3. Monitoring Network

This section describes the particulate, tracer, and meteorological networks and measurement methods of Project MOHAVE. Table 3-1 lists the locations of all the sites included in the Project MOHAVE database and the measurements performed at each site. The descriptions of the headings in Table 3-1 are provided in Table 3-2. Not all of the measurements summarized were made exclusively for Project MOHAVE. The Project MOHAVE Study Plan (USEPA, 1991) provides the rationale for the observables, sample durations, sampling frequency, and monitoring periods for the study measurements.

3.1 Air Quality Monitoring Network

The Project MOHAVE air quality monitoring network characterized both aerosol and gas phase chemical composition throughout the study region.

3.1.1 Aerosol Measurements

Most aerosol collection was done by the IMPROVE aerosol monitoring samplers, which consist of one or more independent modules (Eldred et al., 1988). The fine particle modules (aerodynamic diameters 0-2.5 µm) consist of an inlet to remove large particles and rain, a cyclone to remove coarse particles, attachments for four filter cassettes and solenoids, a critical orifice for flow control, and a pump. Fine modules used for nitrate measurement have a Na_2CO_3 denuder in the inlet stack to remove HNO_3 gases. The PM_{10} module substitutes a standard PM_{10} inlet for the fine inlet and cyclone. The six types of modules used in Project MOHAVE are listed in Table 3-3. The A/S, D/S, and E/L modules had a Teflon filter followed by an impregnated after filter. The IMPROVE sites had modules A, B, C, and D/S with sample sequencing by a clock timer in a separate module. Meadview had an additional E/L module sequenced by the timer. The background sites had the clock timer inside the A/S module. Sites with a weekly change cycle had a pair of identical samplers.

Additional aerosol filter sampling was performed by researchers from BYU at Spirit Mountain, Meadview, Indian Gardens, Hopi Point, Sycamore Canyon, Dangling Rope, and New Harmony during the winter intensive sampling period and Spirit Mountain, Meadview, Hopi Point, Sycamore Canyon, Dangling Rope, and Painted Desert in the summer intensive sampling period. Measurements conducted by researchers at BYU quantified total sulfur oxides, sulfur dioxide, fine particulate sulfate, total fluoride, and spherical aluminoslicate particles and are discussed in detail in Eatough et al. (1997a) and Eatough et al. (1997b). Samples for the determination of particulate organic material using diffusion denuder techniques (BOSS and BIG BOSS) were collected by BYU researchers at Meadview during the summer. Researchers from the University of Minnesota collected aerosol filter samples for the Harvard School of Public Health at Meadview during the day-time for the summer study. A summary of the samplers used by researchers from BYU and Harvard is shown in Table 3-4.

Table 3-1 Ambient and Meteorological Monitoring Sites in Project MOHAVE

		Position			Aerosol				Tracer		Gaseous								Meteorological										Optical			
SITE	Location	LATF	LONF	ELVM	IO	CC	EL	MS	PFT	TR	DN	HL	HN	NOG	OG	O3	SO2	NH	TA	TD	PR	RH	TS	TU	W1	TV	SG	WW	BA	BS	SVR	BE
ABQN	Albuquerque/Int'L Arpt	35.0500	-106.6167	1619															X	X	X	X	X					X				
ACVN	Arcata - Airport	40.9833	-124.1000	70															X	X	X	X	X					X				
ALSN	Alamosa/Bergman Field	37.4500	-105.8667	2300															X	X	X	X	X					X				
AMAN	Amarillo	35.2333	-101.7000	1095															X	X	X	X						X				
AMBO[1]	Amboy	34.5625	-115.5458	213	X	X	X	X	X								X		X			X							X	X	X	
ASTN	Astoria/Clatsop County Ar	46.1500	-123.8833	3															X	X	X	X	X					X				
BAKE	Baker	35.2833	-116.0667	283	X	X	X	X	X								X												X			
BAND	Bandelier Nat. Mon.	35.7847	-106.2608	2011															X			X									X	X
BANN	Banning Pass	33.9100	-116.9000	730																					X			X				
BAR1	Barstow	34.8400	-117.1200	710																					X			X				
BARS[2]	Barstow	34.9166	-116.9500	590	X	X	X	X	X								X												X			
BCFO	Bullhead City, Field Off.	35.1503	-114.5669	169										X		X	X		X	X	X	X	X	X			X	X				
BCRI	Bullhead City, Riviera	35.1147	-114.6250	167															X	X	X	X						X				
BFLN	Bakersfield/Meadows Field	35.4167	-119.0500	152															X	X	X	X	X					X				
BIBE	Big Bend Nat. Park	29.3439	-103.2067	1082															X			X									X	X
BILN	Billings/Logan Int'L Arpt	45.8000	-108.5333	1092															X	X	X	X	X					X				
BOIN	Boise/Air Terminal	43.5667	-116.2167	876															X	X	X	X	X					X				
BRCA	Bryce Canyon	37.6167	-112.1667	2438	X	X	X	X	X								X												X			
CAJO	Cajon Pass	34.3333	-117.4000	1076	X	X	X	X	X								X		X			X							X	X	X	
CAJC	Cajon Pass - Ucd Coll.	34.3333	-117.4000	1076	X	X	X	X									X												X			
CANY	Canyonlands Nat. Park	38.4639	-109.8217	1806															X			X									X	X
CDCN	Cedar City – FAA Arpt	37.7000	-113.1000	1710															X	X	X	X	X					X				
CEDR	Cedar City	37.6750	-113.0667	1771															X	X	X	X						X				
CHIR	Chiricahua Nat. Park	32.0097	-109.3883	1567															X			X									X	X
CIBO[2]	Cibola Nwr	33.3000	-114.7000	73	X	X	X	X	X								X												X			
COCE	Cottonwood Cove, East	35.3472	-114.6655	201															X	X	X	X						X				
COCO	Cottonwood Cove, West	35.4833	-114.6833	274	X	X	X	X	X					X		X	X		X	X	X	X	X	X			X	X	X			
COSN	Colorado Springs/Municipa	38.8167	-104.7167	1857															X	X	X	X	X					X				
CPRN	Casper/Natrona Co Int'L A	42.9167	-106.4667	1621															X	X	X	X	X					X				
CYSN	Cheyenne/Municipal Arpt	41.1500	-104.8167	1866															X	X	X	X	X					X				
DAGN	Daggett/FAA Airport	34.8667	-116.7833	585															X	X	X	X	X					X				
DARO	Dangling Rope	37.1333	-111.0500	1158	X	X	X	X		X							X												X			
DECE[2]	Desert Center	33.7000	-115.3666	270	X	X	X	X	X								X												X			
DENN	Denver/Stapleton Int'L Ar	39.7667	-104.8833	1611															X	X	X	X	X					X				
DOS1	Dolan Springs (Tab)	35.5027	-114.2744	1015															X	X	X	X						X				
DOSP	Dolan Springs	35.5833	-114.2833	853	X	X	X	X	X								X												X			
DRAN	Desert Rock	36.6167	-116.0167	1007															X	X	X	X	X					X				
DRMO	Dri Mountain	35.2111	-114.5556	366										X		X	X		X	X	X	X	X	X			X	X				

SITE	Location	Position			Aerosol				Tracer		Gaseous								Meteorological										Optical			
		LATF	LONF	ELVM	IO	CC	EL	MS	PFT	TR	DN	HL	HN	NOG	OG	O3	SO2	NH	TA	TD	PR	RH	TS	TU	W1	TV	SG	WW	BA	BS	SVR	BE
DRTN	Del Rio	29.3667	-100.9167	313															X	X	X	X						X				
EKON	Elko/Municipal Arpt	40.8333	-115.7833	1548															X	X	X	X	X					X				
ELCE[2]	El Centro	32.8333	-115.3833	-4	X	X	X	X		X							X		X			X							X	X	X	
ELC1	El Cajon	32.8100	-116.9800	183																					X			X				
ELPN	El Paso	31.8000	-106.4000	1199															X	X	X	X						X				
ELYN	Ely/Yelland Field	39.2833	-114.8500	1907															X	X	X	X	X					X				
EMPN	Empalme, Mexico	27.9500	-110.8000	11															X	X	X	X						X				
ESSE[2]	Essex	34.7500	-115.2500	520	X	X	X	X	X								X												X			
EUGN	Eugene/Mahlon Sweet Arpt	44.1167	-123.2167	111															X	X	X	X	X					X				
FATN	Fresno/Air Terminal	36.7667	-119.7167	100															X	X	X	X	X					X				
FCAN	Kalispell/Glacier Pk Int’	48.3000	-114.2667	907															X	X	X	X	X					X				
FLGN	Flagstaff/Pulliam Arpt	35.1333	-111.6667	2132															X	X	X	X	X					X				
FOMO	Fort Mohave	35.0406	-114.5989	174										X		X	X		X	X	X	X	X	X			X	X				
GEGN	Spokane/Int’L Arpt	47.6333	-117.5333	719															X	X	X	X	X					X				
GGWN	Glasgow/Int’L Arpt	48.2167	-106.6167	695															X	X	X	X	X					X				
GJTN	Grand Junction/Walker Fie	39.1167	-108.5333	1473															X	X	X	X	X					X				
GLCA	Glen Canyon	36.9400	-111.4900	1128															X			X						X		X		
GRCA	Grandview Point, Gcnp	35.9964	-111.9917	2256															X			X									X	X
GRCW	Yavapai Point, Gcnp	36.0664	-112.1167	2145															X			X									X	X
GTFN	Great Falls/Int’L Arpt	47.4833	-111.3500	1117															X	X	X	X	X					X				
GUMO	Guadalupe Mtns. Np	31.8322	-104.8094	1616															X			X									X	X
GUPN	Gallup/FAA Airport	35.5167	-108.7833	1973															X	X	X	X	X					X				
HESP	Hesperia	34.3800	-117.4100	1166																					X	X		X				
HLNN	Helena/Arpt	46.6000	-112.0000	1188															X	X	X	X	X					X				
HOP5	Hopi Point (12 Hour)	36.0667	-112.1500	2164	X	X	X	X									X												X			
HOPO	Hopi Point	36.0667	-112.1500	2164	X	X	X	X	X								X												X	X		
HOSH	Holiday Shores	35.1164	-114.6056	161										X		X	X		X	X	X	X	X	X			X	X				
HUMO[1]	Hualapi Mountain	35.1167	-113.8667	2408	X	X	X	X	X								X												X			
HVRN	Havre/City-County Arpt	48.5500	-109.7667	788															X	X	X	X	X					X				
ING5[*]	Indian Gardens (12 Hour)	36.0833	-112.1167	1158	X	X	X	X									X												X			
INGA	Indian Gardens	36.0833	-112.1167	1158	X	X	X	X	X								X												X			
INWN	Winslow	35.0167	-110.7333	1487															X	X	X	X						X				
JALA[1]	Jacob Lake	36.7000	-112.2167	2487	X	X	X	X	X								X												X			
JOT2	Joshua Tree (24 Hr Hg Se)	34.0500	-116.2333	1250	X	X	X	X									X												X			
JOTR	Joshua Tree	34.0500	-116.2333	1250	X	X	X	X	X								X		X			X							X	X	X	
KELS[2]	Kelso	34.8995	-115.6533	860	X	X	X	X	X								X		X			X							X	X	X	
KING[2]	Kingman	35.2500	-114.0500	1040	X	X	X	X	X								X												X			
LAGA	Larrea Gardens	35.3000	-114.8000	794											X																	
LASN	Las Vegas/McCarran Int’L	36.0833	-115.1667	664															X	X	X	X	X					X				
LAXN	Los Angeles/Int’L Arpt	33.9333	-118.4000	33															X	X	X	X	X					X				
LBFN	North Platte	41.1333	-100.6833	847															X	X	X	X						X				
LGBN	Long Beach/Wso Airport	33.8167	-118.1500	20															X	X	X	X	X					X				

