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APPENDIX B

SOLAR PATHFINDER
QUALITY ASSURANCE PROJECT PLAN AND RESULTS

NAVARRO RIVER WATERSHED
TECHNICAL SUPPORT DOCUMENT

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APPENDIX B

SOLAR PATHFINDER
QUALITY ASSURANCE PROJECT PLAN AND RESULTS

B.1 Introduction and Problem Description

Stream temperature is affected by a variety of environmental factors including riparian vegetation, stream morphology, hydrology, climate, and geographic location. These environmental factors influence the heat transfer experienced by a stream and are associated with direct solar radiation, longwave radiation, evaporation of water from the stream surface, convection between the stream and air, and conduction between the stream and its bed. Solar radiation only delivers energy to a stream, while the other processes are capable of either delivering or removing heat from a stream. When a stream surface is exposed to midday solar radiation, large quantities of heat energy can be delivered to the stream (Beschta et al. 1987). The proportion of solar radiation intercepted by local topographic features and riparian vegetation becomes an important parameter in understanding temperature regimes in streams.

The Solar Pathfinder was developed for use in siting solar collectors or photovoltaic panels. Since its development, this tool has found application by natural resource managers and researchers in characterizing the relationships among site (streamside) conditions and solar radiation reaching a stream (Platts et al. 1987). The Solar Pathfinder integrates the effects of azimuth, topographic altitude, vegetation height and position, sunrise and sunset angle, latitude, time of year, and hour angle to estimate the amount of solar radiation reaching a point of interest (Solar Pathfinder 1995).

B.2 Data Quality Objectives and Record-Keeping

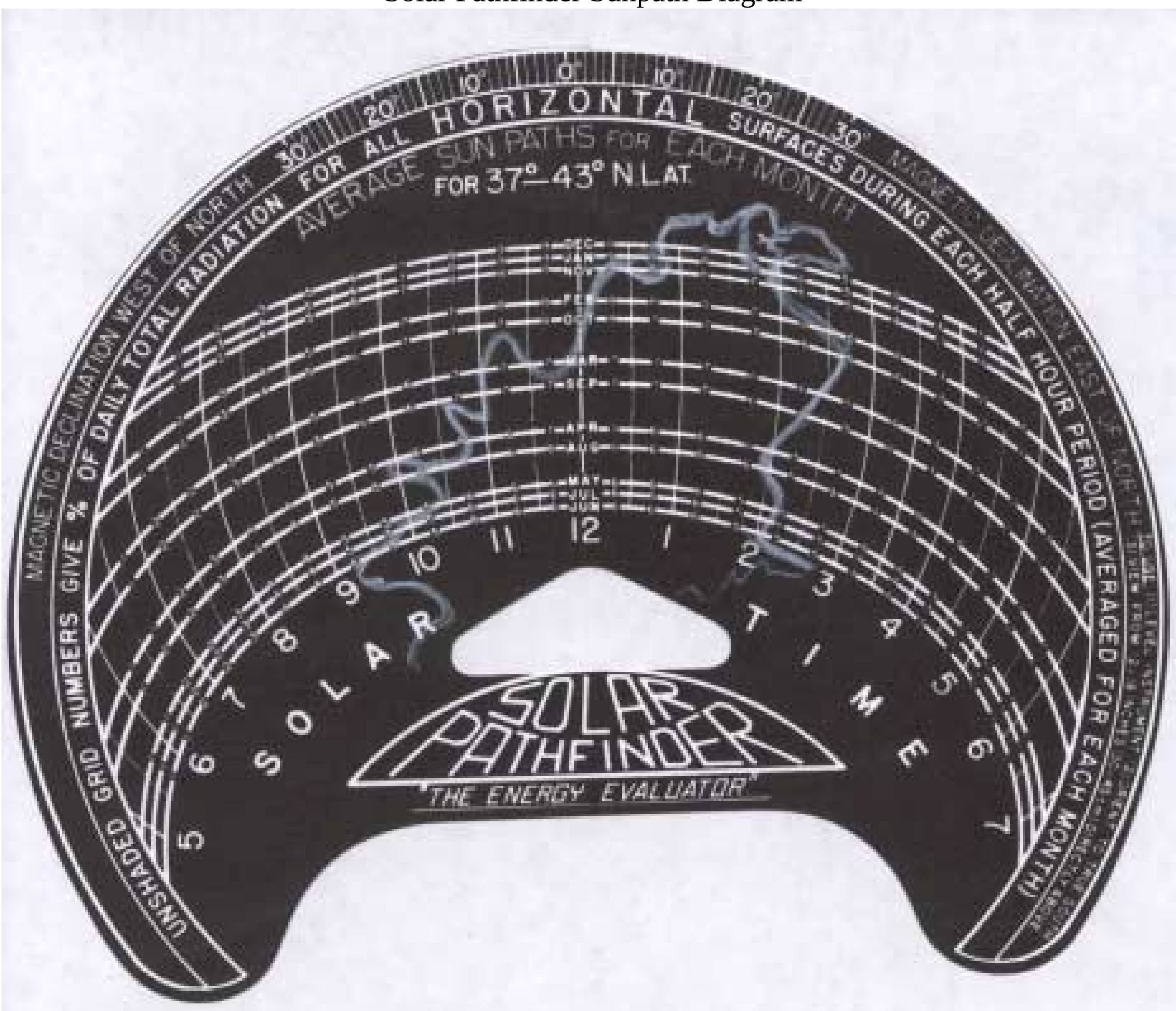
B.2.1 Data Quality Objectives for Measurement Data

