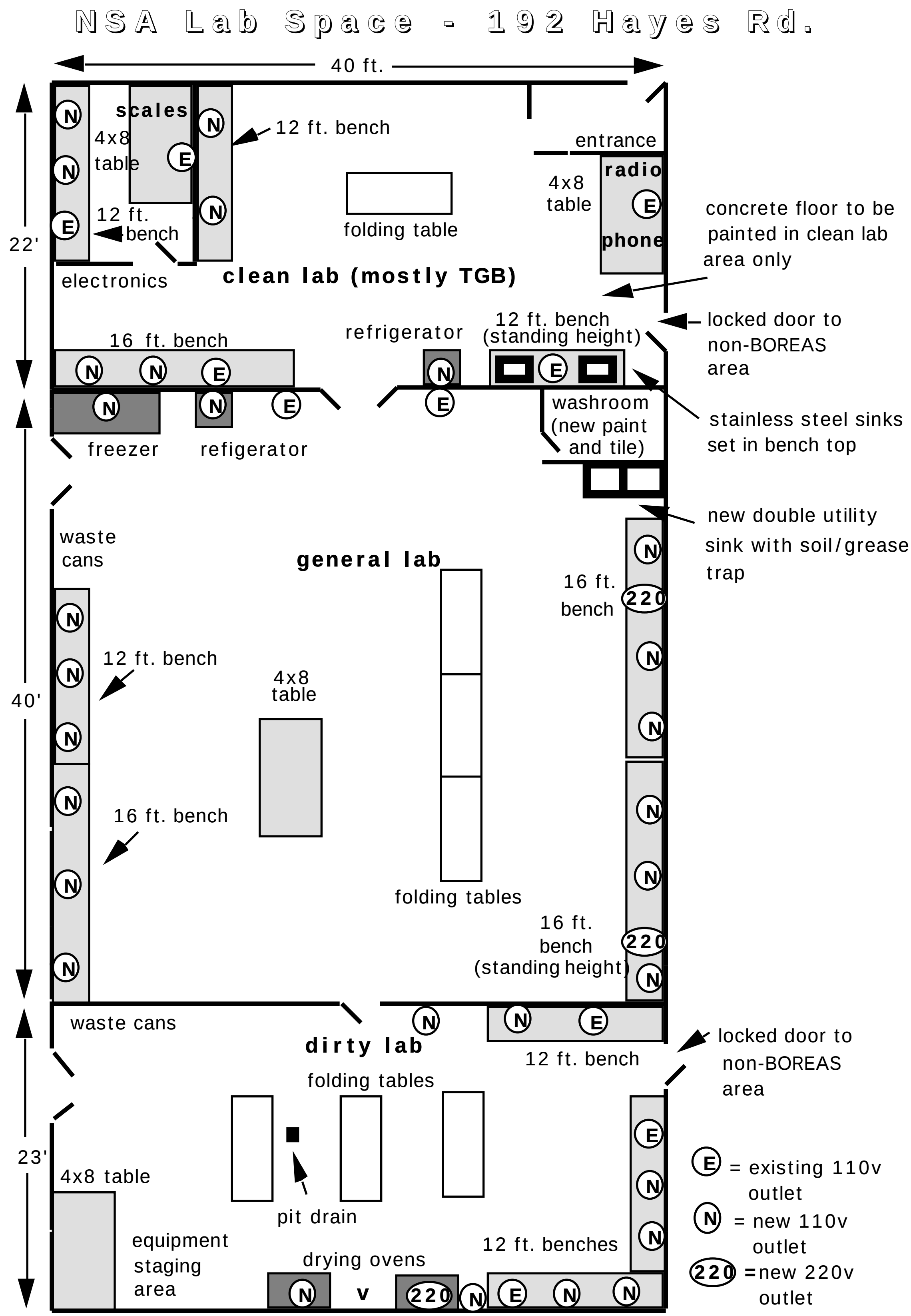

Figure 3.4.2a Layout of NSA Lab at 192 Hayes Road, Thompson

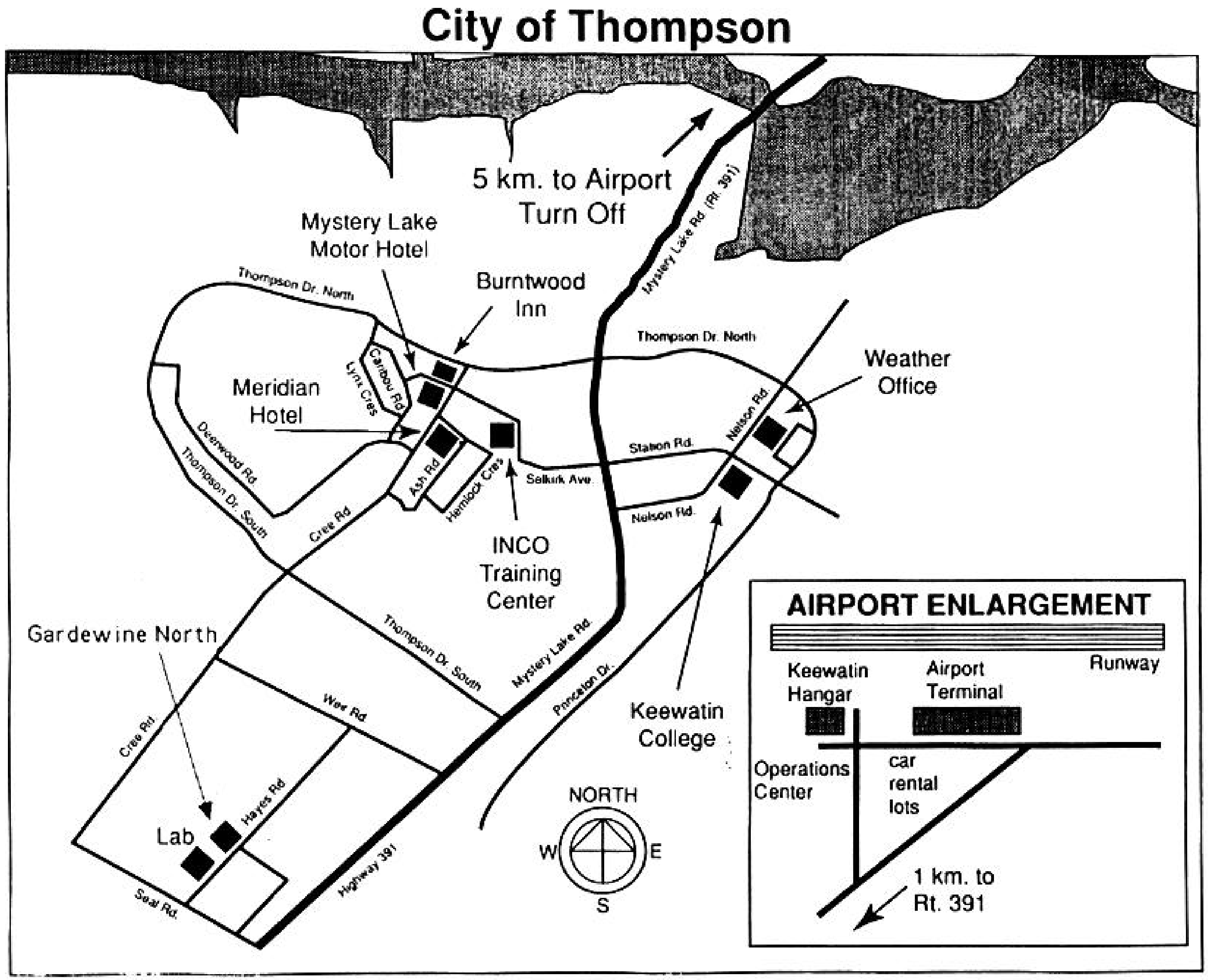

Figure 3.4.2b **Location of NSA Lab and other sites in the Thompson Area**

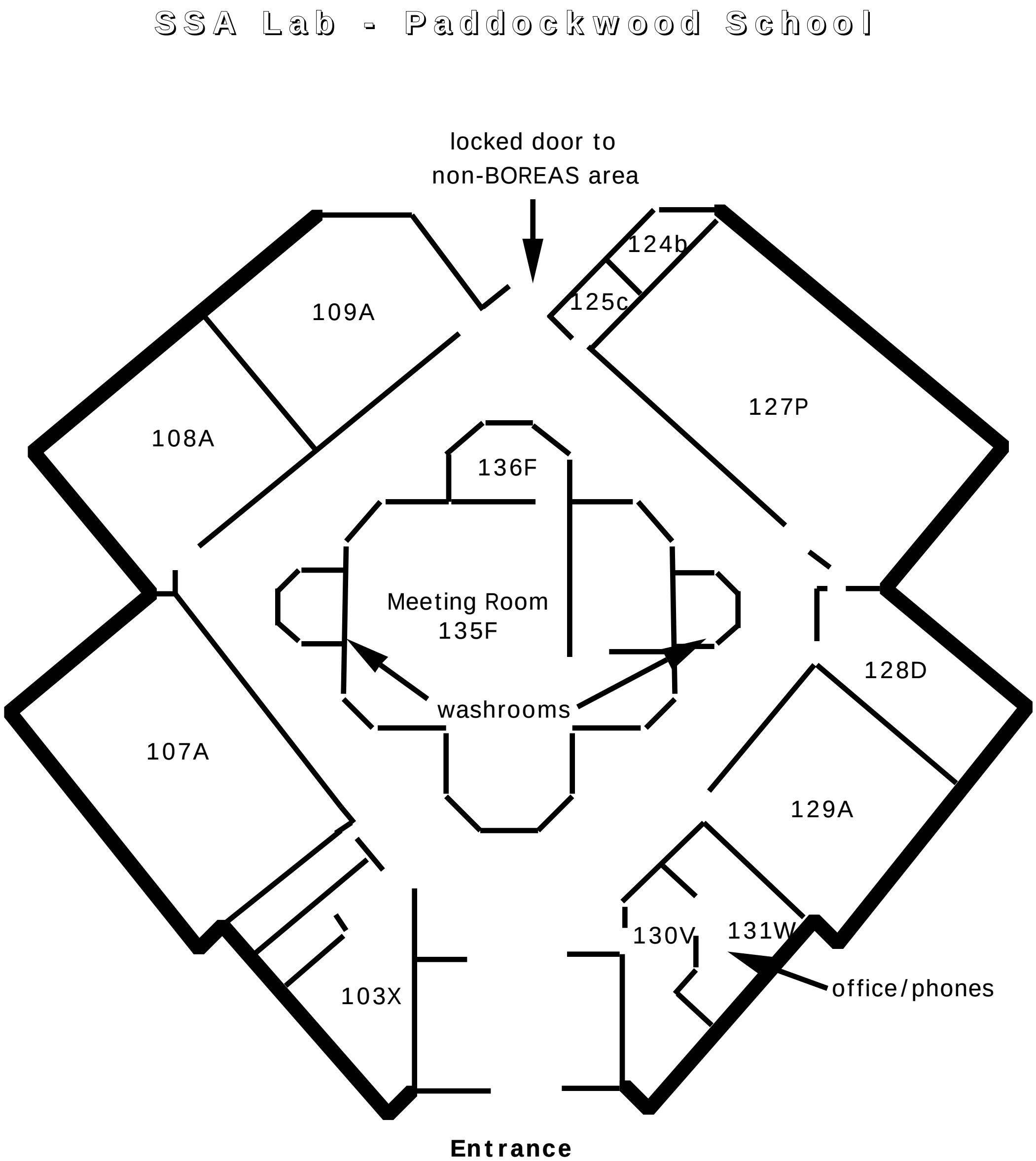

Figure 3.4.2c Layout of SSA Lab at Paddockwood School, Paddockwood (see Figures 2.1.1.2 for location)

common instrumentation and equipment. The project will provide a chest freezer, a refrigerator, and a dual range balance in this area.

3.5 The BOREAS Information System (BORIS)

An organizational chart of BORIS personnel is included as Figure 3.5.