SITE	Location	Position			Aerosol				Tracer		Gaseous								Meteorological										Optical			
		LATF	LONF	ELVM	IO	CC	EL	MS	PFT	TR	DN	HL	HN	NOG	OG	O3	SO2	NH	TA	TD	PR	RH	TS	TU	W1	TV	SG	WW	BA	BS	SVR	BE
LNDN	Lander/Wso Ap	42.8167	-108.7333	1695															X	X	X	X	X					X				
LOLN	Lovelock - FAA Arpt	40.0667	-118.5500	1190															X	X	X	X	X					X				
LOME	Long Mesa	36.1000	-112.7000	1786					X			X			X	X	X		X	X	X	X	X				X	X		X		
LVWA	Las Vegas Wash	36.1167	-114.8500	457	X	X	X	X	X								X												X			
LWSN	Lewiston/Wso Ap	46.3833	-117.0167	439															X	X	X	X	X					X				
MACN[1]	Marble Canyon	36.8000	-111.6500	1219	X	X	X	X	X								X												X			
MEAD	Meadview	36.0222	-114.0675	905	X	X	X	X	X		X	X	X		X	X	X	X	X		X	X			X		X	X	X	X	X	X
MED5	Meadview (12 Hour)	35.9833	-114.0667	902	X	X	X	X									X												X			
MED6	Meadview (Ions)	35.9833	-114.0667	902	X	X	X	X									X												X			
MEVE	Mesa Verde Nat. Park	37.2186	-108.4933	2245															X			X									X	X
MFRN	Medford/Jackson County Ar	42.3667	-122.8667	396															X	X	X	X	X					X				
MOJA	Mojave	35.0600	-118.1500	836																					X			X				
MOPP	Mohave Power Plant	35.1453	-114.5906	213						X				X		X	X		X	X	X	X	X	X	X		X	X				
MOSP	Mountain Springs Summit	35.9833	-115.5167	1753	X	X	X	X	X								X												X			
MSON	Missoula/Johnson-Bell Fld	46.9167	-114.0833	976															X	X	X	X	X					X				
NEED	Needles	34.7639	-114.6150	278															X	X	X	X			X			X				
NEHA	New Harmony	37.5000	-113.3000	1524	X	X	X	X	X								X												X			
NKXN	Miramar Nas	32.8667	-117.1500	147															X	X	X	X						X				
OAKN	Oakland Int Ap	37.7500	-122.2167	6															X	X	X	X						X				
OLMN	Olympia/Arpt	46.9667	-122.9000	59															X	X	X	X	X					X				
OTHN	North Bend/FAA Airport	43.4167	-124.2500	1															X	X	X	X	X					X				
OVBE	Overton Beach	36.4333	-114.3667	396	X	X	X	X	X								X												X			
OVER	Overton	36.8080	-114.4644	424																					X			X				
PAGE	Page	36.9300	-111.4500	1326															X	X	X	X						X				
PALM	Palmdale	34.5900	-118.0400	787																					X			X				
PARK	Parker	34.1500	-114.2667	137	X	X	X	X	X								X												X			
PAUL[1]	Paulden	34.9167	-112.5667	1341	X	X	X	X	X								X												X			
PDTN	Pendleton/Municipal Arpt	45.6833	-118.8500	459															X	X	X	X	X					X				
PDXN	Portland/Int'L Arpt	45.6000	-122.6000	8															X	X	X	X	X					X				
PEFO	Petrified Forest Nat. Prk	34.9139	-109.7958	1690					X										X			X									X	X
PEFR	Petrified Forest	35.1000	-109.7500	1676	X	X	X	X									X												X			
PHXN	Phoenix/Sky Harbor Int'L	33.4333	-112.0167	338															X	X	X	X	X					X				
PIHN	Pocatello/Municipal Arpt	42.9167	-112.6000	1360															X	X	X	X	X					X				
PRCN	Prescott – Municipal	34.6500	-112.4333	1531															X	X	X	X	X					X				
PRES	Prescott	34.5667	-112.2667	1450															X	X	X	X						X				
PUBN	Pueblo/Memorial Arpt	38.2833	-104.5167	1420															X	X	X	X	X					X				
RDDN	Redding/Municipal Arpt	40.5167	-122.3000	153															X	X	X	X	X					X				
RDMN	Redmond/FAA Airport	44.2667	-121.1500	932															X	X	X	X	X					X				
RKSN	Rock Springs/FAA Airport	41.6000	-109.0667	2055															X	X	X	X	X					X				
RNON	Reno/Cannon Int'L Arpt	39.5000	-119.7833	1341															X	X	X	X	X					X				
ROWN	Roswell/Industrial Air Pa	33.3000	-104.5333	1113															X	X	X	X	X					X				
SACN	Sacramento/Executive Arpt	38.5167	-121.5000	6															X	X	X	X	X					X				

		Position			Aerosol				Tracer		Gaseous								Meteorological										Optical			
SITE	Location	LATF	LONF	ELVM	IO	CC	EL	MS	PFT	TR	DN	HL	HN	NOG	OG	O3	SO2	NH	TA	TD	PR	RH	TS	TU	W1	TV	SG	WW	BA	BS	SVR	BE
SAGO	San Gorgonio Wilderness	34.1933	-116.9133	1710					X										X			X									X	X
SAGR	San Gorgonio	34.2000	-116.9167	1713	X	X	X	X									X												X			
SANB	San Bernardino	34.1800	-117.3800	514																					X	X		X				
SAND	San Diego	34.9700	-117.1600	111																					X	X		X				
SANN	San Diego/Lindbergh Field	32.7333	-117.1667	10															X	X	X	X	X					X				
SBAN	Santa Barbara/FAA Airport	34.4333	-119.8333	2															X	X	X	X	X					X				
SEAN	Seattle/Seattle-Tacoma In	47.4500	-122.3000	137															X	X	X	X	X					X				
SELI	Seligman	35.2833	-112.4833	1661	X	X	X	X	X								X												X			
SFON	San Francisco/Int'L Arpt	37.6167	-122.3833	27															X	X	X	X	X					X				
SHRN	Sheridan/County Arpt	44.7667	-106.9667	1202															X	X	X	X	X					X				
SLCN	Salt Lake City/Int'L Arpt	40.7667	-111.9667	1287															X	X	X	X	X					X				
SLEN	Salem/Mcnary Field	44.9167	-123.0167	60															X	X	X	X	X					X				
SMXN	Santa Maria/Public Arpt	34.9000	-120.4500	82															X	X	X	X	X					X				
SPMC	Spirit Mountain - Colloc	35.2500	-114.7333	1498	X	X	X	X									X												X			
SPMO	Spirit Mountain	35.2500	-114.7333	1498	X	X	X	X	X			X				X	X		X	X	X							X	X	X		X
SQMO	Squaw Mountain	35.2167	-113.1000	1981	X	X	X	X	X								X												X			
SYCA	Sycamore Canyon	35.1500	-111.9833	1890	X	X	X	X	X								X												X			
TEBR	Temple Bar	36.0150	-114.3319	485															X						X			X				
TEHA	Tehachapi Summit	35.1000	-118.4333	1280	X	X	X	X	X	X							X		X			X							X	X	X	
TMET	Tonto Plateau, Gcnp	35.0933	-112.0697	1180															X		X	X	X				X	X				
TONT	Tonto Nat. Forest	33.6500	-111.1167	732	X	X	X	X	X								X												X			
TPHN	Tonopah/FAA Airport	38.0667	-117.0833	1654															X	X	X	X	X					X				
TRUX	Truxton	35.4861	-113.5639	1350	X	X	X	X	X								X								X			X	X			
TUSN	Tucson/Int'L Arpt	32.1167	-110.9333	786															X	X	X	X	X					X				
UILN	Quillayute/Wso Airport	47.9500	-124.5500	54															X	X	X	X	X					X				
WICK	Wickenburg	33.9333	-112.8000	732	X	X	X	X	X								X												X			
WMCN	Winnemucca/Wso Airport	40.9000	-117.8000	1310															X	X	X	X	X					X				
WWTR	White Water	33.9000	-116.6800	360																					X			X				
YKMN	Yakima/Air Terminal	46.5667	-120.5333	325															X	X	X	X	X					X				
YUCC	Yucca	34.7500	-114.1667	579	X	X	X	X	X								X												X			
YUM1	Yuma Army Proving Site #1	32.8700	-114.3300	136															X	X	X	X		X				X				
YUM2	Yuma Army Proving Site #2	32.5100	-114.1000	231															X	X	X	X		X				X				
YUMA	Yuma	32.7542	-114.6917	61			X												X	X	X	X						X				

*Supplemental monitoring during winter only
[1]Winter site only
[2]Summer site only

Table 3-2 Field name coding description for the ambient and meteorological observables.