In general, data quality objectives (DQOs) are used to gather data according to the procedure described herein at sites which are representative of the range of salmonid habitat conditions within the Navarro River watershed with particular focus on those locations where temperature has been monitored in recent years, to record the data and site location for comparison with other data, and to note surrounding environmental conditions as possible contributing factors or as alternative means of characterizing riparian shade. DQOs for the Solar Pathfinder measurements are to measure riparian shade in river and stream reaches upstream and near thermal monitoring locations. A minimum of two and up to ten measurements will be collected in each upstream reach. The multiple samples will not function as replicates. Riparian conditions within a reach may vary considerably. The purpose of obtaining at least two samples from each reach is not to determine a level of accuracy, but to characterize the range of riparian shade conditions on the reach.

B.2.2 Documentation and Records

Raw data on sun and shade conditions will be recorded on sunpath diagrams provided with the Solar Pathfinder. For each location measured, a sunpath diagram (Figure B-1) will be developed and retained as a permanent record of the observation. Additional data will be recorded in field notebooks at the time of measurement and will include site number, location, date, time, and environmental conditions. Sunpath diagrams and field notebooks will be kept in a file at the North Coast RWQCB for at least five years.

Figure B-1
Solar Pathfinder Sunpath Diagram



Insert
Figure B-2

(front)

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Figure B-2

(back)

B.3 Measurement/Data Acquisition

B.3.1 Sampling Process Design

Since 1989, various parties have collected stream water temperature records at locations in the Navarro watershed. Louisiana-Pacific (L-P) has measured temperature at locations on L-P lands since 1989. The Mendocino County Water Agency (MCWA) has measured temperature since 1995 at widely distributed locations in the watershed, with the number of locations varying from about twelve to as many as thirty in any given year. MCWA and the State Water Resources Control Board (SWRCB) Division of Water Rights have collected flow periodically over this same period at as many as sixteen of the same monitoring locations. Unfortunately, there are no known surveys of riparian condition or effective shade at or upstream of these locations with which to investigate the potential relationships among temperature, flow, channel conditions and riparian shade. The primary objective of this sampling design is to develop a characterization of riparian shade at existing temperature monitoring locations in the watershed, with the highest priority locations being those where flow has also been measured. Figure B-2 shows locations where temperature has been continuously measured during the dry season and where flow has been measured periodically in the watershed.

The total number of observations made in each reach upstream of an established monitoring location will depend on access and available time. The objective will be to define a reach of an arbitrary length estimated at 500 meters, and to measure riparian shade features at locations at 100-meter increments along this reach. This would result in six measurements for each reach.