3.5.1 Role of BORIS

In broad strokes (which will be prioritized and fine-tuned by the BORIS Working Group), BORIS will:

1) Serve as a single, central collecting and distribution point for data sets and documentation provided by the science investigators.
2) Assist science investigators in documenting submitted data sets. (See 3.5.3.2)
3) Quality-check submitted data for internal consistency, and facilitate the inter-comparison of related datasets by the science working groups.
4) Provide data dissemination between investigators as deemed appropriate by the BORIS Working Group. Current capabilities: E-mail, bulletin-board, 4-mm DAT tape, 8 mm and 9-track tape, MAC and PC floppy diskettes, and CD-ROM.
5) Provide processing of satellite imagery and other staff-collected data to formats that will be of general use (as determined by the BORIS Working Group).
6) After investigator approval, publication of fully documented, cross-compared data sets on CD-ROM for purposes of dissemination to the general science community, and for long-term archive.

BORIS will initially be patterned after the FIFE Information System (Strebel et al., 1990*) and will try to benefit from the lessons learned in FIFE. Standing atop the list of lessons learned in FIFE is the need to thoroughly document data collection. The inter-disciplinary nature of BOREAS highlights the need for documentation to be aimed at data users who are outside (and thus

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*Strebel, D.E., J.A. Newcomer, J.P. Ormsby, F.G. Hall and P.J. Sellers. The FIFE Information System. IEEE Transactions on Geoscience and Remote Sensing, Vol. 28, No. 4., July 1990.

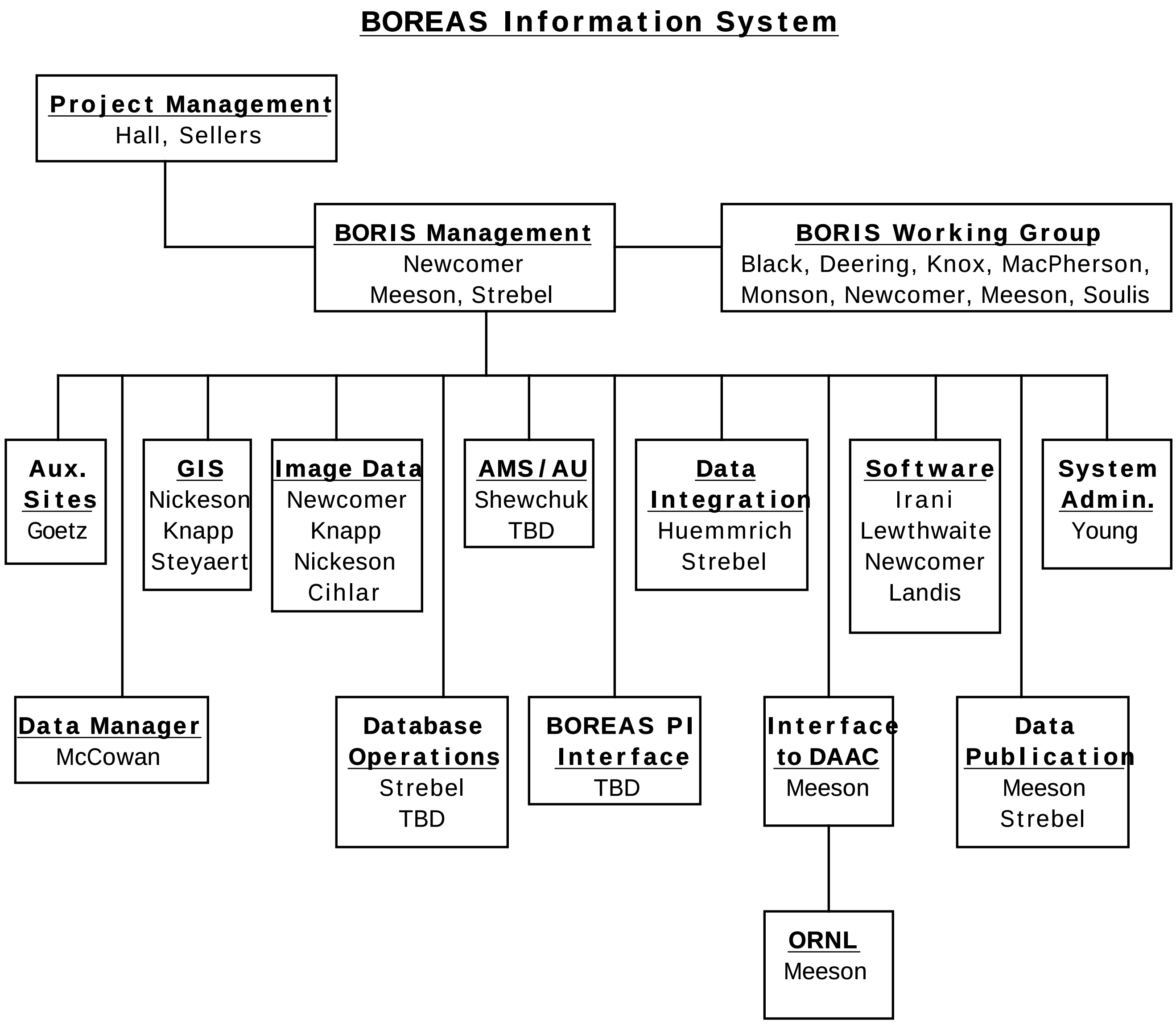

Figure 3.5 Boreas Information System (BORIS) Organization

without expertise in) the discipline that collected the data. To facilitate this process, BORIS staff have developed a software program which will aid investigators in providing appropriate documentation in a format being used by many in the global research community. This software has been distributed to all PI's. A great deal of the documentation effort can be accomplished *before* any data is collected in the field.

This pre-data-collection documentation will aid BOREAS in several ways: 1) BORIS will have a better idea of the scope and variety of data to be submitted and can pre-design database tables so that data can be quickly turned around when it arrives, 2) by knowing ahead of time what documentation will be necessary, we are more likely to note/remember/ submit the appropriate information and 3) *a priori* planning of what data is to be submitted may very well lead to better science.

3.5.2 The BORIS Working Group

A major purpose of BORIS is to facilitate the integrative science of the BOREAS project. It is in the exchange of information among science investigators that BORIS will be vital. BORIS is designed as a service organization. However, the service to be performed is facilitating exchange and that can only be accomplished with cooperation from all sides. As such, there will need to be a great deal of dialogue between the BORIS staff and the science investigators. As a formal means of implementing this communications channel, representative science investigators (one from each of the science groups) have agreed to serve on the BORIS Working Group (BWG), see Table 3.5.2.

Table 3.5.2
BORIS Working Group

Group	Representative	Group	Representative
AFM	Ian MacPherson	HYD	Ric Soulis
TF	Andy Black	TGB	Sue Trumbore
TE	Bob Knox	RSS	Don Deering

The BWG will be responsible for setting information-system priorities and requirements, responding to requirements set by the Science Steering Group, and functioning as the BORIS decision-making body.

3.5.3 General Policies

The following sections describe general policies that will guide the functioning of BORIS. These policies should be regarded as a snap shot in the midst of a fluid process. If BORIS is to fulfill its role as a dynamic, supportive organization responsive to the needs of the BOREAS community, then these policies should be responsive to continual input from the BOREAS community. BORIS will try to respond to as many of the needs of BOREAS as time, resources and manpower allow. When the needs of the BOREAS community exceed the capability of BORIS resources, priorities will be determined heirarchically by the BORIS Working Group,and the Science Investigators.

3.5.3.1 Data Policy

The cooperative use of BOREAS data is predicated on adherence to normal principles of scientific recognition and credit, even though data will normally be obtained through BORIS rather than directly from the investigator. Dataset documentation included in BORIS will identify the sources of data, but reference should also be made to the BOREAS Experiment Plan and other formal documentation for complete information.

1. BOREAS investigators are required to submit any data collected at the BOREAS sites (appropriately processed) to BORIS within a reasonable time of data collection.

2. BOREAS investigators are required to submit documentation along with any data submitted to BORIS. Guidelines for appropriate documentation are supplied in the Handbook for BOREAS Investigators. Documentation should be an evolutionary process: some submitted at the time of experimental design, some immediately after data collection, and complete documentation submitted along with the data.

3. Using BORIS as the medium of data exchange for all investigators will be essential to maintaining a common level of data access and quality for all investigators.

4. BOREAS investigators have access to BORIS on the condition that they submit their processed original and derived data sets to BORIS.

5. Protect account names and passwords. Abuses of a BORIS account will lead to the termination of that account.

6. All publications based on data accessed through BORIS are expected to acknowledge BOREAS, BORIS, and the original principal investigator who collected the data. Contact and/or co-authorship with the originating principal investigator is strongly recommended.

7. Reprints of all BOREAS-related publications are required to be submitted to BORIS.

8. Use of preliminary data may be hazardous to an investigator's career. Publication of data designated with a PRE level of Quality Assurance without explicit permission of the principal investigator should not occur under any circumstances.

3.5.3.2 Data Documentation

Data documentation is important in any scientific study. However, it is critical to the success of a large interdisciplinary project such as BOREAS. For this experiment to succeed completely, the data must be usable years after the field campaigns and be understandable to investigators from other disciplines. This requires extensive and detailed documentation accompany the data. The importance of well written and accurate documentation was learned during FIFE when the staff of the information system were continually required to answer questions from users about the data in the system. From this experience we have developed an outline covering the important points in documenting a data set (see **BOREAS Data Documentation Outline**, below)

BORIS has developed **Data Documenter** software to aid in the production of the data documentation in the data documentation outline format. This software runs on a PC and provides the outline headers and examples of documentation. The program is also able to import text files, so that material previously written can be pasted into the documentation. The software will produce an output file which can be easily handled by the information system.

The information system requests a preliminary description of each investigator's project as soon as possible and hopefully prior to data collection starts. The documentation outline should be filled in as much as possible, including such things as descriptions of instruments, planned procedures, and the theory behind the measurement techniques. This will allow the BORIS staff to be better prepared to process the data when it arrives and to identify possible gaps in the documentation which then may be collected in the field. During the field campaigns it is important to record location and time of all observations, as these two parameters are required to link together different types of data within the information system. Any changes in procedure should be noted, as well as other factors which may affect the measurements, e.g. problems with the instruments, clouds, etc.

The final documentation provided to BORIS is an important part of the data submission. It should be submitted with the data to the information system.

This allows both the staff and other investigators to use the data correctly. The final documentation will be reviewed by the staff and peer reviewed by other investigators before being archived with the data.

3.5.3.3 Data Quality Assurance

BORIS can facilitate the Quality Assurance (QA) of the data submitted to BOREAS, but the ultimate assurance of quality data lies with the science investigators. Datasets submitted to BORIS will routinely be checked for internal consistency, mainly as a check that we have ingested the data correctly. Those checks will search for as many of the following as is feasible: constant sensor readings, sensor readings out of limits, sensor readings out of expected ranges, spikes or outliers that differ greatly from other readings, large changes in sensor readings over a short time period. Of course "out of limits", "expected ranges", "spikes", "outliers" and "large changes" will need to be determined in advance with the investigators. Sensor limits and expected ranges are two examples of data documentation that would greatly speed data processing when supplied well ahead of field data collection.

BORIS will continually be looking for help/suggestions from the science investigators as to what variables should be compared, and how closely related variables can be used to verify each other. Any inconsistencies identified in the QA process will be relayed to the investigator(s) who has(ve) collected the data. No values will be changed by BORIS. All data changes or corrections will be made on the authorization of the investigators only. Hopefully, the questioned data can either be determined to be correct, or some glitch in the data communication process can be identified and eliminated. Datasets will be loaded on the BORIS on-line data facility. Each dataset will have as part of its available documentation what degree of QA it has been subjected to using the following classifications:

PRE = PREliminary: No QA applied to the data. **Not for publication**
CPI = Checked by Principal Investigator: Intra-dataset comparison only
GRC = Checked and reconciled by science GRoup: Intra- plus inter-dataset comparison
REL = Ready for RELease to the general science community.
--? = Replacement for third digit in above codes (i.e. PR?, CP?, GR? or RE?) added when the investigator thinks that dataset may be questionable. The source of the questions will be found in the "Errors" section of the documentation.

