



Operations Plan
Emissions Calibration Study (ECS)
Version 4
August 8, 1991

1.0 Introduction

The Emissions Calibration Study is to be comprised of a set of measurements that will be collected as a contingency experiment, being a part of the 1991 Lake Michigan Ozone Study. The ECS will be conducted on a single day as a one-shot experiment. The measurements to be taken will be a comprised of air quality and meteorological measurements from all the six project aircraft, air quality and meteorological measurements from boat platforms, surface level air quality measurements at selected routine monitoring sites and upper air profiles of temperature, winds and ozone from rawinsondes.

2.0 Objective

These measurements will be taken in an attempt to identify bias in the inventory of VOC and NOx emissions from Milwaukee.

3.0 Approach

Upwind and downwind measurements will be made around Milwaukee employing aircraft, boats, routine monitoring stations and rawinsondes. The measurements to be made will include NOx, SO2, VOC's, carbonyls, ozone, temperature and winds.

4.0 Meteorological Conditions

The ECS measurements will be made during wind conditions that are basically westerly in the Milwaukee region. Three sample flight patterns are designed to accommodate mean wind from approximately southwest to west-northwest (225 to 310 deg). It is desired that the sky condition be cloudy in order to limit transformation of precursors to ozone. However, if cloudy conditions are not predicted, the experiments will be conducted based on the occurrence of the right wind conditions.

5.0 Aircraft Flights

Six aircraft will participate in the ECS measurements. All flights will originate from the Waukegan Airport. Five will fly at assigned altitudes in a "box" pattern around the city and the sixth will conduct spiral soundings. The flight patterns for all six are described here with way points specified for three different flight pattern orientations to accommodate different mean wind directions. The specific flight pattern to be flown will be specified by the LMOS Test Director two hours in advance of the specified take off time.

On a schedule as shown later the five aircraft will take off, fly one of the patterns described below and return to the Waukegan Airport. If possible the described flight pattern will be flown three times during the one experimental day. Due to possible changing mean wind directions during the course of the experimental day, more than one of the following flight patterns may be employed.

The concept to be employed here is to:

- 1) Fly all six aircraft sequentially (two minute separation at take off).
- 2) Fly all aircraft at the same altitude along a data comparison leg and as close in time as is practical (hopefully maintaining the two minutes time separation).
- 3) Fly five aircraft at assigned altitudes from 800 ft AGL at 800 ft vertical separation to 4000 ft AGL. After moving to the assigned altitude, all five aircraft fly the same box flight pattern at the same air speed.
- 4) fly five airplanes in a "semi-stacked" pattern (stacking not coordinated).
- 5) Fly the sixth airplane as a "spiral" airplane.

5.1 Flight Pattern For Five Aircraft

All aircraft will take off from Waukegan at 2-minute intervals. After take off each aircraft will climb as quickly as possible to 2000 ft AGL and fly to way point 1. This first leg will be the comparison leg when the wind is southwest. From way point 1, each aircraft will turn right and fly to way point 2 and will move to their assigned altitude while traversing from way point 1 to way point 2. Upon reaching way point 2, each aircraft will turn onto the leg between way points 2 and 3 and will fly toward way point 3, then toward way point 4, then toward way point 5 and then toward way point 2 to complete the box pattern. One after another each aircraft will follow this pattern so that the airplanes all fly along the comparison leg at the same altitude at approximately 2-minute intervals. then each will go to his assigned altitude to complete the box pattern. All turns at the corners of the flight pattern box will be made as 270 deg turns in order to allow enough time to change sample media. After completing all the legs of the plan, each airplane will return to Waukegan for servicing and preparation for the next flight. Note that the comparison leg is the second leg during conditions of west and northwest winds. When using those flight boxes, the 2000 feet AGL comparison will be maintained for ten minutes flying time, then altitude changes will be made in order to begin the leg from way point 2 to 3 at the assigned altitude.