B.3.2 Field Procedure

Much of the information in this section is derived from the Solar Pathfinder Instruction Manual (Solar Pathfinder 1995).

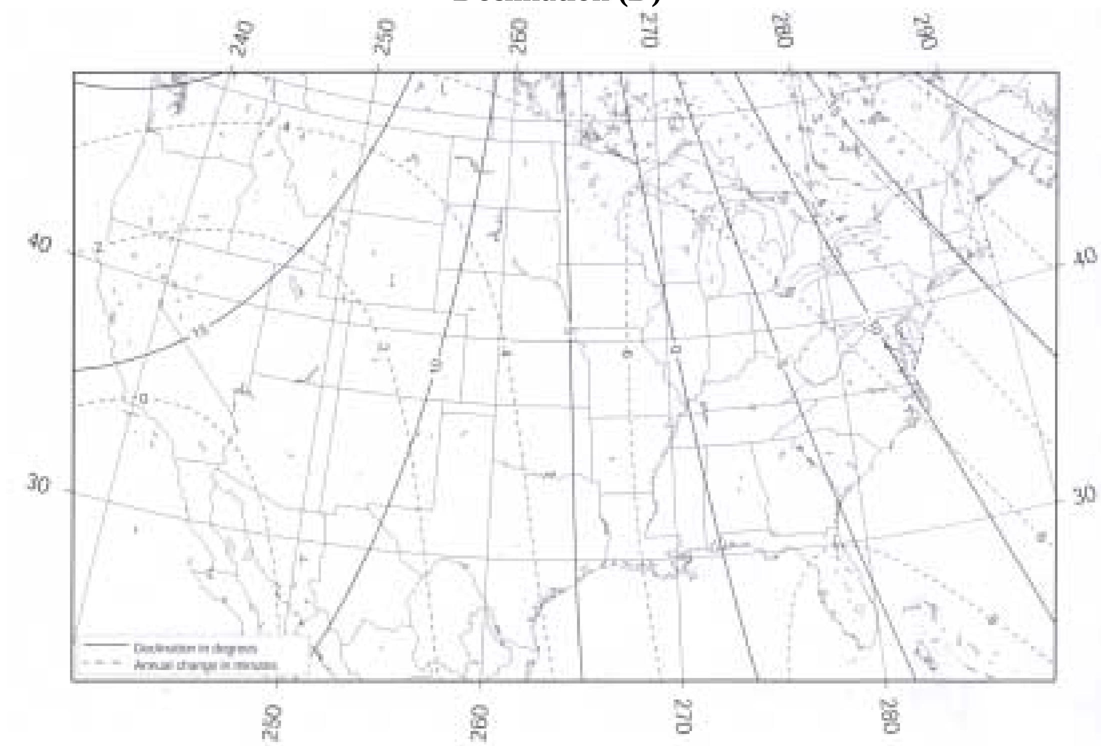
The Solar Pathfinder consists of four parts: the dome assembly, the diagram platform (containing the compass), the base, and the tripod. The following steps should be used to operate the instrument in the field.

1. Attach the base to the tripod by separating the tripod legs and inserting each rounded aluminum end into one of the rubber grommets on the base. Pull on the tripod's rubber leg ends to slide out the inside sections of the legs. Adjust the legs to approximately level the base. The base doesn't need to be precisely level, as the diagram platform and dome assembly both pivot on the base to provide additional leveling and directional orientation.

2. Put a sunpath diagram over the center pivot of the diagram platform. For stream shade measurements, use the diagrams labeled "Horizontal."

3. Orient the diagram to true south using the following directions:
   - Use the magnetic declination map (Figure B-3; USGS, 1995) to find the declination for the location being measured. In Region 1, declinations vary from 16-17.5°East.