There will occasionally be demand for fast-turnaround, "quick-and-dirty" PRE-data. User beware! There is a legitimate use for such preliminary data in the midst of a field campaign for quick inter-comparisons between sensors, sites, disciplines, etc. However, the use of such data for anything but a quick, subjective comparison is foolhardy at best and unethical at worst.

3.5.3.4 Data Plans

Each Science Group will need to develop a data plan which will specify:

1) Variables to be measured by the group members.
2) Units of measurement to be used by the group.
3) Temporal and/or spatial resolution/frequency of collected data.
4) A common set of data formats to be used by the group.
5) Documentation and data submission deadlines.

The following guidelines apply to all groups and investigators:

Units must be standardized within each group and between groups when there is overlap.
Agreement must be reached on values being reported, e.g. winds reported as either speed/direction or as vector components but not a mixture of some PI's using one method and other PI's the other method.

Each time period will have the following variables associated with it:
- Investigator
- Team number
- Location in BORIS grid units
- Time (GMT), date
- Investigator's Quality Assurance assessment (see Data Quality Assurance, above)
    - Preliminary (PRE)
    - Investigator checked (CPI)
    - Group checked (CGR)
    - Ready for release (REL)
    - Known problems (PR?, CP?, CG? RE?)

A BORIS timeline for 1993 and 1994 is presented in Table 3.5.3.4. The BORIS proposals for group data plans immediately follow the BORIS timeline.

3.5.3.4.1 Proposed AFM Data Plan

Special attributes of AFM data submissions:
Both raw and smoothed data should be submitted.

Each time period for AFM data will also need the following information associated with it:
- Altitude of measurement
- Flux measurement method

Table 3.5.3.4 BORIS Timeline

	Mar-94	Jun-94	Sep-94	Dec-94	Mar-95	Jun-95	Sep-95	Dec-95
Image Processing								
Satellite Images								
AVHRR-LAC			Level-3					
ERS-1			Level-1					
GOES			Level-2					
JERS-1				Level-1				
Landsat TM	Level-1	Level-1a	Level-1b		Site Extract		Level-2	Level-3
Landsat MSS		Level-1		Level-1a	Level-1b	Site Extract		Level-2
SPOT		Level-1		Level-1a	Level-1b	Site Extract		Level-2
Aircraft Images								
AIRSAR		Level-1						
AOCI				Level-0	Level-1			
ASAS			Level-1b		Site Extract			
AVIRIS			Level-1b	Level-2				
CASI			Level-1b	Level-2		Site Extract		
CV-580 SAR				Level-1				
MAS			Level-1b					
MEIS								
NS001			Level-1b		Level-2	Site Extract		
Software Development								
Data Documenter	Version 1.2							
DAFT	Version 1.0							
DCS		Version 1.0						
BOR_CORD		Version 2.0						
Data Base Development								
On-line Inventory System		Staff Access	User Access					
Data Access			All Access					
Staff Data Loading		Start						
Map Inventory			All Access					

Table 3.5.3.4 BORIS Timeline (continued)

	Mar-94	Jun-94	Sep-94	Dec-94	Mar-95	Jun-95	Sep-95	Dec-95
Staff Data Processing								
Meteorological								
AES Surface	FTP		data base					
AES Upper Air	FTP		data base					
SRC Surface			data base					
GIS								
AVHRR Land Cover		Tape						
Forest Cover								
Manitoba (1:15840)	Raw							
Saskatchewan (1:1M)	Raw							
Saskatchewan (1:12.5K)	Raw							
Landsat TM Land Cover								
NSA		Tape						
SSA			Tape					
Soils (1:125K)	Raw	Gridded						
Soils (1:1M)	Raw	Gridded						
Topo (1:50K)		Raw		Gridded				
Topo (1:250K)		Raw	Gridded					
Other								
ECMWF Model Data			data base					
Site Locations	Ex Plan		data base					
PI Data								
AFM		1993 Doc	1993 Data	1994 Doc	1994 Data			
HYD		1993 Doc	1993 Data	1994 Doc	1994 Data			
RSS		1993 Doc	1993 Data	1994 Doc	1994 Data			
TE		1993 Doc	1993 Data	1994 Doc	1994 Data			
TF		1993 Doc	1993 Data	1994 Doc	1994 Data			
TGB		1993 Doc	1993 Data	1994 Doc	1994 Data			

Major deadlines for AFM group

July 15, 1993	Preliminary documentation
November, 1993	Final 1993-IFC data documentation
January, 1994	1993-IFC data submission
March, 1994	Preliminary 1994 documentation
October, 1994	Final 1994-IFC data documentation
December, 1994	1994-IFC data submission

3.5.3.4.2 Proposed TF Data Plan

Summaries of the data types to be collected by the TF group are shown in tables in Section 4.2.

Major deadlines for TF group

May 15, 1993	Preliminary documentation
November 1, 1994	"Golden" preliminary data submission
March 1, 1995	Preliminary data submission and documentation
November 1, 1995	Final 1994 data submission

A list of preferred data and dates during the 1994 fall campaign to be prepared by BOREAS staff. Data to be submitted for these days is possible.

3.5.3.4.3 Proposed TE Data Plan

Summaries of the data type to be collected by the TE group are shown in Section 4.3.

Major deadlines for TE group

July 15, 1993	Preliminary documentation
November, 1993	Final 1993-IFC data documentation
January, 1994	1993-IFC data submission
March, 1994	Preliminary 1994 documentation
October, 1994	Final 1994-IFC data documentation
December, 1994	1994-IFC data submission

3.5.3.4.4 Proposed TGB Data Plan

Summaries of the data type to be collected by the TGB group are shown in tables in Section 4.4.

Each time period for TGB data will also need the following information associated with it:

- Chemical species being measured
- Measurement methodology
- Sampling method (tower, chamber, cuvette, etc.)

Major deadlines for TGB group

July 15, 1993	Preliminary documentation
November, 1993	Final 1993-IFC data documentation
January, 1994	1993-IFC data submission
March, 1994	Preliminary 1994 documentation
October, 1994	Final 1994-IFC data documentation
December, 1994	1994-IFC data submission

3.5.3.4.5 Proposed HYD Data Plan

Summaries of the data types to be collected by the HYD group are shown in Section 4.5.

Each time period for HYD data will also need the following information associated with it:

- Depth of measurement
- Measurement method
- Calculation method for moisture content (i.e. volumetric/gravimetric)

Major deadlines for HYD group

July 15, 1993	Preliminary documentation
November, 1993	Final 1993-IFC data documentation
November 15, 1993	1993-IFC data submission
January 15, 1994	Preliminary 1994 documentation
March 15, 1994	Winter and Thaw-IFC final documentation Preliminary 1994-IFC documentation
May, 1994	Winter and Thaw-IFC data submission
October, 1994	Final 1994-IFC data documentation
November, 1994	1994-IFC data submission

3.5.3.4.6 Proposed RSS Data Plan

Summaries of the data types to be collected by the RSS group are to be found in Section 4.6.

Each time period for RSS data will also need the following information associated with it:

- Wavelength observed
- Viewing geometry
- Illumination geometry
- Spatial resolution
- Pixel locations

Major deadlines for RSS group

July 15, 1993	Preliminary documentation
November, 1993	Final 1993-IFC data documentation
December, 1994	1993-IFC data submission
March, 1994	Preliminary 1994 documentation
October, 1994	Final 1994-IFC data documentation
November, 1994	1994-IFC data submission

3.5.3.5 Data Delivery

BORIS realizes that the investigator, who has the best understanding of the data, is the best person to design the structure of the data tables. BORIS will provide the investigator with information on factors to consider when organizing the data, and the tools with which to do this.

A software package named **Data Formatter** has been designed by BORIS staff to provide this assistance. Data Formatter allows the investigators to design a database table for their data, read the data in, do some quality checks of the data, and produce a standard output file to be sent to the information system. Data tables consist of rows and columns; each row contains a single set of observations, and each column contains a single type of data. Null values are assigned for missing data. Site, date, time, revision date, and certification level should be provided for all data. Brief descriptions of all columns providing information on the type of data and units used should be included. Data Formatter prompts for all of these requirements and provides examples of existing tables to aid in the design of new tables. The software then produces a spreadsheet-type form based on the table design. It reads in the data and checks that the format of the input data matches the defined format. It also flags questionable data points, and produces a summary report of the data ingested. A batch procedure can be used to load multiple data files.

Data Formatter produces standard data files to be sent to BORIS. These standard files will greatly streamline the flow of data because they can be loaded directly into the database, ready for integration.

3.5.3.6 Data Standards

Standards for the reporting of measurements are required to avoid confusion. Following are several common-sense guidelines of general use:

Units: All data should use System Internationale (SI) units. Some disciplines may have other standards. The use of non-SI units in the data system will be considered on a case-by-case basis.

Time: All time values given should be reported in GMT. In BOREAS, the study areas are located in two different time zones. One zone uses daylight savings time and one zone does not. The use of GMT avoids any confusion. The database allows the times to be adjusted to local time if desired, e.g., to look at diurnal variations.

Angles: Any description of angles, (e.g. viewing angle, should use spherical polar coordinates, target centered, using north as the zero azimuth angle.

Location: A grid scheme has been developed for describing locations within the BOREAS experiment. Locations should be reported using the BORIS grid (see BORIS Grid, below). Software will be provided which will allow the conversion to and from latitude-longitude or UTM coordinates and the BOREAS grid location. Tables 3.5.3.6 provide the BORIS grid, latitude/longitude, and UTM coordinates of current, prominent sites and features in the southern and northern study areas, respectively.

3.5.4 **Mapping and Site Location**

3.5.4.1. BORIS Grid

A key element of the information system effort is to be able to consistently track and locate the data collected over the BOREAS region. This includes satellite and aircraft imagery, biophysical measurements collected along transects, and other measurements of all sorts at specific points in the area. The BOREAS region (including the transect area) covers 18° of longitude (94 W to 111 W) and 9° of latitude (51 N to 60 N). Based on the experience with FIFE, it was felt that an (x,y) grid system would provide a means of performing the requisite data location function needed in organizing and retrieving the data in a consistent manner. However, not just any grid system will serve the needed function. Rather, it was felt that the grid system needed to satisfy at least the following criteria:

1) equal-area grid cells across the region (important for not requiring use of weighted statistics calculations),
2) identification of grid cells at different scales (i.e., hierarchical in nature),