The flight patterns for the three mean wind directions are as follows:

Flight Box SW

<u>Way Point</u>	<u>Lat</u>	<u>Long</u>	<u>Distance f/last WP</u>
1	42/25/00	88/30/00	28 naut. mi.
2	42/33/00	88/02/00	23
3	43/02/00	88/30/00	35
4	43/23/00	87/47/00	35
5	42/53/00	87/22/00	35
5 to 2			35
2 to base			11
			Total distance for 1 circuit=202 naut. mi. plus turns
			Total time @ 140 knots=1 hour 34 minutes

Flight Box W

<u>Way Point</u>	<u>Lat</u>	<u>Long</u>	<u>Distance f/last WP</u>
1	42/13/00	88/29/00	30 naut mi
2	42/43/00	88/29/00	25
3	43/18/00	88/29/00	35
4	43/18/00	87/41/00	35
5	42/43/00	87/41/00	35
5 to 2			35
2 to base			32
			Total distance for 1 circuit=227 naut mi plus turns
			Total time @ 140 knots= 1 hour, 42 minutes

Flight Box NW

<u>Way Point</u>	<u>Lat</u>	<u>Long</u>	<u>Distance f/last WP</u>
1	42/25/00	88/30/00	28 naut mi
2	42/48/00	88/30/00	23
3	43/22/00	88/14/00	35
4	43/09/00	87/28/00	35
5	42/36/00	87/47/00	35
4 to 2			35
2 to base			38
			Total distance for 1 circuit=229 naut mi plus turns
			Total time @ 140 knots = 1 hour, 44 minutes

5.2 Flight Pattern For Sixth Aircraft

The sixth aircraft will fly as a spiral aircraft. That aircraft will take off last of the six, 2-minutes after the one before him. In this way the sixth aircraft will fly the comparison leg as the last one, then will climb to 4500 feet AGL and proceed to way point 2, then to the midpoint of the leg between way point 2 and way point 3 (don't take a shortcut to the spiral location or you may over-run the aircraft ahead). At that midpoint, the spiral aircraft will execute a down-spiral from 4500 feet AGL to as low as is practical (800 or 1000 feet AGL). From that location the spiral aircraft will terminate the spiral and climb to 4500 feet

AGL and traverse around Milwaukee toward the downwind leg of the flight pattern. At the location indicated on the accompanying diagram on the downwind leg, the spiral aircraft will execute another down-spiral to as low an altitude as is practical (200 feet AGL). At 200 feet AGL the spiral aircraft will fly along the downwind leg to the third spiral location (second on the downwind leg). At that location, the spiral aircraft will execute an up-spiral from the 200 feet AGL altitude to 4500 feet AGL. After completing this third spiral, the spiral aircraft will return to Waukegan for servicing and preparation for the next flight.

Flight pattern, Spiral aircraft for Southwest Winds

<u>WP/Spiral</u>	<u>Lat</u>	<u>Long</u>	<u>Distance from last WP</u>
WP 1	42/25/00	88/00/00	28 naut. mi.
WP 2	42/33/00	88/02/00	20
Spiral 1	42/45/00	88/17/00	17
Spiral 2	43/14/00	87/40/00	40
Spiral 3	43/02/00	87/30/00	15
Spiral 3 to base			<u>40</u>
Total distance for flight=			163 naut mi plus spirals
Total time @140 knots & 500 ft/min =			1 hour, 36 min.

Flight Pattern , Spiral Aircraft for West Winds

<u>WP/Spiral</u>	<u>Lat</u>	<u>Long</u>	<u>Distance f/ last WP</u>
WP 1	42/13/00	88/29/00	30 naut mi
WP 2	42/43/00	88/29/00	25
Spiral 1	43/00/00	88/29/00	17
Spiral 2	43/09/00	87/39/00	40
Spiral 3	42/52/00	87/39/00	15
Spiral 3 to base			<u>29</u>
Total distance for flight =			156 naut mi plus spirals
Total time @140 knots and 500 ft/min =			1 hour, 33 min