Field Name	Description
BA	Particle optical absorption
BE	Total extinction coefficient
BS	Particle scattering coefficient
CC	Aerosol carbon
DN	Denuders
EL	Elemental composition of aerosol
HL	Gas phase halocarbons
HN	Nitric and Nitrous acid gas
IO	Aerosol anions
MS	Particulate Matter < 10 microns
NH	Ammonia and ammonium
NOG	NOx
O3	Ozone
OG	Gas phase organics
PFT	Tracer
PR	Barometric pressure
RH	Relative humidity
SG	Standard deviation of wind direction
SO2	Sulfur dioxide
SVR	Standard visual range
TA	Ambient temperature
TD	Dew point temperature
TR	Tracer release
TS	Total solar radiation
TU	Turbulence
TV	Virtual temperature
W1	Vertical wind speed
WW	Wind direction

Size-resolved samples were collected at five sites using the *Davis Rotating drum Unit for Monitoring* (DRUM) sampler, a Lundgren-type rotating drum cascade impactor with a single round jet for each stage (Raabe et al., 1988). Each sampler had eight drum stages with 50% collection cut points at aerodynamic diameters of 10, 5, 2.4, 1.1, 0.56, 0.34, 0.24, and 0.069 µm. A Teflon filter behind the last stage collected particles smaller than 0.069 µm. The drums rotated slowly to provide 6-hour time resolution when analyzed with the UCD focused beam Particle Induced X-Ray Emission (PIXE) strip analysis system. The particles are collected on 16.8 cm mylar strips coated with Apiezon L grease to minimize bounce-off. The final orifice provides flow control at 1.1 LPM by operating as a critical orifice.

Table 3-5 summarizes the sampling configurations using IMPROVE and DRUM samplers. For the names of the sites, see Figure 3-1 and Table 3-1. During the routine monitoring periods, 24-hour samples were collected every Wednesday and Saturday as part of the IMPROVE network. During both intensive sampling periods, 12-hour samples were collected continuously at the receptor sites: Meadview, Hopi Point, and Indian Gardens. Meadview had an additional 12-hour fine Teflon/citric acid module to measure ammonium ions and ammonia gas. Hopi Point and Indian Gardens had an additional 24-hour fine module with a Teflon filter. The other IMPROVE and background sites collected 24-hour samples continuously beginning at 0700 MST. Collocated samplers were located at Joshua Tree during the winter intensive sampling period (Teflon only) and at Cajon Summit and Spirit Mountain (Teflon plus carbonate) during the summer intensive sampling period.

Table 3-3 IMPROVE sampler module types used in Project MOHAVE. The B module has a carbonate denuder.

Module	*Filter*	*Aerodynamic Diameter Range*	*Major Variables*
A	Teflon	0 - 2.5 µm	mass, S, organics by H, soil and trace elements, b_{abs}
B	nylon	0 - 2.5 µm	nitrate, sulfate (QA)
C	quartz	0 - 2.5 µm	organic and elemental carbon
D/S	Teflon / carbonate	0 - 10 µm	PM_{10} mass / SO_2
E/L	Teflon / citric acid	0 - 2.5 µm	nitrate, sulfate, ammonium / ammonia
A/S	Teflon / carbonate	0 - 2.5 µm	mass, S, organics by H, soil and trace elements, b_{abs}/SO_2

Table 3-4 Samplers used by BYU and University of Minnesota in Project MOHAVE

Sampler	Denuder	Filter	d_{ae} range	Major variables
BYU Denuder	Carbonate	Teflon/ Nylon	0 - 2.5 μm	Sulfate, nitrate, fluoride, SO_2, HNO_3, HF
BYU Hi Vol	None	Impaction Quartz/ Carbonate	0.5 - 3.5 μm 0 - 0.5μm	Sulfate, nitrate, SAS Sulfate, nitrate, fluoride, SO_2, HF
BYU BOSS	Charcoal	Quartz/ Charcoal	0 - 2.5 μm	Particulate carbonaceous material
Harvard HEADS	Carbonate/Citric acid	Teflon/ Nylon	0 - 2.5 μm	Sulfate, nitrate, ammonium, SO_2, HNO_3, NH_3

Table 3-5 IMPROVE and DRUM sampling configurations for the various periods.

Sites	Frequency	Modules
Fall 1991 Monitoring	*9/4/91 to 1/11/92*	
9 IMPROVE sites	Wed/Sat	A, B, C, D/S
Meadview, Long Mesa	6-hour	DRUM
Winter Intensive	*1/14/92 to 2/15/92*	
Meadview	12-hour	A, B, C, D/S, E/L
Hopi Point, Indian Gardens	12-hour	A, B, C, D/S, 24h A
6 other IMPROVE sites	24-hour	A, B, C, D/S
21 background sites	24-hour	A/S
Joshua Tree	24-hour	collocated A
Meadview, Hopi Point, Indian Gardens, Long Mesa, Spirit Mtn	6-hour	DRUM
Spring 1992 Monitoring	*2/16/92 to 7/11/92*	
9 IMPROVE sites	Wed/Sat	A, B, C, D/S
Hopi Point, Long Mesa	6-hour	DRUM
Summer Intensive	*7/12/92 to 9/2/92*	
Meadview	12-hour	A, B, C, D/S, E/L
Hopi Point	12-hour	A, B, C, D/S, 24h A
Indian Gardens	Wed/Sat	A, B, C, D/S
6 other IMPROVE sites	24-hour	A, B, C, D/S
23 background sites	24-hour	A/S
Cajon Summit, Spirit Mountain	24-hour	collocated A/S
Meadview, Hopi Point, Long Mesa, Spirit Mountain	6-hour	DRUM
Fall 1992 Monitoring	*9/5/92 to 9/31/92*	
7 IMPROVE sites	Wed/Sat	A, B, C, D/S

Three MOUDI size-fractionated impactors were operated the University of Minnesota Particle Technology Laboratory researchers for 12 hours per day (0700 to 1900 MST) from July 17 to August 30, 1992 . The MOUDI samples provided size distributions for sulfate, nitrate, organic carbon, elemental carbon, and elemental concentrations on 8 stages. A cyclone with 1.8 µm cut point was used upstream of the MOUDI sampler. A more detailed description of the methods and results from both the MOUDI and DRUM experiments is discussed in Pitchford and Green (1997).

3.1.2 Filter Sample Analysis

The IMPROVE sampler filters were analyzed at Davis (UCD), Global Geochemistry (GGC), Desert Research Institute (DRI), and Research Triangle Institute (RTI). The methods and measured variables are summarized in Table 3-6. The Teflon A and carbonate S filters were collected at all sites. The nylon B and quartz C filters were collected at the nine IMPROVE sites. The Teflon E and citric acid impregnated after-filter were collected at Meadview.

Table 3-6 Analytical methods for filter analysis and measured variables

Filter	Lab	Method	Code	Variable	Reference
Teflon A	UCD	gravimetric analysis		mass	Feeney et al., 1984
		integrating plate method	LIPM	coefficient of absorption	Campbell et al., 1989
		proton elastic scattering analysis	PESA	H	Cahill T., 1990
		particle induced X-ray emission	PIXE	Na to Mn, Mo	Cahill T., 1990
		X-ray fluorescence	XRF	Fe to Zr, Pb	Zeng et al., 1993
nylon B	GGC	ion chromatography	IC	nitrate, sulfate, chloride	
quartz C	DRI	thermal optical reflectance (carbon)	TOR	organic and elemental carbon	Chow et al., 1993
Teflon D	UCD	gravimetric analysis		mass	Feeney et al., 1984
Carbonate S	RTI	ion chromatography	IC	SO_2 from sulfate	
Teflon E	GGC	ion chromatography	IC	nitrate, sulfate	
		Technicon colorimetry		ammonium	
citric acid L	GGC	Technicon colorimetry		ammonia from ammonium	

Samples collected by researchers at BYU were analyzed at BYU using a variety of techniques. SO_2, sulfate, and nitrate were analyzed by ion chromatography. Fluoride was analyzed using an ion selective electrode. SAS particles were counted visually on substrates using a scanning electron microscope. Particulate carbonaceous material was analyzed by temperature programmed volatilization analysis. Samples collected by researchers at University of Minnesota were analyzed by ion chromatography at Harvard School of Public Health. Nitric acid vapor was not measured as part of Project MOHAVE.

The DRUM strips for Meadview during the summer intensive were analyzed using the UCD PIXE Strip Analysis System for Na to Pb. Teflon filters from the MOUDI sampler were analyzed using PIXE. The Strip Analysis System was needed to correct for nonuniform deposit on the filters.

3.1.3 Gas Phase Measurements

In addition to the SO_2 concentrations measured by the IMPROVE samplers, several other gas phase measurements were conducted in conjunction with Project MOHAVE. Ozone, NO_x, organic gases, and halocarbons were measured by DRI at multiple sites during the study period. Harvard researchers analyzed samples collected at Meadview for ammonia and ammonium concentrations using annular denuders. BYU researchers also collected and analyzed denuder samples at Hopi Point, Meadview, and Spirit Mountain during both the winter and summer intensive sampling periods.