Name	Notes	Category	BORS X	BORS Y	West Longitude	North Latitude	UTM Easting	UTM Northing	UTM Zone	Source of Location
Flux Tower Sites										
C3B7T	SSA OA	1	317.3	303.4	-106.197	53.629	420,874	5,942,688	13	GPS
F0L9T	SSA Fen	1	419.5	330.6	-104.619	53.799	525,101	5,961,204	13	Air photo
F8L6T	SSA YJP	1	418.9	338.9	-104.647	53.875	523,201	5,969,705	13	Air photo
G8I4T	SSA OBS	1	384.9	348.4	-105.122	53.985	492,000	5,981,904	13	Air photo
G2L3T	SSA OJP	1	413.6	343.2	-104.691	53.916	520,314	5,974,015	13	GPS
D6H4T	SSA YA	1	374.9	316.7	-105.312	53.709	479,400	5,951,000	13	Map
T7Q8T	NSA OJP	1	768.5	617.1	-98.624	55.927	523,501	6,197,997	14	Air photo
T3R8T	NSA OBS	1	778.1	613.3	-98.484	55.879	532,801	6,192,700	14	Air photo
T7S1T	NSA Fen	1	781.2	617.6	-98.422	55.914	536,103	6,196,703	14	Air photo
T8S9T	NSA YJP	1	789.6	616.2	-98.288	55.903	544,498	6,195,502	14	Air photo
T4U6T	NSA Beaver Pond	1	806.9	614.8	-98.026	55.845	561,000	6,189,000	14	Map
Mesonet Stations										
SSA OA AMS Tower	Suite A		317.3	303.5	-106.196	53.629	420,938	5,942,576	13	GPS
SSA OA Flux Tower	Suite B		317.3	303.4	-106.197	53.629	420,874	5,942,688	13	GPS
SSA OA AFM	Precip		317.3	303.1	-106.196	53.626	420,934	5,942,353	13	GPS
SSA OJP AMS Tower	Suite A		413.7	343.3	-104.689	53.916	520,445	5,974,041	13	GPS
SSA OJP Flux Tower	Suite B		413.6	343.2	-104.690	53.916	520,391	5,973,998	13	GPS
SSA OJP AFM	Precip		413.7	343.3	-104.689	53.916	520,456	5,974,043	13	GPS
The Pas AMS Tower	Suite A		649.7	376.7	-101.056	53.968	365,158	5,981,696	14	GPS
The Pas AFM	Precip		649.7	376.7	-101.056	53.968	365,158	5,981,696	14	GPS
NSA OJP Flux Tower	Suite A		768.6	617.2	-98.622	55.928	523,637	6,197,905	14	GPS
NSA Fen-Hut AMS Tower	Suite B		781.3	618.1	-98.420	55.916	536,270	6,196,657	14	GPS
NSA OJP AFM	Precip		768.5	617.3	-98.623	55.929	523,574	6,198,016	14	GPS
Thompson Airport AMS Tower	Suite A		817.1	612.1	-97.874	55.804	570,598	6,184,614	14	GPS
Thompson Airport AFM	Precip		817.2	612.0	-97.873	55.803	570,663	6,184,503	14	GPS
Lynn Lake AMS Tower	Suite A		601.2	698.4	-101.093 *	56.888	372,492	6,306,422	14	GPS
Lynn Lake AFM	Precip		601.2	698.6	-101.093	56.888	372,499	6,306,644	14	GPS
Flin Flon AMS Tower	Suite A		598.1	446.6	-101.690	54.671	326,559	6,061,281	14	GPS
Flin Flon AMS Trestle	Suite B		598.2	446.8	-101.689	54.672	326,626	6,061,390	14	GPS
Flin Flon AFM	Precip		598.2	446.8	-101.689	54.672	326,626	6,061,390	14	GPS
La Ronge AMS Tower	Suite A		363.2	474.0	-105.293	55.124	481,357	6,108,407	13	GPS
La Ronge AFM	Precip		363.2	474.1	-105.293	55.125	481,336	6,108,516	13	GPS
Meadow Lake AMS Tower	Suite A		162.7	350.9	-108.509	54.127	662,824	6,000,295	12	GPS
Meadow Lake AFM	Precip		162.7	350.9	-108.509	54.127	662,824	6,000,295	12	GPS
Saskatoon (SRC-CRS) AMS Tower	Suite A		301.1	137.4	-106.600	52.150	390,530	5,778,711	13	Map
Saskatoon AMS Trestle	Suite B		301.1	137.4	-106.600	52.150	390,530	5,778,711	13	Map
Saskatoon AFM	Precip		301.1	137.4	-106.600	52.150	390,530	5,778,711	13	Map
Upper Air Stations										
Existing Regular										
Baker Lake UA, NWT	YBK		730.0	1559.0	-96.000	64.317	645,032	7,135,725	14	Catalogue
Fort Smith UA, NWT	YSM		-52.1	1006.4	-111.933	60.033	447,894	6,655,490	12	Catalogue
Churchill UA, MB	YYQ		970.4	979.9	-94.083	58.733	437,281	6,510,866	15	Catalogue
The Pas UA, MB	YQD		646.9	376.2	-101.100	53.967	362,245	5,981,855	14	Catalogue
Edmonton-Stony Plain, AB	WSE		-205.2	286.2	-114.100	53.550	692,114	5,937,369	11	Catalogue
Saskatoon, SK	YXE		294.1	136.8	-106.700	52.167	383,732	5,780,939	13	Catalogue
Pickle Lake, ON	YPL		1424.9	264.3	-90.217	51.450	693,393	5,703,543	15	Catalogue
Great Falls, MT	GTF		-27.8	-389.4	-111.367	47.483	472,437	5,258,847	12	Catalogue
Glasgow, MT	GGW		327.4	-288.2	-106.617	48.217	379,956	5,341,643	13	Catalogue
Bismark, ND	BIS		786.6	-410.5	-100.750	46.767	366,409	5,180,722	14	Catalogue
International Falls, MN	INL		1282.9	-105.3	-93.383	48.567	471,731	5,379,364	15	Catalogue
Existing DND										
Primrose Lake, AB	WO		61.1	417.8	-110.050	54.750	561,146	6,067,886	12	Catalogue
Shilo, MB	WLO		816.4	-66.3	-99.650	49.763	453,234	5,514,744	14	Catalogue
BOREAS Sites										
Thompson Zoo, MB	YTH		818.7	606.3	-97.867	55.750	571,137	6,178,837	14	Map
Candle Lake, SK	WLZ		377.6	319.6	-105.267	53.733	482,409	5,953,886	13	Map
Key Lake, SK	YKJ		324.3	706.6	-105.617	57.250	462,791	6,345,384	13	Map
Cooperative Sites										
Quill Lake, SK	WQH		452.3	138.2	-104.409	52.050	541,144	5,766,769	13	Catalogue
Lynn Lake, MB	YYL		602.1	696.3	-101.083	56.867	373,001	6,304,478	14	Catalogue
Other points of interest:										
SAHQ			378.0	319.7	-105.262	53.734	482,750	5,953,900	13	Map
Prince Albert Airport			354.6	259.9	-105.660	53.220	454,370	5,896,374	13	Map
Thompson Airport & NAHQ			817.7	611.6	-97.870	55.800	571,048	6,184,190	14	Map
SSA LIDAR			414.8	358.3	-104.650	54.050	522,916	5,988,925	13	Map
SSA Profiler			415.2	342.6	-104.667	53.909	521,896	5,973,232	13	Map
SSA RADAR			769.1	616.0	-98.612	55.934	524,262	6,198,576	14	Map
AVIRIS Sensor Calibration Site			354.5	250.8	-105.686	53.133	453,468	5,887,107	13	Unknown
AVIRIS Sensor Calibration Site			352.7	274.8	-105.696	53.350	453,701	5,911,210	13	Unknown

Table 3.5.3.6 Coordinates for selected features in the BOREAS Region

Name	Notes	Category	BORIS X	BORIS Y	West Longitude	North Latitude	UTM Easting	UTM Northing	UTM Zone	Source of Location
Auxiliary sites:										
Southeast of SSA:										
A1A	Salcche	3	328.3	205.2	-106.134	52.742	423,500	5,844,000	13	Map
A2P	Nisbet	3	317.9	255.4	-106.237	53.198	417,400	5,894,800	13	Map
SSA:										
B9B7A	AIM-13	2	317.7	299.2	-106.195	53.591	420,942	5,938,470	13	GPS
D9G4A	AMH-16	2	364.4	319.5	-105.468	53.741	469,282	5,954,618	13	GPS
D0H6S	BMM-1	3	376.8	310.6	-105.291	53.653	480,824	5,944,699	13	GPS
D9I1M	AIH-3	2	381.6	319.3	-105.207	53.727	486,366	5,952,968	13	GPS
D6L9A	ADH-2	3	419.5	316.1	-104.639	53.669	523,888	5,946,556	13	GPS
E7C3A	AMM-12	3	323.2	327.5	-106.061	53.841	428,916	5,966,173	13	GPS
F5I6P	JIH-4	3	386.6	335.3	-105.111	53.866	492,737	5,968,441	13	GPS
F7J0P	JMH-5	3	390.6	337.6	-105.048	53.884	496,881	5,970,405	13	GPS
F7J1P	JMH-A1	5	391.7	337.4	-105.031	53.881	497,992	5,970,082	13	GPS
F7J1P	JMH-A2	5	391.7	337.4	-105.031	53.881	497,992	5,970,082	13	GPS
G2I4S	SMH	3	384.3	342.2	-105.137	53.930	491,027	5,975,486	13	GPS
G2I4S	BIH	5	384.3	342.2	-105.137	53.930	491,027	5,975,486	13	GPS
G4I3M	MW-1	3	393.4	344.1	-105.149	53.947	490,276	5,977,457	13	GPS
G1K9P	JMM-6	3	409.9	342.0	-104.749	53.908	516,552	5,973,092	13	GPS
G5K8S	BMH-9	2	408.6	346.3	-104.763	53.948	515,691	5,977,484	13	GPS
G7K9P	JMM-6A	3	409.1	347.3	-104.769	53.958	515,239	5,978,595	13	GPS
G8K8P	JMM-6B	3	408.4	348.2	-104.762	53.965	515,617	5,979,367	13	GPS
G2L7S	B7L	3	417.3	342.1	-104.637	53.904	523,899	5,972,824	13	GPS
G8L6P	JDM-8	3	416.7	348.5	-104.637	53.961	523,846	5,979,032	13	GPS
G9L0P	JMH-10	2	410.2	349.4	-104.733	53.974	517,522	5,980,417	13	GPS
H2D1M		3	331.3	353.2	-105.931	54.066	439,100	5,991,000	13	Map
H2D1S		3	331.7	352.7	-105.925	54.061	439,500	5,990,500	13	Map
H3D1M		3	331.2	353.6	-105.931	54.069	439,100	5,991,400	13	Map
H1E4S		3	344.4	351.3	-105.733 *	54.040	452,000	5,988,000	13	Map
I2I8P	JIH-7	2	388.3	361.9	-105.051	54.112	496,702	5,995,729	13	GPS
G9I4S	BDL-20	2	384.7	349.5	-105.121	53.995	492,084	5,982,703	13	Map
G4K8P	JMM-5	3	408.5	344.5	-104.767	53.932	515,344	5,975,797	13	Map
F1N0M	Jail Site	3	430.8	332.0	-104.447	53.801	536,468	5,961,343	13	Map
E7B7C	HYD-5 Tower	3	317.3	327.9	-106.171	53.848	423,000	5,967,000	13	Map
E6C5W	HYD-5 Tower	3	325.9	326.6	-106.041	53.831	431,500	5,965,000	13	Map
Transect:										
O1P		3	514.5	499.7	-102.886	55.219	634,500	6,121,000	13	Map
O2S		3	515.1	499.2	-102.879	55.215	635,000	6,120,500	13	Map
O3S		3	519.5	500.1	-102.808	55.218	639,500	6,121,000	13	Map
O4P	Deleted									
O5P		3	514.5	500.2	-102.886	55.224	634,500	6,121,500	13	Map
O6P		3	513.1	499.1	-102.910	55.215	633,000	6,120,500	13	Map
O7S		3	517.0	499.9	-102.847	55.219	637,000	6,121,000	13	Map
O8M		3	796.1	542.8	-98.403	55.227	538,000	6,120,000	14	Map
O9P		3	744.1	608.1	-99.034	55.885	497,900	6,193,100	14	Map
NSA:										
P7V1A	AMH-1	3	811.2	577.4	-98.069	55.508	558,800	6,151,500	14	Map
Q1V2M	MW-2	3	812.3	581.9	-98.039	55.546	560,629	6,155,735	14	GPS
Q3V3P		3	813.0	583.3	-98.024	55.557	561,600	6,157,000	14	Map
R8V8A		3	818.9	598.6	-97.887	55.682	570,000	6,171,000	14	Map
S9P3A	AIH-14	3	753.8	609.8	-98.877	55.886	507,724	6,193,162	14	GPS
S8W0P		3	820.2	608.7	-97.837	55.768	573,000	6,180,700	14	Map
T0P5M	MW-1	3	755.0	610.5	-98.856	55.890	509,093	6,193,599	14	GPS
T0P7S	BMM-9	3	757.1	610.1	-98.824	55.883	511,059	6,192,847	14	GPS
T0P8S	BMH-7	3	758.4	610.4	-98.802	55.894	512,423	6,192,928	14	GPS
T2Q6A	TE Carbon	1	766.1	612.2	-98.676	55.888	520,267	6,193,392	14	Sat. Image
T5Q7S	BMH-6	3	767.7	615.7	-98.641	55.916	522,450	6,196,563	14	GPS
T6Q9P	JIH-2	3	769.9	618.6	-98.597	55.938	525,174	6,199,016	14	GPS
T9Q8P	JIL-1	2	768.9	619.8	-98.610	55.951	524,404	6,200,425	14	GPS
T6R5S	BIH-9	2	775.4	616.2	-98.519	55.908	530,101	6,195,719	14	GPS
T7R9S	BDH-3	3	779.6	617.6	-98.448	55.914	534,534	6,196,454	14	GPS
T7S9P	JIM-4	3	789.1	617.3	-98.300	55.896	543,824	6,194,546	14	GPS
T8S4A		3	784.4	619.0	-98.368	55.919	539,500	6,197,000	14	Map
T9S9P	JDH-3	3	789.9	618.5	-98.284	55.905	544,808	6,195,513	14	GPS
T6T6S	BIL-2	3	796.4	616.8	-98.186	55.880	550,943	6,192,742	14	GPS
T7T3S	BML-21	3	793.7	617.9	-98.225	55.894	548,492	6,194,272	14	GPS
T8T1P	JDM-1	3	791.2	618.8	-98.262	55.906	546,151	6,195,583	14	GPS
T3U9S	BIM-12	3	810.0	613.8	-97.982	55.831	563,817	6,187,459	14	GPS
T4U5A	AIM-1	3	806.0	614.9	-98.041	55.847	560,071	6,189,197	14	GPS
T4U91-S	BIM-1	3	809.4	614.5	-97.989	55.838	563,367	6,188,231	14	GPS
T4U92-S	BIH-1	3	810.0	614.3	-97.980	55.835	563,934	6,187,972	14	GPS
V5X7A	AIH-30	3	837.7	635.3	-97.460	55.973	594,911	6,203,870	14	GPS
W0Y5A	AIM-20	2	845.9	640.5	-97.336	56.004	603,801	6,207,559	14	GPS
U6W5S	BIL-21	2	925.9	627.0	-97.693	55.920	581,700	6,197,712	14	Map