Figure B-3
The Magnetic Field in the United States, 1995
Declination (D)



- Pull out the brass tab near the compass ¼" to unlock the center triangle and the black disk.
- Rotate the sunpath diagram on the central pivot counterclockwise for east declinations, and clockwise for west declinations, until the small white dot on the rim of the base is opposite the appropriate "Magnetic Declination East (or West)". The declination figures are marked on the outside edge of the sunpath diagram.
- Relock the tab.

4. Set the diagram platform on the base.

5. Put the dome in place on top of the diagram platform.

6. Level the Pathfinder. Use the legs to get the Pathfinder as level as possible. Slide the instrument portion around on the cupped base until the bubble is centered in the circle.

7. Rotate the base until the south end of the compass needle is directly above the "S" on the compass. Make sure the base is still level. Make sure the compass needle is free to rotate.

8. View the Pathfinder from between 12 and 18 inches above the dome, and within ten to fifteen degrees of the vertical centerline of the sunpath diagram. Aligning the Pathfinder vertically can be assisted by aligning the dimple on the dome with the center triangle on the base. To avoid glare from the sun, take site readings on cloudy days. On sunny days, shade the dome using your hand or orient yourself to block the sun so that you do not stare at the sun's reflection on the dome surface.

9. Using a white grease pencil, trace the shapes of the objects reflected in the dome on the sunpath diagram. To minimize movement of the diagram and dome, trace lightly, then remove the diagram and brighten the tracing. Note any features that are solely topographic in nature and any deciduous trees for use in subsequent interpretation.

B.3.3 Analytical Methods

Average percentage of monthly total radiation that will fall on the measurement location will be derived by adding the unshaded (unobstructed sky) half-hour numbers across the arc of the selected month or months, or by subtracting the shaded half-hours from 100 percent. Alternatively, average percentage of monthly shade at the location will be derived by adding the shaded (obstructed sky) half-hour numbers across the arc of the selected month or months, or by subtracting the unshaded half-hours from 100 percent. By noting those portions of the obstructed sky attributable to deciduous trees, it will be possible to account for variations in tree density associated with coniferous versus deciduous tree cover.

The results from individual samples collected on a reach will be combined into a single distribution as a means of estimating reach-average conditions. Standard deviations of the mean will also be calculated and reported.

B.3.4 Quality Control Requirements

The field technician will prepare the Solar Pathfinder for use in the field each day before leaving for the field. Preparation will consist of checking that all necessary components of the instrument are in the carrying case, and that adequate sunpath diagrams are available to complete the number of planned measurements. To provide independent observations at each measurement location, photographs will be taken to show the riparian cover condition recorded on the sunpath diagram.

B.3.5 Instrument Testing, Inspection, and Maintenance Requirements

No testing is necessary for the Solar Pathfinder. The instrument will be inspected before and after use for visible damage. It will be cleaned immediately after use.

B.3.6 Instrument Calibration and Frequency

The instrument requires calibration of pathfinder diagram declination and compass headings for each measurement. These calibration steps are included in the Field Procedure (Section B.3.2). To check compass accuracy, the compass will be checked against another compass of known reliability prior to going in the field and regularly while in the field.

B.4 Data Validation and Usability

Regional Water Board staff will discuss these requirements with data reviewers and come to consensus with them on whether to accept, reject, or qualify parts of the resulting data. Once data have been entered into a spreadsheet, the spreadsheet will be printed out and be proofread against the raw data. Errors in data entry will be corrected. Outliers and inconsistencies will be flagged for further review and discussion. Problems with data quality will be discussed in the technical support document.

As soon as possible after data collection and interpretation, the data will be checked for accuracy and completeness. If DQOs are not met, the cause will be evaluated and a decision will be made about whether to discard the data or apply correction factors. The cause will be corrected by retraining or by reassessing equipment and methods. Any limitations on data use will be detailed in the technical support document or appendices.