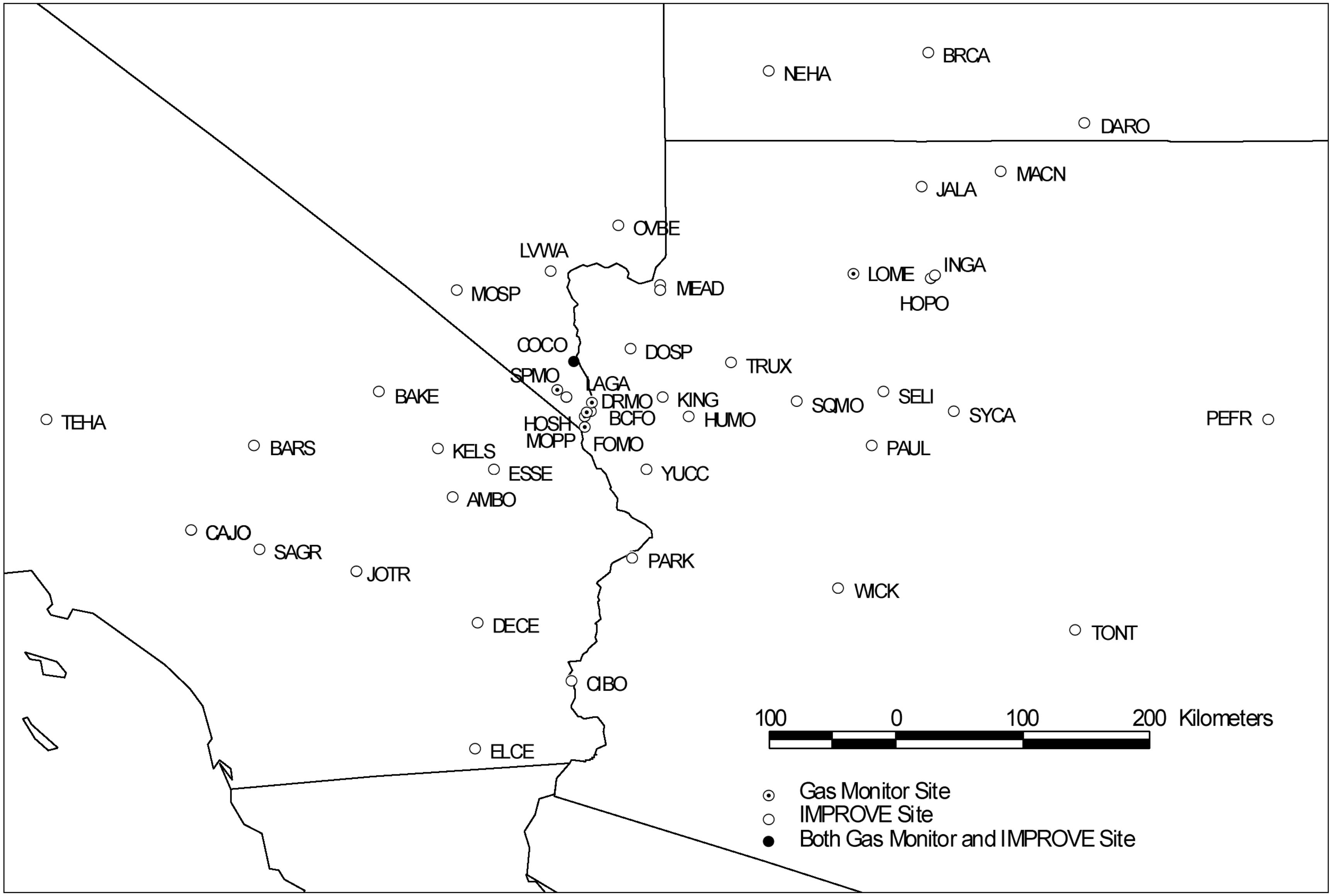

Figure 3-1 Air quality monitoring network for measurements of aerosol composition and gaseous species.

3.2 Tracer Release Network

The locations of the tracer release sites are shown as the open circles in Figure 3-2. Perfluorocarbon tracers (PFT's) used in Project MOHAVE are fully fluorinated hydrocarbons with low solubility in water and moderate vapor pressure, and are therefore inert and non-depositing, as well as non-toxic. At MPP, ortho-perfluorodimethylcyclohexane (oPDCH) tracer was injected into the power plant stack at a height of 20 meters. At the other tracer release locations, tracer was released into the ambient air within a few meters of the surface. The tracer gases were stored in liquid form in stainless steel tanks. A peristaltic metering pump pumped the material from the tank past a linear mass flowmeter and a cumulative mass totalizer onto the surface of a heated disk, which vaporized the tracer. A fan moved the vaporized tracer up a pipe to the atmosphere (or into the MPP stack).

oPDCH was released continuously from the stack of MPP during the 30-day winter and 50-day summer intensive periods. Forty-five percent of the oPDCH consists of the isomer ortho-cis (oc) PDCH, which is measured at the receptor site. The rate of oPDCH release was proportional to power production. This was done to maintain a nearly constant ratio of tracer to SO_2 emissions, which is preferable for receptor and hybrid modeling. This also allows the calculation of the amount of sulfur from the MPP associated with a given tracer concentration. A constant tracer emission rate would have simplified the evaluation of transport and dispersion models used. Sufficient periods of nearly constant tracer emission rates existed to perform these evaluations, thus minimizing the trade-off between tracer release approaches optimized for receptor modeling and deterministic modeling.

Specifically, the tracer release rate was constant when power production stayed within a 10% range of maximum load. For example, if power production was between 90% and 100% of capacity, oPDCH release rates were at their maximum and constant. If the power production dropped to between 40% and 50% of capacity, tracer release rates were reduced to one-half the maximum rate. Figure 3-3 shows the time series of the tracer release rate, power production, and SO_2 emissions from MPP during the winter intensive sampling period. The standard deviation of the ratio of SO_2 emissions (from continuous emission monitors) to oPDCH for the winter was 8.4%; the squared correlation coefficient between oPDCH and SO_2 emissions was 0.95. For the summer, accurate SO_2 emissions measurements were not available; however the winter emissions monitoring showed a high correlation (r^2=0.99) of SO_2 emissions with power production. Thus, power production is a good surrogate for SO_2 emission rate. Figure 3-4 shows the oPDCH tracer release rate and power production at MPP during the summer intensive. For the summer, the ratio of power production to tracer release rate had a standard deviation of 6.9% and an r^2 of 0.83.

The average SO_2 to ocPDCH release ratio from MPP was 78.1 g SO_2/mg ocPDCH (488,000 moles SO_2/mole ocPDCH) in winter and 73.3 g SO_2/mg ocPDCH (455,000 moles SO_2/mole ocPDCH) during the summer. The wintertime hourly release ratio remained within 10% of these constants for 84% of the release period. Note that, MPP Unit 1 was off from 1/20/92 at 2100 to 1/28/92 at 1600 and Unit 2 was off from 1/29/92 at 0500 to 2/11/92 at 1800, 7/24/92 at 2000 to 7/27/92 at 0800, and 8/16/92 at 1800 to 8/17/92 at 0400. The tracer release rate was adjusted to account for the resultant changes in SO_2 emissions at these times.

Additional perfluorocarbon tracers were released from other locations to identify times during which emissions from other significant source areas are present throughout the monitoring network. During the winter intensive study, the tracer perfluoromethylcyclopentane (PMCP) was released at Dangling Rope, northeast of the Grand Canyon. This was done to tag the air flow down the Colorado River drainage, which may include emissions from the NGS, other coal-fired power plants in the Colorado River drainage, and from the Salt Lake City urban and industrial area. Prevailing winter mesoscale and nocturnal drainage winds transport emissions from these sources toward GCNP. The time series of PMCP release rates from Dangling Rope is shown in Figure 3-5.

During the summer intensive study, tracer was released from two additional locations in Southern California: Tehachapi Pass and near El Centro in the southern Imperial Valley. Tehachapi Pass separates the San Joaquin Valley from the Mojave Desert and is an important exit route for emissions from oil development and urban areas in the San Joaquin Valley and emissions from the San Francisco Bay area. The El Centro tracer is expected to represent emissions from the San Diego-Tijuana and the Calexico-Mexicali border areas. These two release locations, one to the south of the Los Angeles Basin, and one to the north provide a method for bracketing emissions from the Los Angeles Basin. There are limitations to this approach since emissions from the Los Angeles Basin may impact some sites while neither the Tehachapi or El Centro tracer is detected. This is an inherent difficulty of representing emissions from an area source with one or more point released tracers.

Both PMCP and perfluoromethylcyclohexane (PMCH) were released from Tehachapi Pass using a combination of continuous release and 6-hour pulses every 4 days. PMCP was released continuously from July12 to July 27 during which period three pulses of PMCH were released beginning at 1400 MST. Continuous release of PMCH began on July 27 and continued to the end of August, during which period seven pulses of PMCP were released during selected afternoons. Pulses were designed to time the transport of the PFT through the monitoring network. The hourly average summertime release rates for PMCH and PMCP are shown in Figure 3-6 and Figure 3-7.

Perfluorotrimethylcyclohexane (PTCH) was released from El Centro continuously from July 12 to the end of August with the exception of two 3-day interruptions from August 1 to 4 and from August 22 to 25 (Figure 3-8). The interruptions in tracer release were designed to permit timing of the tracer front through the monitoring network without the need for a second tracer at this site (unavailable for this study). Table 3-7 contains PFT emission rate information for all release locations and seasons. The amount of material available for each of the PFTs for summer and winter was limited. In many cases, released tracer concentrations at receptors were indistinguishable from background concentrations. Due to the large transport distances from the California release locations to the Grand Canyon, it would have been desirable to release more tracer material than was available for these locations in order to improve the signal-to-noise ratio.

Halocarbons, in particular methylchloroform, have been identified as endemic tracers of the greater Los Angeles urban area (White *et al.*, 1990). These compounds are associated with mainly weekday emissions from certain manufacturing facilities such as electronics and aircraft.

Halocarbon measurements for Project MOHAVE were made at Spirit Mountain, Meadview, and Long Mesa.

3.3 Tracer Monitoring Network

Figure 3-2 is a map of the locations of all of the tracer monitoring sites for both the winter and summer intensive sampling periods. The filled circles indicate the locations of the tracer samplers. With the exception of a single monitor operated at Long Mesa, every tracer sampler was collocated with an IMPROVE aerosol sampler (see section 3.1). The sampling periods for both the aerosol and tracer samplers were synchronized to permit direct comparison of aerosol and tracer data.

For the routine tracer monitoring network (Figure 3-2), programmable Brookhaven Atmospheric Tracer Samplers (BATS) were used for sample collection. The sampler consists of two sections: the lid, containing the sample tubes, and the base, containing the power control. The BATS base contained a constant volume flow pumping system which drew sample air through each sampling tube. The flow rate is selected by setting an internal switch to 10,20,30,40, or 50 mL/min of air (at standard temperature and pressure); the switch controls the on/off cycling rate of the pump over a one-minute period. For Project MOHAVE, the sampling rate was 50 mL/min. The sample air flows consecutively through the tubes by means of a multiple port switching valve. A digital printer and integrated circuit memory module recorded the start time, day of week, and the tube number for each sample. The BATS removable lid held 23 stainless steel sampling tubes, each packed with approximately 150 mg of Ambersorb adsorbent. The Ambersorb adsorbed the tracers from the sample air flowing through the tube. Breakthrough of the perfluorocarbon tracer gases was less than 0.1%. The tracer gases remain adsorbed until heat is applied to desorb the tracers during analysis.