Table 3.5.3.6 (cont) Coordinates for selected features in the BOREAS Region

Name	Notes	Category	BORIS X	BORIS Y	West Longitude	North Latitude	UTM Easting	UTM Northing	UTM Zone	Source of Location
AES Surface Weather Station Collecting15 Minute Data for BOREAS										
15 minute Data for '93 and '94										
Collins Bay	WWC		428.5	622.6	-103.700	58.183	576,449	6,449,648	13	
Lucky Lake	WLE		270.6	1.9	-107.150	50.950	348,976	5,646,247	13	
Meadow Lake	WLJ		162.1	351.5	-108.517	54.133	270,258	6,003,857	13	
Melfort	WFF		430.6	221.8	-104.600	52.817	526,959	5,851,734	13	
Nipawin (AES)	WBU		465.3	283.0	-104.000	53.333	566,594	5,909,801	13	
Rosetown East	WRJ		213.9	67.7	-107.917	51.567	297,855	5,716,657	13	
Southend	WJH		475.7	620.3	-103.283	56.333	606,139	6,244,290	13	
Spiritwood West	WSR		229.4	268.9	-107.550	53.367	330,332	5,915,874	13	
Waskesiu Lake	WLV		323.6	336.0	-106.067	53.917	429,940	5,974,561	13	
Watrous East	WIW		387.3	89.7	-105.400	51.667	472,335	5,723,822	13	
Bachelors Island Marine	WBL		763.9	144.4	-99.900	51.750	437,869	5,733,398	14	
Flin Flon	WFO		598.4	450.0	-101.683	54.683	327,017	6,062,645	14	
Gilam	WGX		996.9	714.9	-94.700	56.367	765,550	6,254,979	14	
Hunters Point	WHH		672.7	274.9	-100.933	53.033	370,356	5,877,509	14	
15 min. Data during IFC's only (hourly otherwise)										
Buffalo Narrows	WVT		160.6	541.1	-109.433	55.833	284,990	6,192,649	13	
Uranium City	WDC		142.4	956.7	-108.463	59.567	303,224	6,608,106	13	
Wynyard Lake	WDY		469.0	106.1	-104.200	51.767	555,207	5,735,171	13	
Fisher Branch	WSZ		936.0	100.2	-97.550	51.063	601,565	5,659,873	14	
Grand Rapids	WJD		780.3	306.8	-99.267	53.183	482,179	5,892,481	14	
Swan River	WEQ		667.1	171.0	-101.233	52.117	347,064	5,776,149	14	
Hudson Bay	YHB		583.8	238.5	-102.317	52.817	680,830	5,855,034	13	
Key Lake	YKJ		324.3	708.6	-105.617	57.250	462,789	6,345,172	13	
Dauphin	YDN		764.9	71.4	-100.050	51.100	426,479	5,661,251	15	
A complete set of AES Surface Weather and Climate Stations in the region are in an appendix.										
BOREAS Regional Grid	NW		0.0	1000.0	-111.000	59.979	500,100	6,648,824	12	
	NE		1000.0	1000.0	-93.502	58.644	471,015	6,522,585	15	
	SE		1000.0	0.0	-96.970	50.089	645,272	5,550,297	14	
	SW		0.0	0.0	-111.000	51.000	500,060	5,649,599	12	
Northern	NW		750	650	-98.82	56.247	510884	6233565	14	N/A
Study	NE		850	650	-97.24	56.081	609930	6216458	14	N/A
Area	SE		850	570	-97.49	55.377	595766	6137770	14	N/A
	SW		750	570	-99.05	55.54	497150	6154889	14	N/A
NSA	NW		760	630	-98.72	56.055	517312	6211970	14	N/A
Modeling	NE		800	630	-98.09	55.99	556757	6205124	14	N/A
Sub-Area	SE		800	600	-98.18	55.726	551608	6175619	14	N/A
	SW		760	600	-98.81	55.79	512162	6182466	14	N/A
Extension	SE		750	615	-98.92	55.938	504876	6198930	14	N/A
of NSA	SW		760	615	-98.76	55.922	514737	6197218	14	N/A
Modeling	NW		760	605	-98.79	55.834	513020	6187383	14	N/A
Sub-Area	NE		750	605	-98.95	55.849	503159	6189095	14	N/A
Southern	NW		310	380	-106.23	54.319	420187	6019734	13	N/A
Study	NE		440	380	-104.24	54.223	549799	6008564	13	N/A
Area	SE		440	290	-104.37	53.419	542029	5919013	13	N/A
	SW		310	290	-106.32	53.513	412468	5930178	13	N/A
SSA	NW		380	360	-105.18	54.093	488258	5993612	13	N/A
Modeling	NE		430	360	-104.42	54.053	536103	5989312	13	N/A
Sub-Area	SE		430	320	-104.48	53.695	534652	5949512	13	N/A
	SW		380	320	-105.23	53.735	484815	5953813	13	N/A
Coordinates are based on NAD83 datum. except for UTM coordinates.										
UTM Coordinates are based on the NAD27 datum.										

Table 3.5.3.6 (cont) Coordinates for selected features in the BOREAS Region

3) ability to identify areas from 1 by 1 km down to 1 by 1 m in a meaningful fashion.

With these criteria in mind, the Albers Equal-Area Conic (AEAC) projection was selected. The key advantages of the AEAC projection include: 1) easily derived grid cells of equal area, 2) extremely small distortion over the BOREAS region using the established rules of standard parallel selection, and 3) the ability to perform circumpolar mapping/ location of data in the boreal forest region (potentially valuable for long term boreal region research). The origin of the grid will be located at the lower left corner of the area using 51.00° N and 111.00° W as its physical location. This should provide enough of a boundary around the area without having to go outside the current region bounds. To minimize mapping error over the area, the standard parallels of 52° 30' 00.00'' N and 58° 30' 00.00'' N were used. Figures 3.5.4.1a and b provide a visualization of how the grid falls over the area.

Once the projection was selected, it was then a matter of determining how to identify grid cells of different spatial sizes. Since the dimensions of the region are 1,000 X 1,000 km, a base grid matrix of 1,000 columns and 1,000 rows with 1 km resolution for each cell would cover the area. The "anchor-point" for each cell is the lower left corner of that cell. Thus, by specifying increasing resolution of the anchor-point grid lines, one can specify a grid of increasing resolution (see Figure 3.5.4b) : a cell designated as (280,530) is a cell 1 kilometer on a side anchored at the intersection of the 280 and 530 kilometer grid lines. A cell designated as (280.2,530.8) is a cell 0.1 km (or 100 m) on a side anchored at the intersection of the 280.2 and 530.8 grid lines. Cell (280.42, 530.28) is likewise a 10 m on-a- side cell anchored at the intersection of the 280.42 and 530.28 grid lines. This system could, in theory, be extended further if necessary.

The last element of the grid was to select a map datum to establish the center of the earth's reference spheroid and the associated eccentricity parameters. A large majority of the existing maps are based on the Clarke 1866 datum (also known as North American Datum 27 (i.e., NAD 27)). However, the coordinates from hand-held and aircraft GPS systems that will be used in BOREAS are based on the NAD 1983 (NAD 83) which is based on the World Geodetic System 1984 (WGS 84). The main difference is that the NAD 83 datum places the center of the earth spheroid at the center of mass (which is quite appropriate for satellite-based geodesy) while the NAD 27 datum was fit to the earth's shape only over the North American continent. A review of the two datums over the BOREAS region gave differences of up to 200 m in site locations. A decision was made to use the WGS 84 ellipsoid based on: 1) the National Geodetic Survey and the USGS are currently in the process of updating their standard topographic maps to the WGS 84 ellipsoid, 2) the desire to not have to correct aircraft based positions as part of the operational data

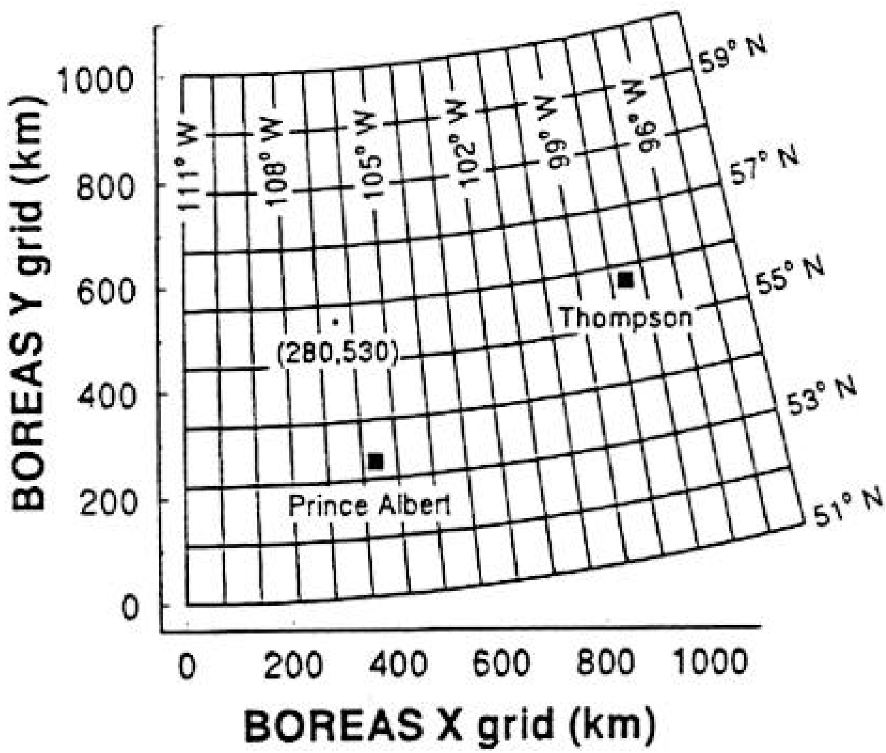

Figure 3.5.4.1a Latitude/Longitude grid superimposed on the BOREAS grid with the 1 km x 1 km grid square (280,530) enlarged in Figure 3.5.4.1b