Flight Pattern , Spiral Aircraft for Northwest Winds

<u>WP/Spiral</u>	<u>Lat</u>	<u>Long</u>	<u>Distance f/ last WP</u>
WP 1	42/25/00	88/30/00	28 naut mi
WP 2	42/48/00	88/30/00	23
Spiral 1	43/10/00	88/20/00	17
Spiral 2	43/00/00	87/33/00	40
Spiral 3	42/45/00	87/41/00	15
Spiral 3 to base			<u>22</u>
Total distance for flight =			145 naut mi plus spirals
Total time @ 140 knots and 500 ft/min =			1 hour, 30 min

6.0 Flight Schedule

Three flights will be scheduled. The first will be just before the morning air traffic rush hour at the Milwaukee Mitchell Airport, the second will be during the mid day and the third will be during the early evening. The actual times of the three flights are as follows:

0700 to 0830	Morning flight
1100 to 1230	Mid day flight
1700 to 1830	Evening flight

7.0 Measurements

<u>Measurement</u>	<u>Spiral Acft (NOAA)</u>	<u>Acft 1 to 5</u>
Temp	Contin.	Contin.
Winds	Contin.	Contin.
Ozone	Contin. (if psbl)	Contin. (if psbl)
NOx	Contin.	Contin.
SO2	Contin.	Contin. (if psbl)
VOC Canister	Compar. leg, spirals & Low level leg (S2-S3)	Compar. leg All box legs
Carbonyl bags	Grab bottom 3-min of spiral & low lvl leg (S2-S3)	Grab all mid legs

Since the WDNR aircraft has very limited space aboard and can carry fewer canisters and bags than the other aircraft, the sampling schedule for that aircraft will be altered. The WDNR aircraft will take samples of air quality parameters on a continuous basis as possible, and will take canister samples on the comparison leg, the upwind leg and the downwind leg. It will take bag samples on the upwind and downwind legs only.

All canister samples will be taken with the aid of flow controllers so as to obtain an integrated sample over the length of the sample leg. Carbonyl bag samples will be taken as grab samples at approximately the midpoint of each sample leg. On the Spiral aircraft the bag grab sample will be taken in the lower three minutes of the spiral.

8.0 Flight Assignments

The spiral flights will be assigned to the NOAA aircraft. The 800 feet AGL altitude will be assigned to the WDNR aircraft because that aircraft operates with a low altitude waiver. The other flight altitude assignments will be made by the NAWC manager.

9.0 Supporting Measurements

9.1 Boats

Three boats will operate during the three measurement periods. One will be located at each end of the downwind line and the third will be located at the midpoint of that line. Each boat will operate the full compliment of air quality measurements the same as is done for the regular intensive days. Canister and cartridge sampling schedules will be 15 minute duration and will be matched to the aircraft schedule such that the samples will be taken during the time the aircraft fly the downwind leg. For the three flights the sampling times will begin 65 minutes after the first aircraft take off time. Notification of the takeoff time will be

made by the NAWC manager. Rawinsondes will also be operated from each boat.

9.2 Rawinsondes

Conventional rawinsondes will be operated from the two boats located at the ends of the downwind line and an ozonesonde will be operated from the mid line boat. A fourth rawinsonde will be operated from a location west of metropolitan Milwaukee. The desired location for the fourth rawin is at the Wakesha Airport. It will also be an ozonesonde. The release schedule for the rawinsondes will be at 30 minutes after the first take off time for each flight and the release will be coordinated with the NAWC aircraft manager. One set of rawin flight will be made for each flight schedule. All rawins will be operated as is done for the regular intensive days except the soundings will be terminated at 10000 ft AGL.