In addition to the 24- and 12-hour sampling, higher time resolution monitoring of PFTs was conducted for limited periods of time at the Meadview and Dolan Springs sites. A field version of the electron capture gas chromatograph with a dual trap (one sampling while the other is analyzed) was employed at Meadview to collect and analyze on-site the PFT concentrations with 15 minute time resolution for a two week period from July 28 to August 11, 1992. Occasional electrical power interruptions meant that this system was not operated continuously during this period. The Department of Energy collocated a BATS system programmed for two-hour sampling at the Dolan Springs site to take advantage of the nearby release of tracer at MPP. This higher temporal resolution data is available from DOE for a three week period from July 9 to July 31, 1992.

The PFT samples were analyzed at Brookhaven National Laboratory using electron capture gas chromatography. For analysis, the PFTs, retained on the adsorbent in the BATS tubes, were desorbed by resistance heating of the tubes to 460°C. The sample was passed through a precut column and a Pb catalyst bed before being reconstituted in an in situ Florisil trap. Once the trap was thermally desorbed, the sample again passed through the same catalyst bed, and then through a permeation dryer. The sample was then passed into the main column of the gas chromatograph where it was separated into the various perfluorocarbon constituents and ultimately into the electron capture detector. The experimental procedure is described in more detail by Dietz (1996).

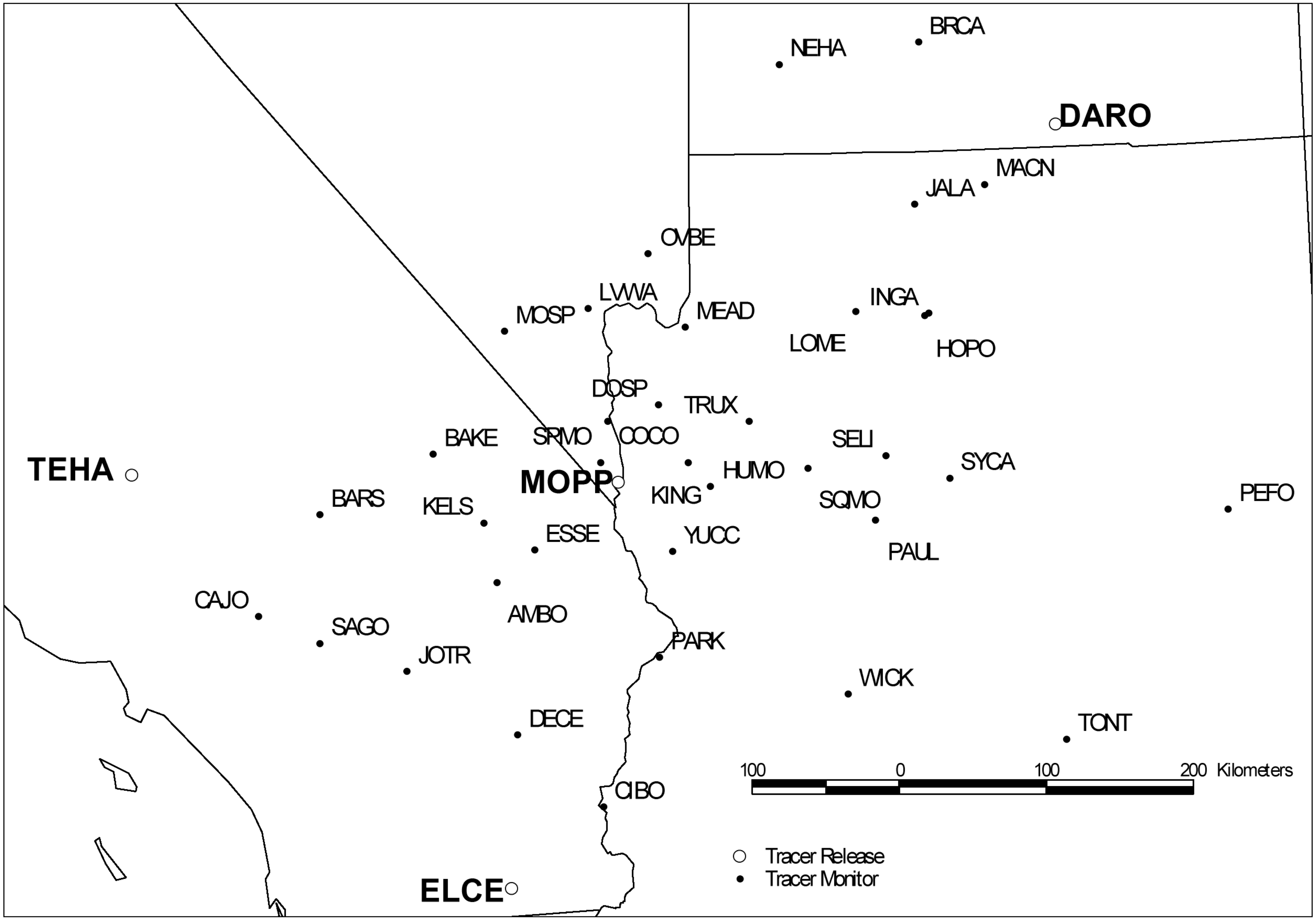

Figure 3-2 Tracer release and monitoring network.

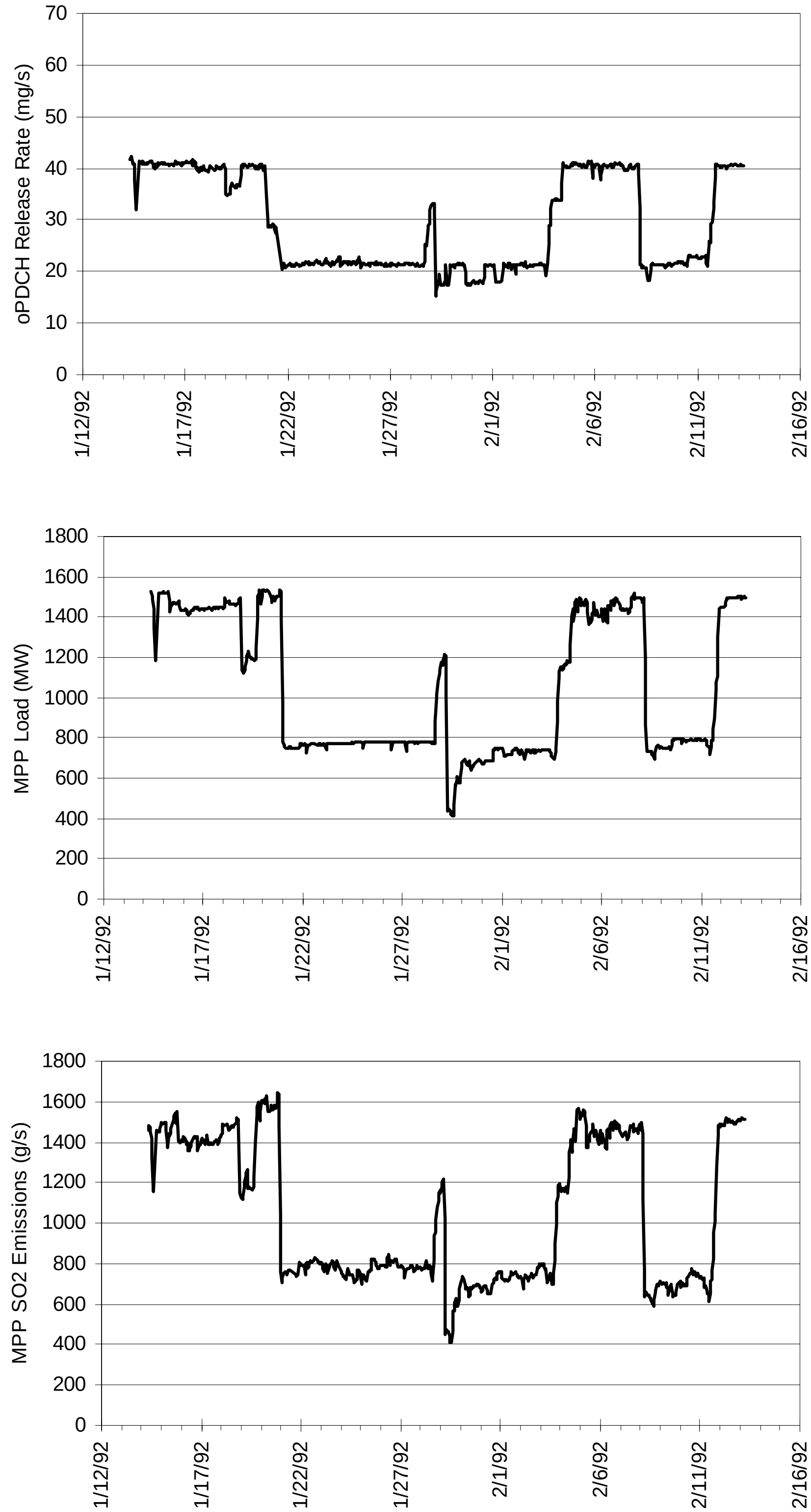

Figure 3-3 Time series of oPDCH tracer release rate, power load, and SO_2 emission at MPP during the winter intensive.