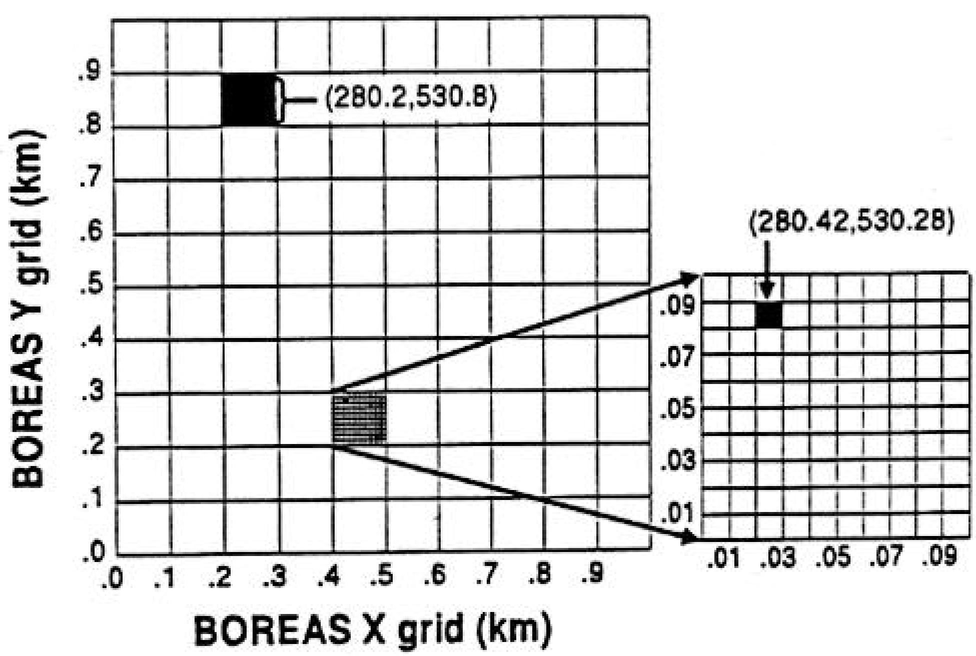

Figure 3.5.4.1b 1 km x 1 km grid square (280,530) with 100m x 100 m grid square (280.2, 530.8) and 10 m x 10 m grid square (280.42, 530.28) shaded.

collection activities, and 3) the desire to make the data set as viable as possible for future use.

BORIS staff had previously made available a coordinate conversion utility that calculated UTM, BOREAS grid, and latitude, longitude coordinates based on the Clarke 1866 ellipsoid. As it exists, the software will give coordinates within 200 m (or better) of the WGS 84 locations. However, based on our misfortune of working in North America, the conversion between the datums is not simply a matter of some spherical trigonometric equations. Rather, adjustments made in the original surveys must be accounted for in the conversion. The current BOR-CORD program (Version 2.0) handles the datum shift calculations properly. The software is written in C and has been tested successfully on many computer systems (MacIntosh, IBM PC, VAX, Unix Workstations).

3.5.4.2 BOREAS Operational Grid

The BOREAS operational grid is a simple map reference system developed by the project to locate and identify sites within the BOREAS region. Each study area is divided up into 1km squares, each identified by a four-character string, see Figure 3.5.4.2. A fifth character defines vegetation type. (Two special cases exist for this fifth character): a T will designate a Tower Flux site and number (0-9) will indicate that there are at least two auxiliary sites in the same 1 km x 1 km square - therefore navigate carefully! The current (fifth character) identifiers are:

T	Tower Site
S	Spruce
P	Pine
A	Aspen
M	Mixed
F	Fen
C	Clearing
W	Water
0-9	Multiple sites in a single 1 km x 1 km block.

The operational grid coordinates are in the BORIS grid projection described in the Section 3.5.4.1. Each grid cell is 10 km by 10 km. In the Southern Study Area (SSA), the letters B through N are used to represent each each grid in the north and east directions. The letter A is reserved as a wild card for any sites that fall to the west or south of the SSA. The origin (southwest corner) of the SSA operational grid is located at BORIS grid coordinate (x = 310, y = 290).

In the Northern Study Area (NSA) the letters P through Y have been used to label each 10 km by 10 km cell. The letter O has been reserved to label the auxiliary sites that fall between the SSA and NSA. The letter Z has been reserved for sites that fall to the east or north of the NSA. The origin of the NSA operational grid is located at BORIS grid coordinate (x = 750, y = 570).

The Operational Grid coordinates will be in y, x order in deference to aircraft crews who assimilate locations in latitude (y) and longitude (x). The 10km x 10km cell QV will refer to the cell in the Qth row (y) and Vth column (x). This is recognized as a departure from normal (x, y) nomenclature. This places the burden of "processing" where QV is located upon the ground troops who can process at our leisure. It allows the air crews to function instinctively and removes the "processing" from the cockpit where things happen quickly, margins of error are smaller and the cost of a mistake can be extreme.

A 1 km subgrid exists within each 10 km cell to more precisely locate each site. Each subgrid cell is numbered 0 through 9. In the sample shown, two sites fall within the TQ grid cell. The sites used in this example would be designated Q3V3P and Q1V2M because they are Jack Pine and Mixed sites respectively.

Note that the definitions of the NSA and SSA have been modified to correspond with this operational grid. For the purposes of formally defining the NSA and SSA, we are proposing that the following conventions be adopted:

SSA: The rectangle defined by operational-grid cells (B,B) in southwest through (N,J) in northeast [BORIS grid (310,290) through (439,389);
Lat/Long: Corners clockwise, starting at southwest:
53.51°N, 106.32°W, 54.41°N, 106.22°W;
54.31°N, 104.22°W, 53.42°N, 104.37°W.]

NSA: The rectangle defined by operational grid cells (P,P) in southwest through (Y,W) in northeast [BORIS grid (750,570) through (849,649);
Lat/Long: Corners clockwise starting at southwest:
55.54°N, 99.05°W, 56.25°N, 98.82°W;
56.08°N, 97.24°N, 55.38°N, 97.49°W.]

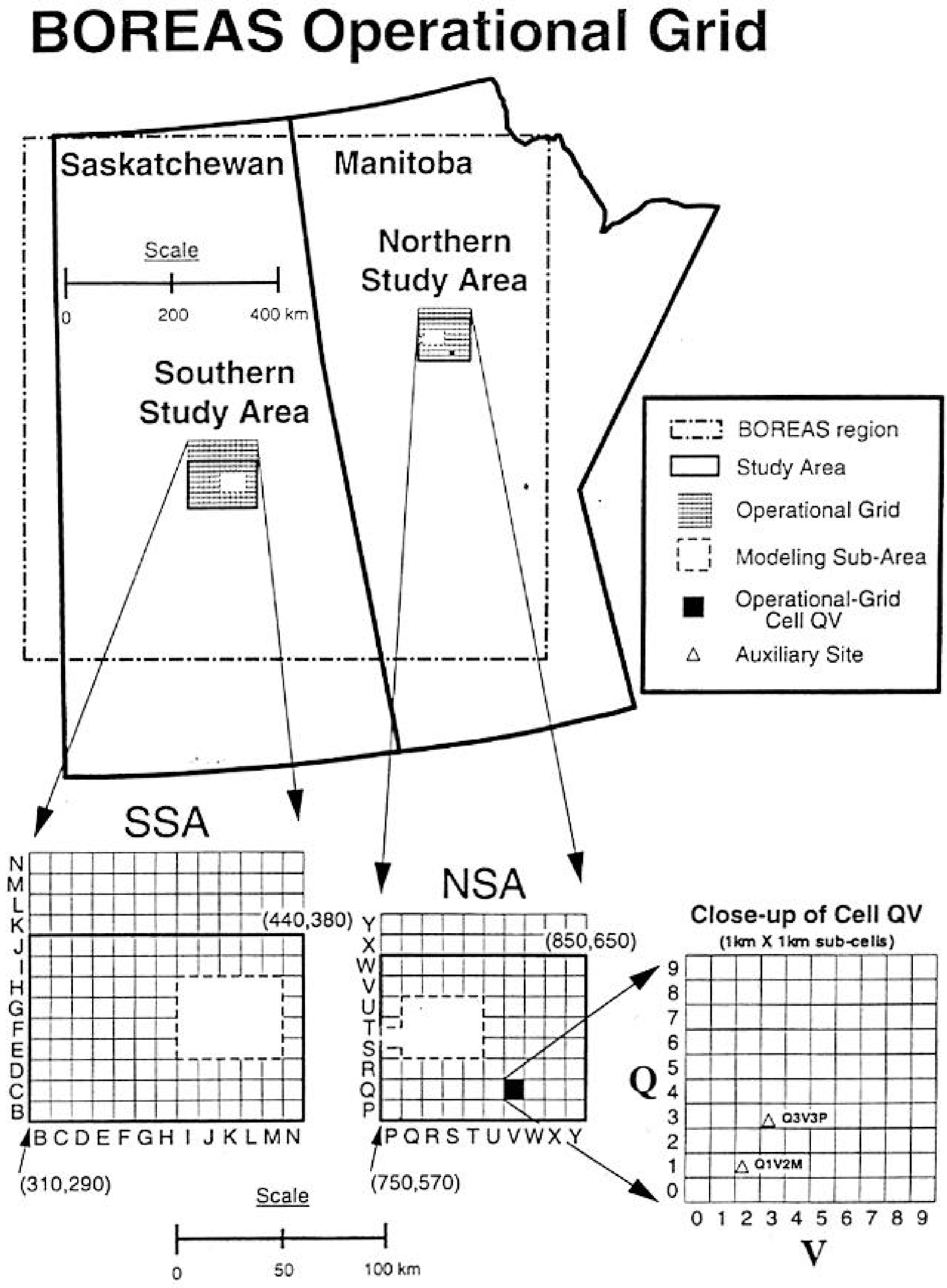

Figure 3.5.4.2 BOREAS Operational Grid

3.5.5 **Gridded Data Products**

BORIS staff and certain PIs will be producing gridded data sets aimed specifically for use by the modeling community. The initial attempts for defining the details of exact specifications for such data sets were made at the Winnipeg Workshop (May, 1993), the TE/RSS mini-workshop in Columbia, MD (July, 1993), and the October, 1993 workshop at Coolfont, West Virginia. Several modelers involved with BOREAS have defined their minimum requirements for initialization and validation of their models in terms of:

- Geographic Coverage
- Spatial Resolution
- Temporal Resolution
- Time Periods

For additional detail, see preceding sections in Chapter 3 plus sections 4.3.5.3, 4.6.1 and Appendix J.

With the help of Lou Steyaert (AFM-12) and input from many of the investigators, BORIS proposes to generate (or coordinate the generation of) gridded data products listed in Table 3.5.5.

Notes:

1. RAMS Grids. Several BOREAS investigators require high resolution nested mesoscale meteorological model data for the Modeling Sub-Areas to include atmospheric forcing and integrated flux outputs for intercomparisons with tower site, A/C, and model flux estimates. After parameterization and fine-tuning for the boreal forest domain, the Colorado State University Regional Atmospheric Modeling System (RAMS) will be used to provide nested grid outputs (for example, 1-, 4-, 16-, and 64 km cell sizes) for selected "golden days" during the IFC's (Drs. Roger Pielke and T. J. Lee: AFM-12). Although the nested grid cell sizes are yet to be determined, a 1 km analysis for the Modeling Sub-Areas in the SSA and NSA and associated nested grid coverage for other portions of the region are envisioned

2. Operational Meteorological Models. Several BOREAS investigators require meteorological model data sets at grid cell sizes of 100 km or less over the BOREAS region and during the entire IFC's (and between IFC's for seasonal analysis, if possible). These operational model outputs are needed to support multiscale atmospheric, hydrologic and ecologic modeling activities including intercomparisons of various model, surface-based, and satellite-derived data sets. The model data should be based on 4-D data assimilations that incorporate BOREAS special upper air and AMS network data sources. Dr. Alan Betts (AFM-8) is coordinating this activity and is