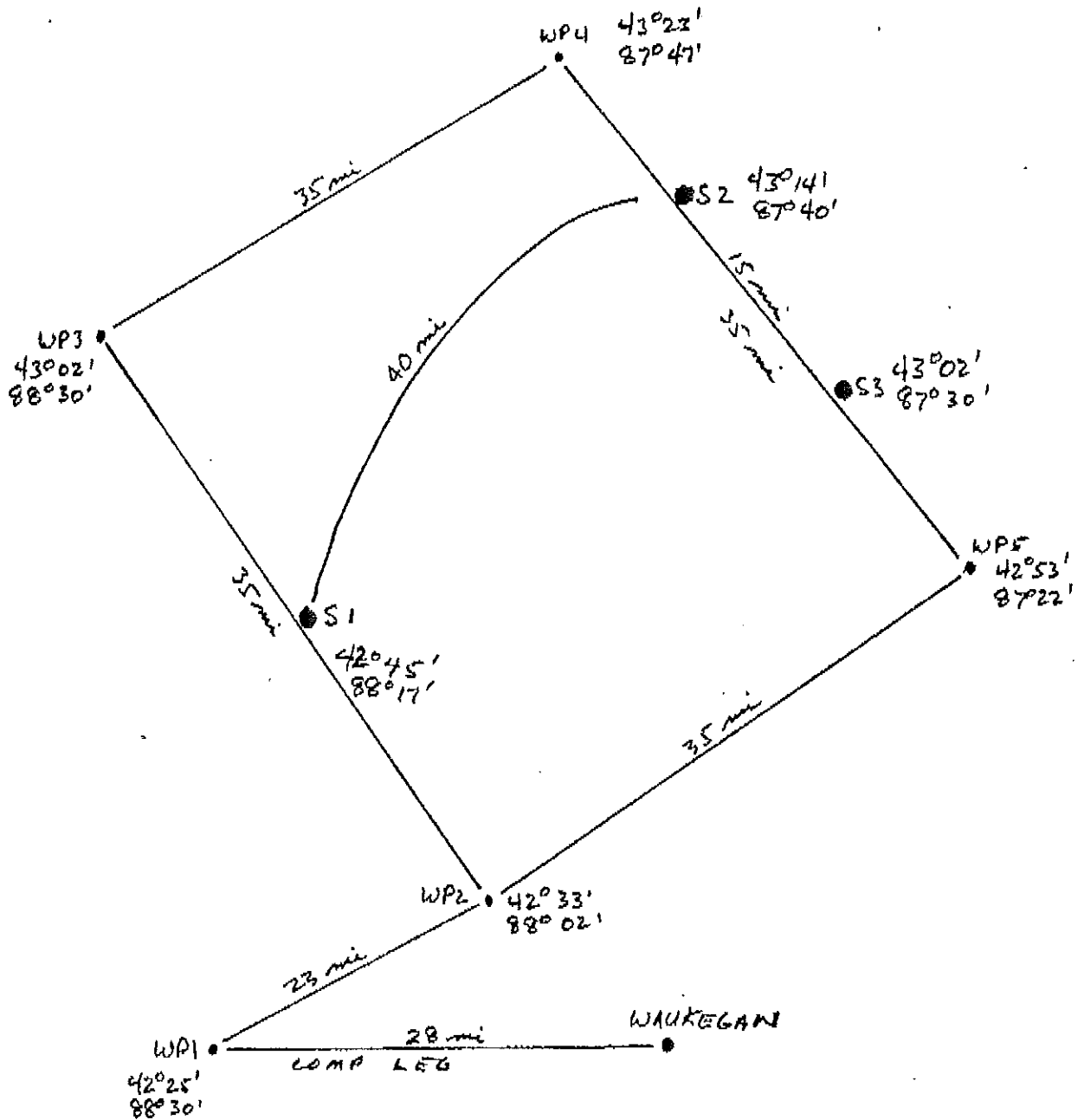
9.3 Ground Based Sampling

Routine air quality sampling will be conducted at Grafton, Bayview, UWM North (and at Zion-2 if southwest winds are employed). Additionally 15 minute VOC canisters and Carbonyl cartridges will be collected. They will be collected between 0800 and 0815, 1200 and 1215 & 1800 and 1815. The carbonyl cartridges will be operated at increased flow rate in order to collect a viable sample.