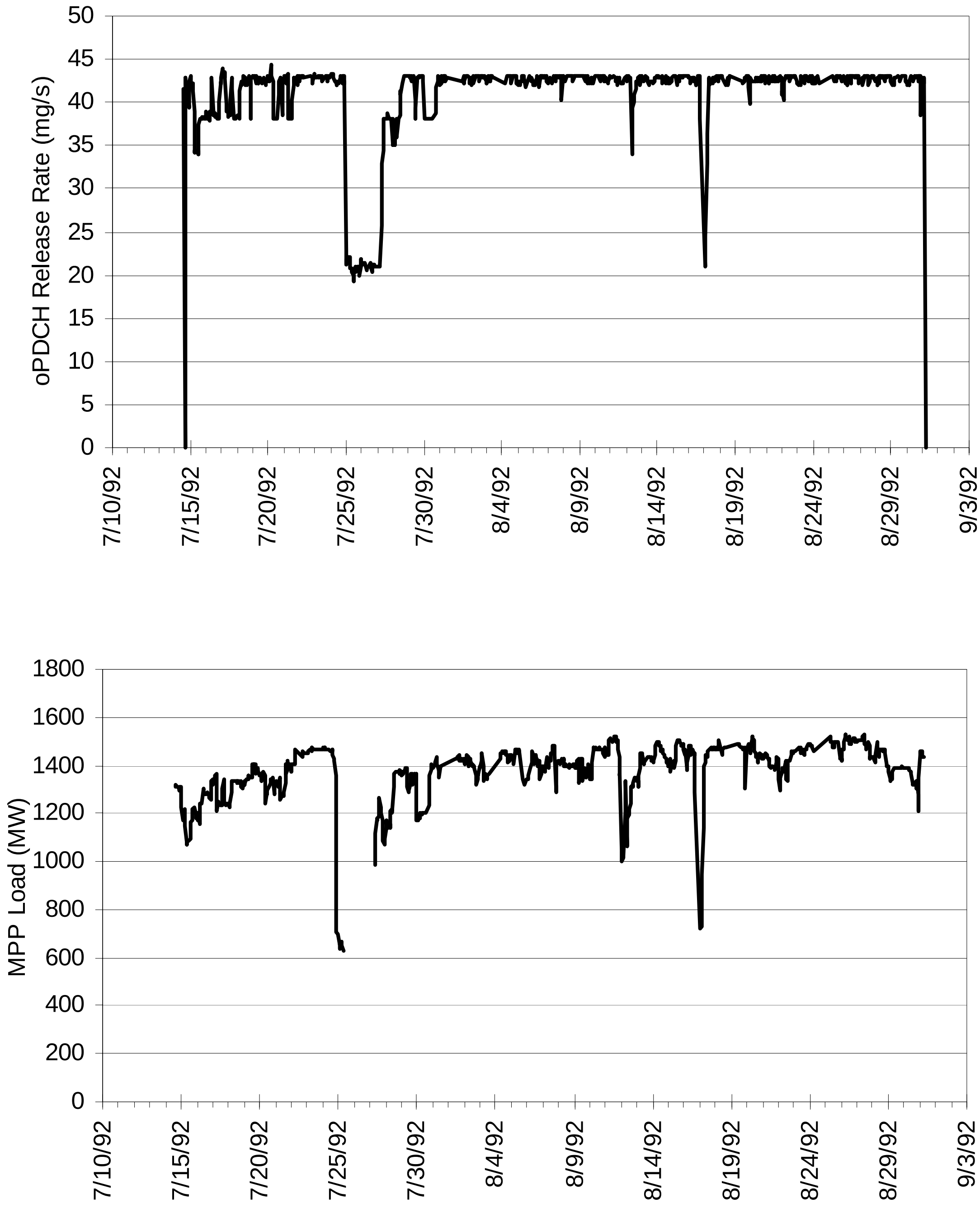

Figure 3-4 Time series of oPDCH tracer release rate and power production at MPP during the summer intensive.

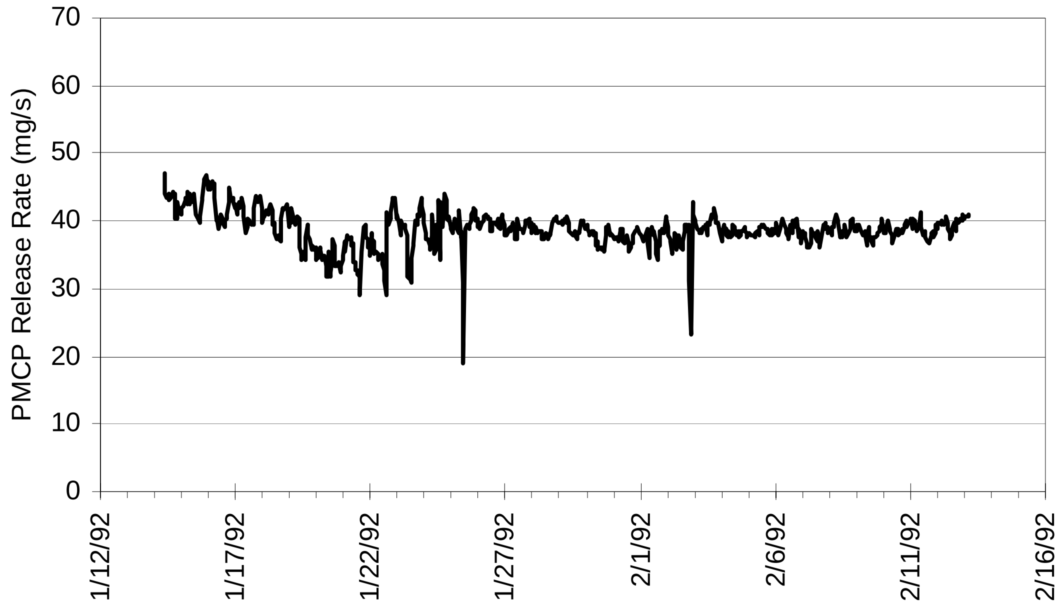

Figure 3-5 Time series of hourly average PMCP tracer release rate from Dangling Rope during the winter intensive.

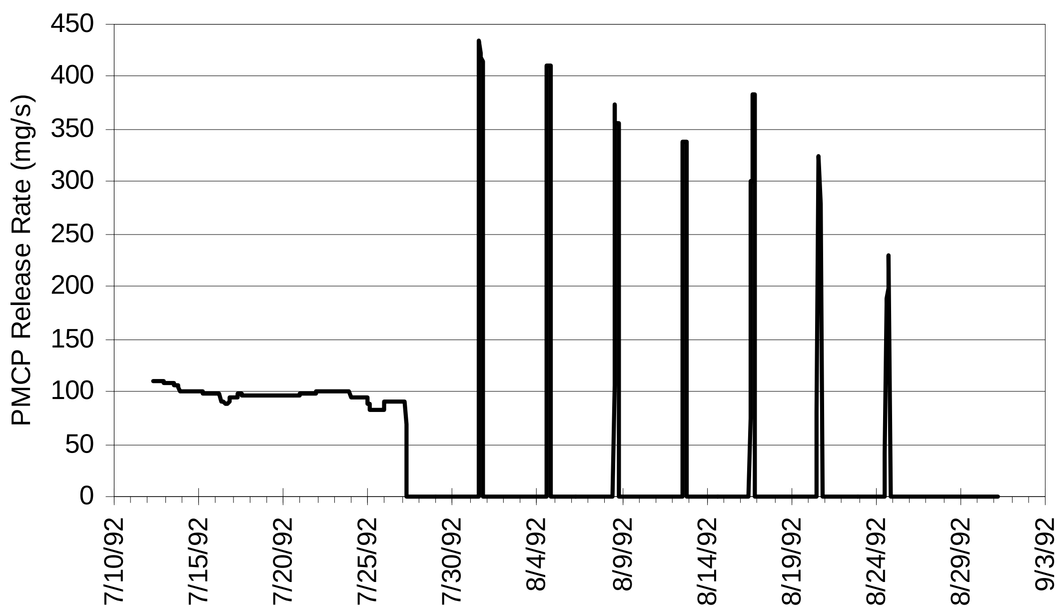

Figure 3-6 Time series of hourly average PMCP tracer release rate from Tehachapi Summit during the summer intensive.

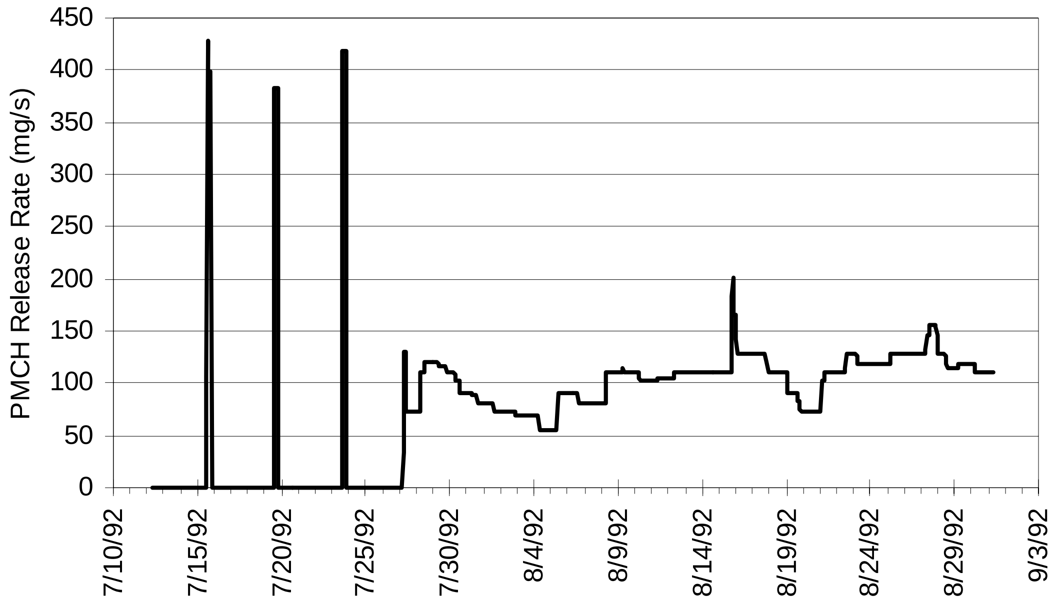

Figure 3-7 Time series of hourly average PMCH tracer release rate from Tehachapi Summit during the summer intensive.