Table 3.5.5 Gridded Data Products
Minimum Resolutions by Region

Scale:	Sites:	Sites:	Modeling	Study Area	Transect	Region	Temporal Resolution	Period
	Process - 21m x 1m Aux - .01 km^2	TF 1 km^2	Sub-Area in Study Area	10^3 km^2	(400x13) km^2	10^6 km^2		
Flux	Point	Point	A/C Stacks; RAMS Grids(1), (2)	RAMS Grids(1) Plus(2)	A/C Trans. (6 km); RAMS Grids(1); Op. Met. Models(2)	RAMS Grids(1); Op. Met. Models(2)	30 min.; Synoptic	Sel. Days; IFC's
Met	Point	Point	Sfc-Obs Interpol. (3); RAMS Grids (1), (2)	Sfc-Obs Interpol. (3); RAMS Grids (1), (2)	Sfc-Obs Interpol.(3); RAMS Grids(1); Op Met Models (2)	RAMS Grids(1); Op Met Models(2)	15 min.; Synoptic	Continuous; Sel. Days; IFC's
Satellite R.S. (4)	Full	Full	Full	Full	1 km AVHRR	1 km AVHRR	Weekly	Continuous
A/C R.S. (5)	Full	Full	Full	---	Full	---	Varies	IFC's
Soil Properties (6)	Point	1:5K Scale	1:125K SSA; NSA	1:125K SSA; NSA	1:1M	1:1M	Once	Once
Soil Moisture (7)	Point	Point	A/C Flight Lines	A/C Flight Lines	A/C Flight Lines	---	Varies	Continuous
Topographic (8)	?	?	1:50K	1:50K ?	1:250K ?	1:1M	Once	Once
Land Cover Parameters (9), (10)	Forest Cover	Forest Cover	TM 30 m Gridded Data	TM 30 m	AVHRR-Land Cov. Char at 1 km; TM	AVHRR-Land Cov. Char at 1km	Once	Once
Radiation (11)	Point	Point	GOES 2,14,28 km	GOES 2,14,28 km	GOES 2,14,28 km	GOES 2,14,28 km	30 min.	Continuous
Snow (12)	Point	Point	A/C Flight Lines	A/C Flight Lines	SSM/I 25 km; AVHRR ?; A/C Flight Lines	SSM/I 25 km; AVHRR ?;	Weekly	Continuous

Point = Point observations are georeferenced, not gridded
Full = full resolution of satellite instrument
? = unresolved and to be determined (TBD)
--- = not available

developing an archive plan for ECMWF GCM and NOAA ETA (AFM-11) mesoscale model data sets based on feedback from P.I's

The ECMWF GCM provides a standard operational 4DDA product consisting of horizontal fields at approximately 50 km delta-x including near-surface data at 30 m height, but only at 6 hour synoptic time intervals. Efforts will be made to get the lowest atmospheric layer and surface data from this operational product beginning August 5, 1993.

In addition, ECMWF will produce 2 new products from their new integrated forecast system (IPS) at ECMWF which became operational this spring, thereby permitting the operational archiving of subsets of model data and diagnostics at higher time resolution than has been previously possible. The first product consists of vertical profile time series at 6 selected points every hour giving full model diagnostics at higher vertical resolution (e.g., in the PBL). These 6 "good-point" time series will represent approximately 60 x 60 km squares over 6 selected points of importance to BOREAS across the forest zone. These are shown on Figure 3.2.1. From SW to NE, they are centered roughly on Rosetown (as representative of the region South of the forest), PA Park, Nipawin, Flin Flon, Thompson, and Churchill. This product is under development: it is hoped to have it on line by mid-April. The second high-time resolution product for BOREAS will be spatial averages of similar hourly grid-point time series to provide a 4 x 4 grid at lower resolution (approximately 250 x 250 km) for extended area and time studies (see Section 3.2.2.1).

Data will be archived at approximately 2° latitude intervals from 51°N to 60°N and at 4.5° longitude intervals from 94°W to 110°W. Each of these low-resolution grid cells is itself an average of a 4 x 4 gird of the full GCM resolution. At present, the memory available in the operational model does not permit the archiving of a higher resolution grid at high-time resolution. Model data will be for 0-120 hours for the daily 12Z archived forecast and (probably) 0-48 hrs for the 00Z forecast for comparisons of model spinup. Figure 3.2.1 shows the ECMWF grid cells as well as, key upper air and surface weather reporting stations for BOREAS.

NOAA is using and evaluating the NOAA ETA Mesoscale Model for North America. Although NOAA plans called for a 40 km delta-x product by early July, 1994, the land surface parameterization will still be under test and evaluation. A GCIP archive of analysis from the ETA model is planned for June - September, 1994 at 3-hourly time intervals. NOAA has agreed to make available hourly soundings for selected sites in the NSA and SSA.

As noted by Dr. Betts, all these model data sets reflect the state of model parameterizations and problems. The need for caution in using these outputs is illustrated by some of the difficulties in resolving such variables as daily minimum temperature based on model output for a 30 meter elevation, use of noisy surface skin temperature data, and model outputs only available at six-hourly synoptic data time intervals. Additional feedback on user requirements is needed. (Coordinator is A. Betts, AFM-8)

3. Surface-Observations Interpolation. Many BOREAS modelers require detailed gridded surface weather data as a primary input to hydrologic and ecologic models for scaling up research at the Modeling Sub-Area and Transect scales. Various surface weather data will be available from the AMS stations, the tower sites, watershed rain gauge network, and selected AES surface stations to develop interpolated surface weather data gridded products for the Modeling Sub-Areas in the SSA and NSA, Transect, and region, as appropriate for the effective spatial distributions. A conventional weather radar will be available to provide additional data for the SSA, particularly HYD watershed studies. Figure 3.2.1 shows available surface weather station data sources. Section 3.2.1 describes available data sources. Table 3.2.1a shows the total set of surface stations. (Coordinators are A. Betts, S. Running, and L. Steyaert)

4. Satellite Remote Sensing. Multi-resolution, multitemporal satellite data are essential to the success of BOREAS, for example as the basis for multiscale land cover characterizations and to develop remote sensing algorithms for regional extrapolations. Data required include Landsat TM and MSS for Study Areas and the Transect, potentially SPOT 1, 2, and 3 NOAA 11 and 12 AVHRR for the region, and ERS-1 radar data. The data from GOES and DMSP SSM/I sensors are listed in notes 11) and 12), respectively. Satellite data available through BORIS is discussed in section 3.5.7 (Coordinator is J. Newcomer).

5. Aircraft remote sensing. Aircraft remote sensing data sets are fundamental to BOREAS research. Data sets will be generated primarily for the Modeling Sub-Areas and portions of the Transect. (Coordination is S. Goetz).

6. Soil Properties. Soils data are essential to the success of process level research and multiscale modeling in BOREAS. Soils data will be available in BORIS at three scales including 1:5K-scale soil mapping at the tower site level, 1:125K-scale data for the Modeling Sub-Areas, and 1:1M-scale data for the Transect and BOREAS region. PIs need to advise BORIS staff on the types of gridded attributes needed for online availability in BORIS for the 1:5K-, 1:125-, and 1:1M-scale products, as appropriate for each region. Minimum mapping areas for each scale include 50 m x 50 m areas for the 1:5K-scale data at tower sites, 1.6 km^2 areas for the 1:125-scale data in the SSA, and 100 km^2 areas for the 1:1M-scale data at the BOREAS regional level. Section 3.2.3.3 describes the soil survey and characterization support. (Contacts are E. Levine and D. Knapp)

7. Soil Moisture. Many BOREAS investigators require soil moisture data. Point data sets in Modeling Sub-Areas will be supplemented with surface measurements for the ground-truthing of airborne gamma radiation measurements made with flight lines near roads in Study Areas and portions of Transect. A 4DDA product will be available as part of the ECMWF Analysis (Section 3.2.3.4 describes soil moisture and temperature measurements. (Coordinators are E. Peck, airborne measurement; R. Cuenca, ground measurements, A. Betts, 4DDA product).

8. Topographic. Digital elevation model (DEM) data are a fundamental requirement of many BOREAS investigators. Three types of topographic data are potentially available to meet these needs. The sources include digital elevation contour data from 1:50K- and 1:250K-scale quad sheets from EMR Canada plus 1:1M-scale elevation contours from the digital chart of the world (DCW). The horizontal delta-x resolution of the DEM from each source is TBD for the 1:50K data, 100 m for the 1:250K data, and 1 km for the DCW data.

To answer several pressing DEM related issues, a select group of hydrologists have agreed to coordinate the resolution of intercomparison and data conversion issues. This group includes D. Lettenmaier, D. Marks, L. Band, and R. Soulis. Based on preliminary analysis this group has recommended that the DEMs for NSA and SSA be based on the 1:50K-scale Quads with the highest priority on the modeling sub-areas. The Group also recommends that DEMs be generated from the 1:250-scale data for the NSA and SSA for intercomparisons to determine the potential utility for the Transect. Finally, the 1 km DEM from the DCW is recommended for regional analysis. Dr. L. Band and J. Nickeson have agreed to provide Dr. J. Cihlar with a listing of 1:50K and 1:250K quads to be ordered from EMR.

In addition, L. Band has agreed to convert 1:50K-scale digital contour data into DEM's for the modeling sub-areas, and if possible the entire NSA and SSA. This includes the gauged watersheds for the White Gull and Sapochi watersheds.

Sue Jenson at EROS Data Center has developed 100 m DEM data based on conversion of 1:250K-scale digital contour data for 1-degree blocks covering coordinate the comparison of similarly derived 100 m DEM's from selected 1:250K-scale digital contour maps in the SSA with a 100 m DEM data set that D. Marks procured for most of the SSA. Although the quality of these 100 m DEM's is questionable, only 10-12 1:250K quad sheets would be needed to complete the transect from SSA to NSA. Sue Jenson is converting DMA digital chart of the world data to a 1-km DEM for the BOREAS region (estimated availability is July, 1994).

In addition to uncertainty concerning published estimates, the accuracy of these topographic products varies with individual mapsheets and as a function of map scale. For example, the 1:50K-scale digital contour data (contour intervals of about 8-10 m) have horizontal accuracies in the range of +/- 25 to 50 m, with vertical accuracies within +/- 1 contour interval, or greater. The accuracy of 1:250K digital contour data is believed to be comparable to 100 m DEM data which has an absolute horiz. accuracy of about 130 m and an absolute vertical accuracy of +/- 30 m for 33 m contour intervals. The Digital Chart of the World data have a contour interval of 333 m (1 km pixel size) with an absolute horiz. accuracy of 2,000 m and an absolute vertical accuracy of +/- 650 m. In addition to more refined information on DEM accuracies, questions to be resolved include: will the 1:50K-scale derived- DEM's meet HYD requirements, therefore the requirements of other BOREAS investigators?, are conversions of 1:50K-scale data necessary for other portions of or all of the NSA and SSA?, and do the 1:250K-scale data have any role, such as for the Transect? (Coordinators are D. Lettenmaier, D. Marks, L. Band, and R. Soulis with BORIS contact J. Nickeson).

9. Land cover Parameters. Multiscale, multitemporal land cover data and associated parameters are essential for many BOREAS investigations including TE and RSS modeling scaling up research. Three primary data sets in progress include: i) 1:12K- and 1:15.84K-scale forest cover maps for 10-km square blocks within Saskatchewan and Manitoba, respectively, based on analysis of aerial photos and other information sources by the Canadian Government, ii) Landsat TM land cover classifications underway at NASA (F. Hall and others), and iii) an AVHRR-land cover characterization under development (T. Loveland and L. Steyaert). In addition, basic remote sensing parameter data sets for the Modeling Sub-Areas in the SSA and the NSA corresponding to the 30 m Landsat TM pixel size will be developed as described elsewhere in this EXPLAN. These land cover parameters include Species Composition/Forest Type, FPAR and LAI, Biomass, Canopy Temperatures, Albedo, Incoming PAR and shortwave solar radiation, Stand Structure/Successional State, Freeze/Thaw state and duration, and Canopy Moisture and Soil Moisture. Unresolved issues include the amount of forest cover data for the NSA and auxiliary sites, and amount of Landsat data needed for the Transect. In addition, a set of consensus-derived land cover parameters for initial 1-D test and intercomparison of water and energy exchange models were defined by a group of modelers attending a Dr. Steve Running coordinated workshop at Missoula, MT in February, 1994. (Coordinators are F. Hall and J. Ranson). See table 4.6.1a for additional detail on Remote Sensing parameters.