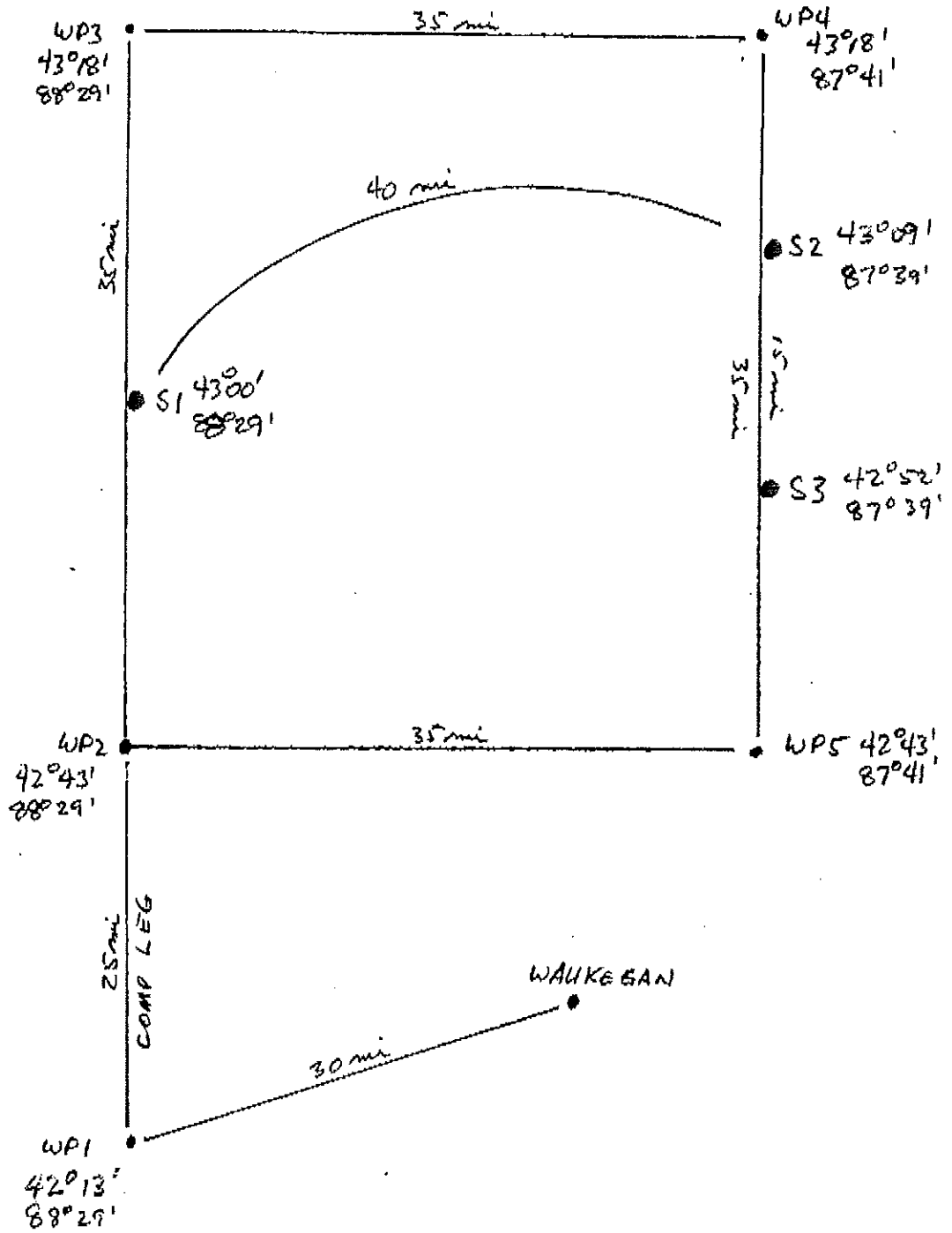
Radar profilers at Grafton and Zion shore will be operated to give vertical profiles of winds and temperatures.