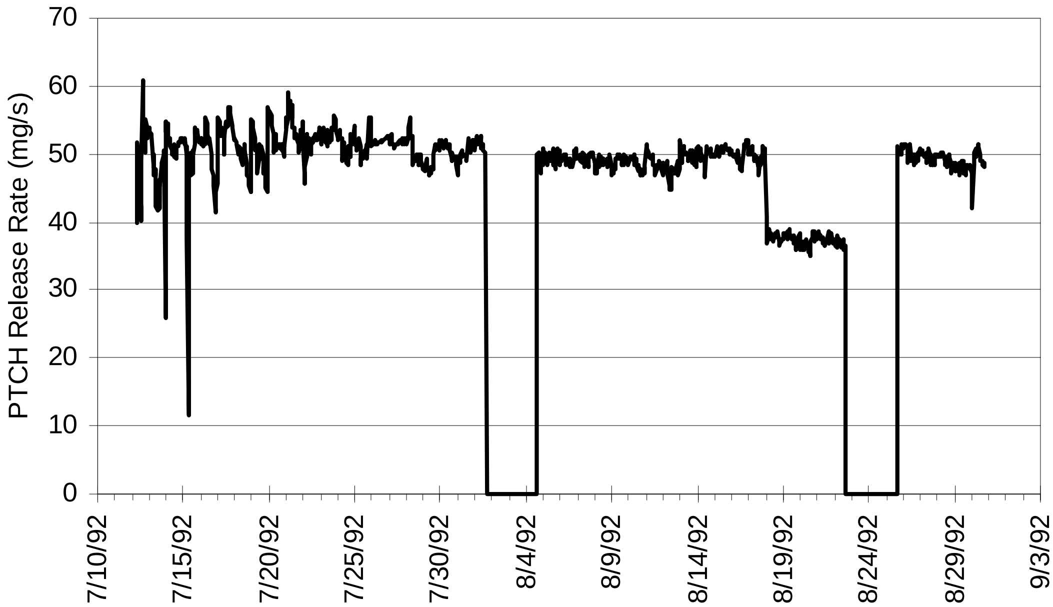

Figure 3-8 Time series of hourly average PTCH tracer release rate from El Centro during the summer intensive.

Table 3-7 Summary of the location and quantity of PFT's released during Project MOHAVE

PFT	Release Location	Total Released (kg)	Start Date (MST)	Stop Date (MST)
PMCP	Dangling Rope	100	1/14/92 0900	2/13/92 0500
PMCP	Tehachapi Summit	125	7/12/92 0700	7/27/92 0700
PMCP	Tehachapi Summit	9	7/31/92 1400	7/31/92 2000
PMCP	Tehachapi Summit	9	8/4/92 1300	8/4/92 2000
PMCP	Tehachapi Summit	8	8/8/92 1300	8/8/92 2000
PMCP	Tehachapi Summit	8	8/12/92 1400	8/12/92 2100
PMCP	Tehachapi Summit	7	8/16/92 1300	8/16/92 2000
PMCP	Tehachapi Summit	7	8/20/92 1300	8/20/92 2000
PMCP	Tehachapi Summit	5	8/24/92 1300	8/24/92 2000
oPDCH	Mohave Power Project	73	1/14/92 0700	2/13/92 0700
oPDCH	Mohave Power Project	176	7/12/92 0700	8/31/92 0700
PMCH	Tehachapi Summit	9	7/15/92 1300	7/15/92 2000
PMCH	Tehachapi Summit	9	7/19/92 1300	7/19/92 2000
PMCH	Tehachapi Summit	9	7/23/92 1400	7/23/92 2000
PMCH	Tehachapi Summit	315	7/27/92 0600	8/31/92 0700
PTCH	El Centro	90	7/12/92 0700	8/1/92 1600
PTCH	El Centro	72	8/4/92 1600	8/22/92 1600
PTCH	El Centro	22	8/25/92 1600	8/30/92 2000

3.3.1 Calculation of Ambient PFT Concentrations

Prior to the winter tracer study, during November and December 1991, a background study was conducted in the study area for a period of 10 days at each site. The BATS samplers were deployed at 27 sites. Each sampling period was 12 hours. The pump flow rates for each sampler were measured at Brookhaven National Laboratory before and after the background study and standardized to standard temperature and pressure conditions. The volume sampled depends on the density of air at the sampling location, so density was estimated at each location. At two sites, hourly temperature, pressure, and humidity data was available to calculate atmospheric density. At the other sites, density was calculated using hourly virtual temperature and pressure estimates from measured data and application of the hydrostatic equation. Standards were run on each of the two gas chromatographs to determine the response curve of the instrument. Each sample run could then be determined to represent a quantity of perfluorocarbon in femtoliters (10^{-15} l). The atmospheric concentration was then obtained by dividing by the sample volume.

Average background concentrations for each perfluorocarbon were calculated. For ocPDCH, one episode of elevated concentrations up to 50% above background occurred at many sites during the background study. These elevated values had an insignificant effect upon the average background concentration (less than 0.01 fl/l ocPDCH). Calculated ambient backgrounds of the released PFTs were: ocPDCH, 0.52 fL/L; PMCP, 5.45 fL/L; PMCH, 4.83 fL/L; PTCH, 0.61 fL/L.

For the winter and summer intensive sampling periods, sample volumes were not explicitly determined. To determine concentrations of released PFTs, ratios of the chromatogram peak heights of each released PFT to ptPDCH (not released) were compared to the pre-release ratio. By correcting for non-linearities in the chromatograph response curve and some response change between the pre-release study and the winter and summer studies, the sample concentrations can be calculated as:

$$C_{T,S} = \frac{\left(\frac{H_{T,S}}{H_{R,S}}\right)}{\left(\frac{H_{T,BG}}{H_{R,BG}}\right)} \, x \, C_{T,BG} \, x \, F_{CAL} \tag{3–1}$$

where $C_{T,S}$ = tracer concentration in sample; $H_{T,S}$ and $H_{R,S}$ = peak heights of released and reference (ptPDCH) tracers in sample; $H_{T,BG}$ and $H_{R,BG}$ = peak heights of released tracer and reference tracer from background study; $C_{T,BG}$ is the concentration of the released tracer from the background study; and F_{CAL} is a factor that accounts for changes in the chromatograph response to the released and reference tracer from the background study. The tracer concentration due to the release is then given by $C_{T,S}$ minus a background concentration.

Rather than subtracting the concentrations determined from the background study, the concentrations due to the Project MOHAVE releases were calculated by subtracting average concentrations for the few days of sampling immediately before tracer release for the winter and summer studies. This data set contained 105 values for the winter and 132 values for the summer. For the released tracers, calculated concentrations rose slightly between the background and winter studies and more between the winter and summer studies. The increase in calculated background between the background and summer studies was 8% for ocPDCH, 9% for PMCH, and 15% for PMCP. PFT samples were collected during the interim period between the winter and summer intensive sampling periods at Long Mesa and Hopi Point. Background levels and standard deviations are shown in Table 3-8. It should be noted that the winter and summer backgrounds were not calculated using measured volumes as in the background study; they were calculated using the ratio to ptPDCH method described above. The ptPDCH concentration was assumed to be invariant during all three studies. It is expected that the true background values did not rise as much as the 8%,9%, and 15% amounts; rather, variability in the analytical methods and assumptions used in the concentration calculations are more likely the reason for the increase. The variability, of course, increases the uncertainty in the calculated PFT concentrations.

Increases in background could occur due to releases associated with Project MOHAVE and through manufacturing and use of the PFTs for other purposes. In an article on background PFT measurements taken in 1994 in Austria in support of the European tracer experiment (ETEX) Piringer et. al. (1997) suggest that atmospheric levels of PFTs have been increasing over the last decade or so. The approximate increase in atmospheric PFT levels due to Project MOHAVE can be estimated by comparing the mass of PFTs released by Project MOHAVE to the estimated atmospheric mass of PFTs. Assuming the mass of the atmosphere is 5.2×10^{18} kg (Warneck, 1988), the troposphere contains 80% of the mass of the atmosphere (Wallace and Hobbs, 1977), and the PFTs are well mixed through the troposphere, the increase in PFTs due to Project MOHAVE releases is 0.13% for PMCP; 0.14% for PMCH, 0.38% for ocPDCH and 0.47% for PTCH.

Table 3-8 Background perfluorocarbon concentrations (fL/L). Uncertainties are the standard deviation of the background measurements.

PFT	Background study (Nov 25-Dec 5, 1991)	Winter study (Jan 11-13, 1992)	Interim Period (Feb 22-Jun 26, 1992)	Summer study (Jul 5-11, 1992)
ocPDCH	0.52 ± 0.06	0.53 ± 0.05	0.52 ± 0.04	0.56 ± 0.06
PMCP	5.5 ± 0.3	5.7 ± 0.8	5.3 ± 0.6	6.3 ± 0.6
PMCH	4.8 ± 0.3	4.9 ± 0.4	5.0 ± 0.3	5.3 ± 0.3
PTCH	0.61 ± 0.16	Not determined	Not determined	0.6 ± 0.6

3.4 Optical Monitoring Network

During the winter intensive sampling period (1/11/92 – 2/13/92), three Optec, Inc. Next Generation Nephelometers (NGN's) were installed by Air Resources Specialists at Amboy, Cajon Pass, and Joshua Tree National Monument. Nephelometers measure the scattering of light by particles which is an important component of the total extinction budget. Each nephelometer was equipped with sensors to measure chamber temperature, ambient temperature, and relative humidity. In addition to the particle scattering coefficient, the total extinction coefficient was also measured using transmissometers at the following locations: Meadview, Bandelier National Monument, Big Bend National Park, Canyonlands National Park, Chiricahua National Monument, Grand Canyon National Park (South Rim and West In-Canyon), Guadalupe Mountains National Park, Mesa Verde National Park, Petrified Forest National Park, and San Gorgonio Wilderness Area. The transmissometers measure the average irradiance of a light source of known intensity over the path length of the instrument.

For the summer intensive sampling period (7/12/92 – 9/3/92), six nephelometers were deployed at Cajon Pass, El Centro, Joshua Tree National Monument, Kelso, Tehachapi, and Meadview. The same network of transmissometers used during the winter intensive sampling remained in operation through the end of the summer intensive sampling period. A map of the locations of each of these monitors is shown in Figure 3-9.

3.5 Meteorological Monitoring Network

Meteorological monitoring is necessary to characterize the speed, direction, and depth of air mass transport in the region and for model validation and initialization. The existing network of National Weather Service and other monitoring sites in the region was insufficient to characterize the complex meteorological setting of the study area. Additionally, for the sparse network of NWS upper air measurement sites, vertical profiles are taken only twice per day. Thus, they do not capture potentially important changes in meteorological conditions, such as the full resolution of a diurnal cycle. While it was recognized that it would be impossible with available funds to set up a meteorological monitoring network to capture all flows of interest, the existing network was supplemented with additional measurement sites.