10. Fire History. Dr. Brian Stocks of Forestry Canada is preparing a national level fire history data set showing the spatial extent of fires for burned areas greater than 200 ha by year throughout all of Canada beginning

with 1980 to the present. Data for Saskatchewan and Manitoba are being digitized. The entire data set should be available to BORIS within the next few months. (Contact is B. Stocks)

11. Radiation. Dr. Eric Smith will provide gridded radiation data sets for a subset of days (TBD) based on data from GOES visible, IR, and water vapor channels. Adjusted by the cosine of latitude for the BOREAS region, the GOES pixel sizes of 1-, 8-, and 16-km for each of these channels are approximately 2-, 14-, and 28-km, respectively. Derived gridded products include incoming PAR, incoming total solar radiation, and outgoing solar radiation. (Coordinator is E. Smith)

12. Snow. Point measurements of snowpack properties at the plot and TF site levels will be supplemented with surface-based snow water equivalent (SWE) measurements to calibrate airborne gamma radiation measurements (flightlines mainly along roads) in order to develop algorithms for estimating SWE and snow spatial extent from passive microwave SSM/I (25 km delta-x) and 1 km AVHRR data sets. The anticipated product will be SWE contour maps. (see Section 3.2.3.2. Coordinator for SSM/I products is Dr. B. Goodison)

3.5.6 Data Access

As stated in the BOREAS science plan, Canadian Announcement of Opportunity, and NASA Research Announcement, data collected in BOREAS will be available for the general science community. However, we want to release to the general community the very best data that we can. We can only produce our "very best data" by first sharing it amongst ourselves for some preliminary "massaging". Thus, timely (read: as quickly as possible) submission of data to BORIS is critical. It is the integrative nature of the BOREAS project that makes it valuable. Any integrative project can only be as good as its weakest link. Timely data submission to BORIS will allow this crucial integration to take place.

All BOREAS investigators and only BOREAS investigators and staff will have an account on the BORIS communications facility. The most convenient network access will be through Internet via TCP/IP or DECnet protocols. Modem access over Telenet and phone lines is available.

As the budgets allow, the BORIS communication facility will provide bulletin board service, electronic mail, and the on-line data facility. Datasets will be loaded onto this on-line facility as soon as BORIS staff can accomplish the intra-dataset level of QA. The delay between data collection and on-line availability will depend upon the speed of data submission by investigators and the speed of processing and ingest by BORIS. With advanced documentation submission, and some pre data-collection collaboration with

BORIS staff, we anticipate that we should be able to have most datasets online within one month of submission. If there is a logjam of many datasets submitted at once, BORIS staff will turn to the BORIS Working Group for help in prioritizing data to be loaded on line.

For investigators accessing the online data, it will be important to note when the data is retrieved. BORIS staff will keep a record of any changes in each version of a dataset, and when those changes are made in the online dataset. E-mail messages and bulletin board announcements can keep BORIS users abreast of these changes. With the many cooperators, disciplines, agencies and institutions involved in BOREAS, it is imperative that the flow of data proceeds from source to other investigators through the BORIS system. In that way proper record-keeping, documentation and accuracy are assured, and we can all save ourselves the hassle of putting out data fires.

Small datasets can be downloaded from the online facility. Datasets that are larger than approximately 1 megabyte would be more appropriately requested through BORIS staff and mailed on tape. At the present time, BORIS anticipates being able to read and write 9-track tape (1600 and 6250 bpi), 8-mm tape (2.5 and 5 gigabyte capacity), 4-mm DAT tape, and floppy diskettes (MAC and PC format). Ultimate data distribution and archive for the general science community will be on CD-ROM. If demand warrants it, and data flow allows it, CD-ROM production could be on a several-volumes-per-year schedule. A 12 to 18-month schedule is our current best guess, but this will be tailored to the needs as determined by the BORIS Working Group.

3.5.7 **Satellite Image Data Products**

BORIS currently plans on deriving a core set of satellite and aircraft image data products directed toward the science goals of the project. The content and format of these image products is based on investigator feedback and experience gained through the FIFE effort along with improvements that are anticipated to meet new project requirements. The processing levels to be used in BORIS for image data closely mimic those currently established for the planned NASA Earth Observing System (EOS) data system activities. These levels and associated definitions are provided in Table 3.3.1.

An example of level-0 aircraft data would be NS001 Thematic Mapper Simulator data received in the standard format distributed by NASA Ames Research Center. These data are formatted (reconstructed) but not processed in any way and are at the initial full resolution. The formats of the image data products at each of the subsequent levels will be somewhat similar but will vary based on the specific data characteristics and use.

3.5.8 **BOREAS Data Documentation Outline**

Note: Text surrounded by square brackets ([..]) is an expanded instruction, or set of instructions, for the outline item which appears directly above it. Outline items preceded by an asterisk (*) denote information that will be provided by BORIS staff.

1. Title

1.1 Data Set Identification
[Title or name for the data set, generally a short descriptive phrase, e.g. AVHRR LAC1, LEVEL 1 DATA.]

*1.2 BORIS Data Base Table Name
[Table in BORIS data base in which the data may be found.]

*1.3 CD-ROM File Name
[Name (or class of names) of the file(s) on the CD-ROM in which the data can be found.]

1.4 Revision Date Of This Document
[The last date that this document was edited.]

2. Investigator

2.1 Investigator(s) Name And Title
[Identify the Principal Investigator for this data set, including general affiliation, if applicable]

2.2 Title Of Investigation
[The title of the study for which the data set was collected.[

2.3 Contacts (For Data Production Information)
[Those persons most knowledgeable about the actual collection and processing of the data sets. In many cases this will be a person (or persons), other than the Principal Investigator, who prepared the data for submission to BOREAS and is sufficiently knowledgeable about the data to answer technical questions about it. When the Principal Investigator is a primary contact, full address information should also be given here.]

2.3.1 Name
[The name(s) of the contact person(s).]

2.3.2 Address(es)
[The work address(es) of the contact person(s).]

2.3.3 Telephone Number(s)
[The work telephone number of the contact person(s).]

2.3.4 Electronic Mail Address(es)
[The complete Network address(es) of the contact person(s).[

2.4 Requested Form of Acknowledgment
[How the Principal Investigator would like to be acknowledged when this data set is referenced or used by another investigator.]

3. Introduction

3.1 Objective/Purpose

[Why the study was undertaken, and what the Principal Investigator hoped to achieve by conducting it.]

3.2 Summary of Parameters

[A summary of the phenomena which are being studied, and their parameters. A full description will be given in item 8.]

3.3 Discussion

[A few introductory paragraphs which describe the experiment, the nature of the data, the quality of the data, etc.]

4. Theory of measurements

[Theoretical basis for the way in which the measurements were made (e.g. special procedures, characteristics of the instrument, etc.).]

5. Equipment

5.1 Instrument Description

[A listing of the instrumentation and the characteristics of the instrumentation.]

5.1.1 Platform (Satellite, Aircraft, Ground, Person...)

[What the instrument is mounted on.]

5.1.2 Mission Objectives

[The reason why the mission was undertaken. (Mission here refers, in general, to the general purpose of operational or research satellites and aircraft. The particular study objectives are in item 3.1.)]

5.1.3 Key Variables

[The primary quantities being measured (e.g. surface radiance).]

5.1.4 Principles of Operation

[Fundamental scientific basis for the way the instrument operates. This is a summary; where a full development is required, it should be in item 4.]

5.1.5 Instrument Measurement Geometry

[Describe the sensor location, orientation, and any other parameters which affect the collection or analysis of data, e.g. field of view, optical characteristics, height, etc.]

5.1.6 Manufacturer of Instrument

[Name, address, and telephone number of the company which produced the instrument. If the measuring device was built by the investigator, or specially customized, please specify.]

5.2 Calibration

[Describe how the measurements made by the device(s) are calibrated with known standards. Specific details should be given in the subparagraphs below.]

5.2.1 Specifications

[Record any specifications which affect the calibration of the device, its operations, or the analysis of the data collected with it.]

5.2.1.1 Tolerance

[Describe the acceptable range of inputs and the precision of the output values.]

5.2.2 Frequency of Calibration

[Indicate how often the instrument is measured against a standard. Also indicate any other routine procedures required to maintain calibration or detect miscalibrations. Describe also the actual practice with this device.]

5.2.3 Other Calibration Information

[Give factory calibration coefficients, information about independent calibrations, history of modifications, etc.]

6. <u>Procedure</u>

6.1 Data Acquisition Methods

[Describe the procedures for acquiring this data in sufficient detail so that someone else with similar equipment could duplicate your measurements.]

6.2 Spatial Characteristics

[Describe the actual spatial resolution and coverage of the data collected for BOREAS.]

6.2.1 Spatial Coverage

[Indicate the total area covered by each measurement or set of measurements. Give enough information to locate the geo-graphic position of the measurement with suitable precision.]

6.2.2 Spatial Resolution

[The degree to which the terrain may be resolved into constituent or elementary parts (e.g. The dimensions of each image pixel.).]

6.3 Temporal Characteristics

[Describe the actual temporal resolution and coverage of the data collected.]

6.3.1 Temporal Coverage

[The period(s) of time during which data was collected more or less continuously (e.g. an Intensive Field Campaign).]

6.3.2 Temporal Resolution (3.2)

[Describe the optimum and typical intervals between measurements during the periods in 6.3.1 (e.g. hourly, daily).]

7. <u>Observations</u>

7.1 Field Notes

[Use this section to record observations made during actual data collection, which could bear on the analysis of the data, e.g. condition of site, peculiar procedures or operations, the presence of U.F.O.'s or bears, etc.]

8. <u>Data description</u>

*8.1 Table Definition With Comments

[An annotated description of the BORIS data base table.]
*8.2 Type of Data
[Describe the data submitted, with items 8.2.1 through 8.2.5 (below) being represented as columns in a table]
8.2.1 Parameter/Variable Name (1.1)
8.2.2 Parameter/Variable Description
8.2.3 Data Range
8.2.4 Units of Measurement (1.2)
8.2.5 Data Source (1.3)
8.3 Sample Data Record (13)
[One or more sample records from a data file]

8.4 Data Format
[Indicate the format specifier for the data (as it will appear on the CD-ROM).]
8.5 Related Data Sets
[Note any similar or related data collected by the investigator or other investigators.]

9. <u>Data manipulations</u>
9.1 Formulae
[List any formulae required in processing the data.]
9.1.1 Derivation Techniques/Algorithms
[Describe any special techniques or algorithms used.]
9.2 Data Processing Sequence
9.2.1 Processing Steps
[Indicate the sequence of processing steps.]
9.2.2 Processing Changes
[For long term, repetitive, or revised data sets;
give a history of changes in the processing sequence.]
9.3 Calculations
9.3.1 Special Corrections/Adjustments
9.4 Graphs and Plots

10. <u>Errors</u>
10.1 Sources of Error
[Describe what factors of the instrument or environment may introduce errors in the observations.]
10.2 Quality Assessment
10.2.1 Data Validation by Source
[Describe all efforts to validate the data by the submitter.]
10.2.2 Confidence Level/Accuracy Judgment
[Subjective discussion of data quality.]
10.2.3 Measurement Error for Parameters and Variables
[Quantitative error estimates.]

10.2.4 Additional Quality Assessment Applied

11. Notes

11.1 Known Problems With The Data
[List known problems and discrepancies in the data set.]

11.2 Usage Guidance
[Place any "Truth in Analysis" warnings here.]

11.3 Other Relevant Information
[Use this section for any other information about the study (such as humorous anecdotes, lame excuses, abject apologies, miracles, etc.).]

12. References

12.1 Satellite/Instrument/Data Processing Documentation
[List any published documentation relevant to the data collected, such as manufacturer's instruction manuals, government technical manuals, user's guides, etc.]

12.2 Journal Articles and Study Reports
[List technical reports and scientific publications which concern the methods, instruments, or data described in this document. Publications by the Principal Investigator or investigating group which would help a reader understand or analyze the data are particularly important.]

*12.3 Archive/DBMS Usage Documentation

13. Data access

13.1 Contacts for Archive/Data Access Information

13.2 Archive Identification

13.3 Procedures for Obtaining Data

*13.4 Archive/PLDS Status/Plans

14. Output products and availability

*14.1 Tape Products

*14.2 Film Products

*14.3 Other Products

* denotes information that will be provided by BORIS staff.