10.0 Cannister/Cartridge/Bag Requirements

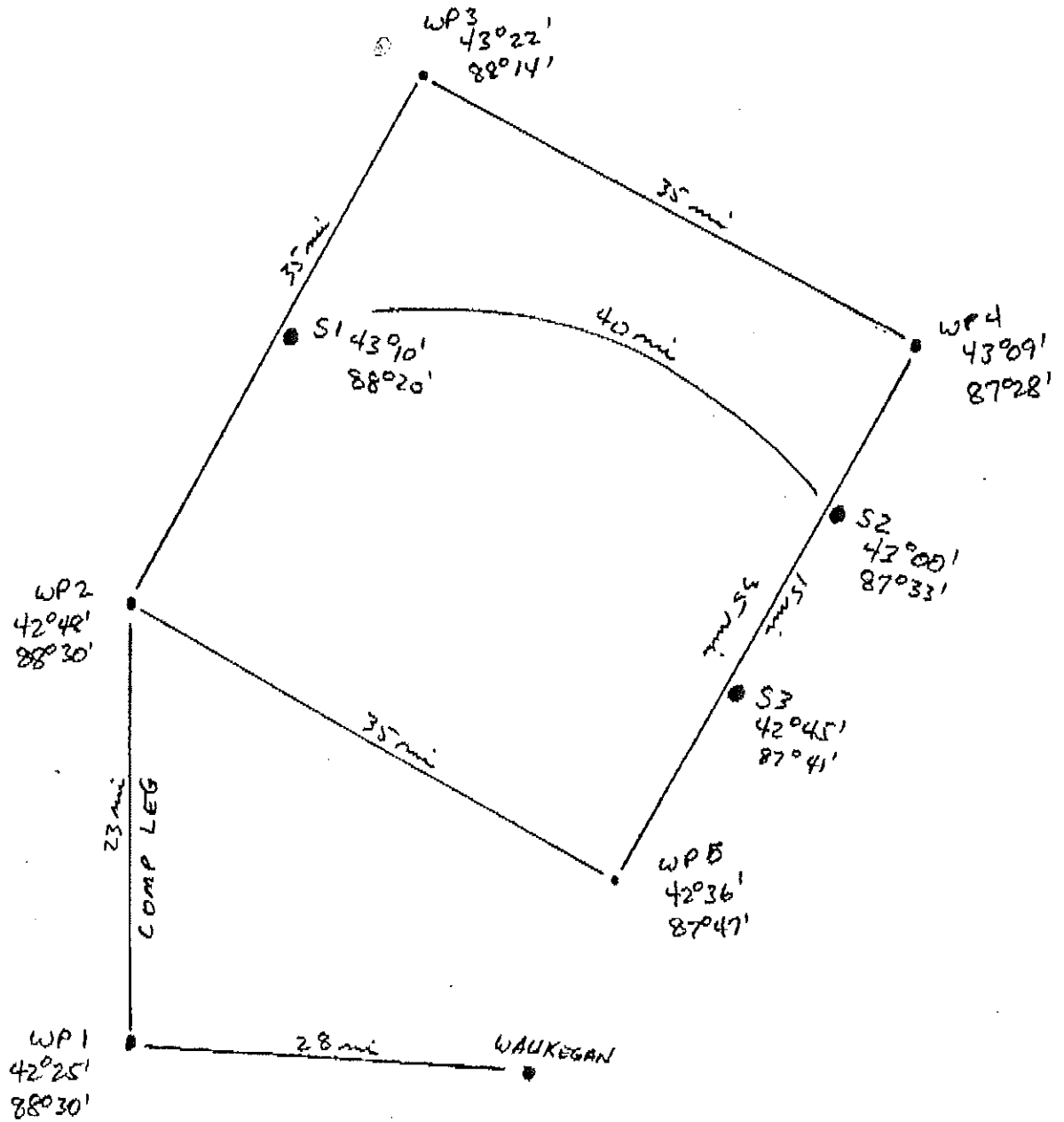
	<u>Canisters</u>	<u>Cartridges</u>	<u>Bags</u>
Aircraft			
NAWC-1	15		15
NAWC-2	15		15
NAWC-3	15		15
NAWC-4	15		15
NOAA	15		15
WDNR	9		6
Boats			
Northline	3	3	
Midline	3	3	
Southline	3	3	
AQ Stations			
Grafton	3	3	
Bayview	3	3	
UWM North	3	3	
Zion-2	<u>3</u>	<u>3</u>	<u>00</u>
Totals	105	21	81



FLIGHT PATTERN FOR SW WINDS
(NOT TO SCALE)



FLIGHT PATTERN FOR WEST WINDS
(NOT TO SCALE)



FLIGHT PATTERN FOR NW WINDS
(NOT TO SCALE)