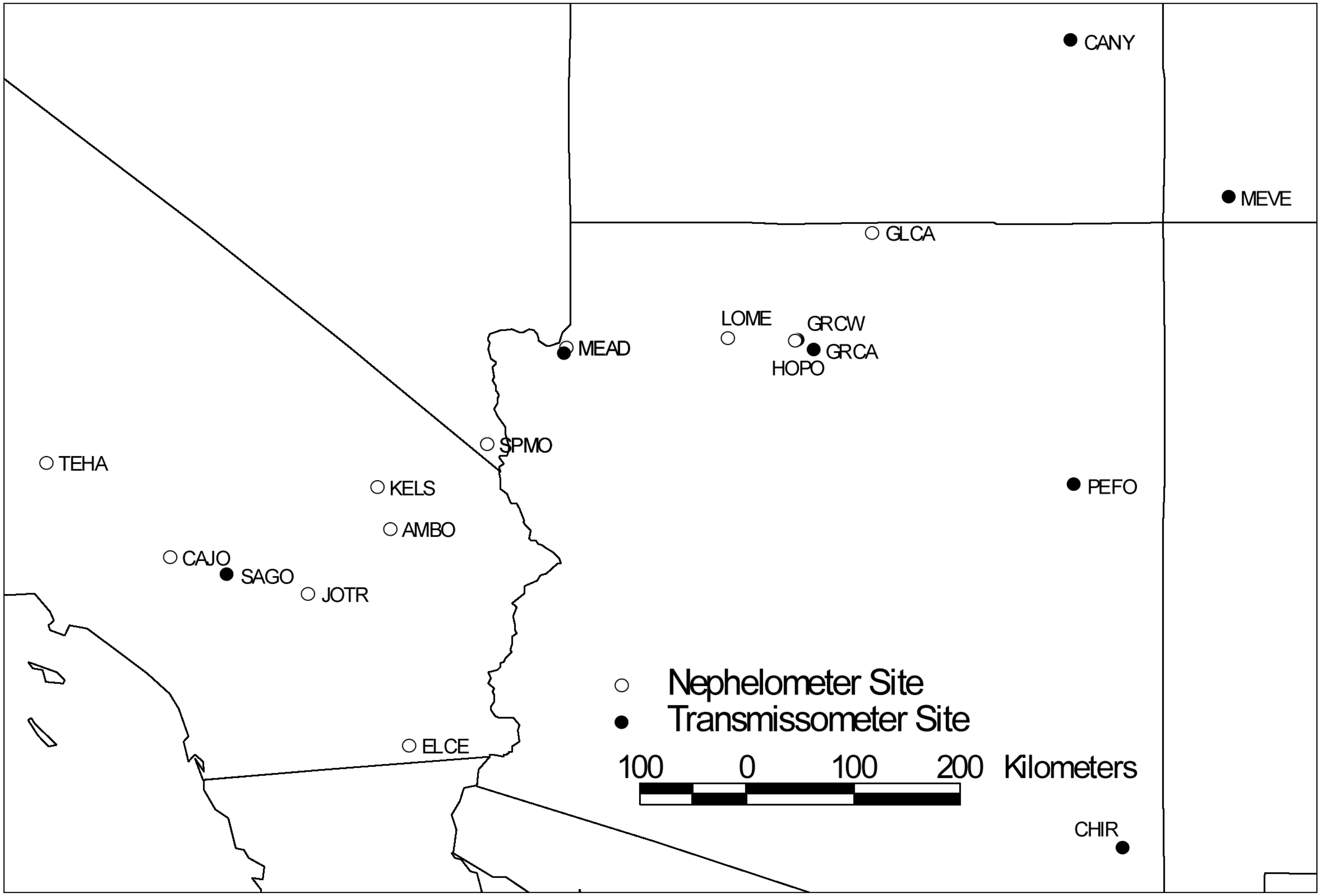

Figure 3-9 Optical properties network from Project MOHAVE including total extinction coefficient and particle scattering coefficient.

The additional sites had both surface and upper-air measurements. They consisted of doppler wind profiling radars (915 MHz), Radio Acoustic Sounding Systems (RASS), doppler sodars, and rawinsondes for upper air measurements and typically, wind speed and direction, temperature, relative humidity, and pressure for surface measurements. The radar wind profilers allow for continuous remote sensing of the three components of wind (u, v, and w) from about 100 m to approximately 3-4 km above the surface, with the maximum height being roughly proportional to absolute humidity. Data are reported as hourly averaged values of horizontal wind speed and direction and vertical velocity for 100 m thick layers at the high resolution mode and 400 m thick layers at the low resolution mode. At the higher levels, the 400 m mode provides greater data recovery than the 100 m mode. The RASS gives virtual temperature profiles by measuring the vertical distribution of the speed of sound using the scatter of radar waves from the vertically propagating acoustic waves (Neff, 1990). The RASS has a range of about 150 m to 600 m with a resolution of about 50 m.

The rawinsondes used for the study use balloon-borne instruments to measure wind speed, wind direction, temperature, relative humidity (RH), and pressure from near the surface to 5000- 6000 m AGL. The resolution for wind speed and direction measurements was typically 50-100 m, while the resolution of the temperature, RH, and pressure measurements was generally 20-30 m. The measurements were usually twice per day, although three times per day measurements were also made. Surface meteorological measurements were also made at the optical monitoring sites and SCE's long-term air quality monitoring sites. Data from all National Weather Service monitoring sites in the study region were also archived and added to the Project MOHAVE database. During the summer, the US Army radiosondes at Yuma, normally used only 5 days per week were augmented to 7 days per week operation. Although they were not sponsored by Project MOHAVE, additional radar wind profilers were also operated in Southern California during the summer intensive study; data from these profilers is included in the Project MOHAVE database. Additional upper air monitoring locations, instrumentation used, and purposes are shown in Table 3-9. The locations of meteorological stations are shown in Figure 3-10.

Table 3-9 Locations and purposes of supplemental upper-air meteorological monitoring for Project MOHAVE.

Location	Instrument	Season	Purpose
MPP	WP,RASS,S	Y	Initial transport of MPP emissions; stability
MPP	R	W	Evaluation of collocated wind profiler; wind, stability, and moisture profiles
Truxton	WP, RASS	Y	Open terrain site representative of regional flow patterns
Meadview	WP, RASS	W, S	Grand Canyon receptor site closest to MPP
Cedar City, Prescott, Yuma	R	W	Fill in gaps in NWS radiosonde network
Needles	WP, R	W	Along Colorado River, downwind of MPP in winter
Overton Beach	S	S	Monitor drainage flow from Reid Gardner power plant toward lower Grand Canyon
Page	R	Y	Monitor transport from northeast of Navajo power plant and other sources
Cottonwood Cove, Dolan Springs	R	S	Possible Colorado River Valley exit locations for MPP plume

WP= Radar Wind Profiler, S= Sodar, R= Radiosonde, Y= Year-round, W= Winter, S= Summer

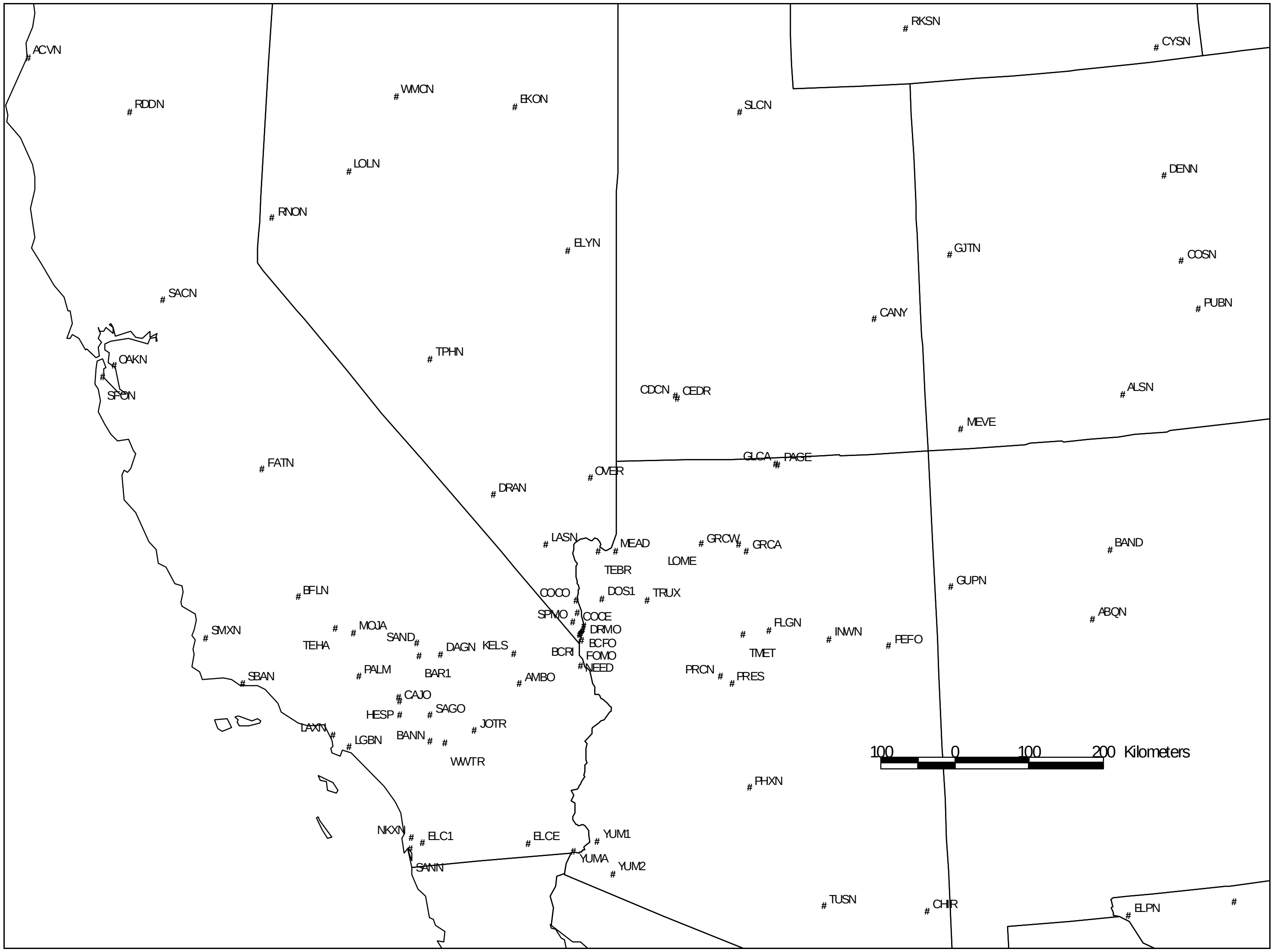

Figure 3-10 Meteorological observation sites.