B.5 References

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TABLE B-1
SOLAR PATHFINDER DATA ANALYSIS
SUMMARY STATISTICS ON SOLAR PATHFINDER DATA

Site	Station	Active Channel Width		Possible Solar Radiation (%)			Effective Shade (%)		
		m	ft	June	July	August	June	July	August
SWRCB-2	2.1	25	82	49	51	32	51	49	68
	2.2	30	98	73	63	86	27	37	14
	Mean	28	90	61	57	59	39	43	41
	Std Dev.	4	12	17	8	38	17	8	38
SWRCB-4	4.1	12	39	81	81	76	19	19	24
	4.2	12	39	88	87	86	12	13	14
	4.3	15	49	84	84	86	16	16	14
	4.4		0	66	65	68	34	35	32
	Mean	13	43	80	79	79	20	21	21
	Std Dev.	2	6	10	10	9	10	10	9
SWRCB-6	6.1	4	13	3	7	17	97	93	83
SWRCB-7	7.1	26	85	98	98	88	2	2	12
	7.2	47	154	96	96	96	4	4	4
	7.3	30	98	89	90	93	11	10	7
	7.4	32	105	90	90	79	10	10	21
	7.5	35	115	94	93	88	6	7	12
	7.6	22	72	68	63	58	32	37	42
	Mean	32	105	89	88	84	11	12	16
	Std Dev.	9	28	11	13	14	11	13	14
SWRCB-8	8.1	24	79	55	52	28	45	48	72
	8.2	27	89	69	68	61	31	32	39
	8.3	26	85	78	78	86	22	22	14
	8.4	57	187	63	59	40	37	41	60
	8.5	38	125	67	62	41	33	38	59
	8.6	23	75	68	66	72	32	34	28
	Mean	33	107	67	64	55	33	36	45
	Std Dev.	13	43	8	9	22	8	9	22
SWRCB-9	9.1	36	118	13	12	7	87	88	93
	9.2	29	95	70	54	22	30	46	78
	Mean	33	107	42	33	15	59	67	86
	Std Dev.	5	16	40	30	11	40	30	11

SWRCB-10	10.1	13	43	80	78	73	20	22	27
	10.2	20	66	13	9	0	87	91	100
	10.3	16	52	39	40	33	61	60	67
	10.4	25	82	39	39	30	61	61	70
	10.5	25	82	50	47	38	50	53	62
	10.6	18	59	33	40	17	67	60	83
	Mean	20	64	42	42	32	58	58	68
	Std Dev.	5	16	22	22	24	22	22	24
SWRCB-10	10.7	16	52	62	55	67	38	45	33
	10.8	16	52	56	52	53	44	48	47
	10.9	18	59	36	34	35	64	66	65
	10.10	16	52	60	59	52	40	41	48
	Mean	17	54	54	50	52	47	50	48
	Std Dev.	1	3	12	11	13	12	11	13
SWRCB-11	11.1	61	200	100	100	99.8	0	0	0.2
	11.2	64	210	100	100	100	0	0	0
	11.3	52	170	96	96	98	4	4	2
	11.4	57	187	87	88	92	13	12	8
	11.5	32	105	69	70	72	31	30	28
	11.6	75	246	99	99	96	1	1	4
	11.7	97	318	73	68	64	27	32	36
	Mean	63	205	89	89	89	11	11	11
	Std Dev	20	66	13	14	15	13	14	15
SWRCB-12	12.1	54	177	64	64	73	36	36	27
	12.2	37	121	88	77	51	12	22	49
	12.3	35	115	93	93	94	7	7	6
	12.4	46	151	41	37	19	59	63	81
	12.5	37	121	73	64	49	27	37	51
	12.6	42	138	79	80	78	21	20	22
	Mean	42	137	73	69	61	27	31	39
	Std Dev.	7	24	19	19	27	19	19	27
SWRCB-12	12.7	52	171	93	94	97	7	6	3
	12.8	47	154	70	64	62	30	36	38
	12.9	53	174	98	96	58	2	4	42
	12.10	63	207	97	96	91	3	4	9
	12.11	55	180	91	86	75	9	14	25
	12.12	66	216	90	88	74	10	12	26
	Mean	56	184	90	87	76	10	13	24
	Std Dev.	7	23	10	12	15	10	12	15
SWRCB-13	13.1	9	30	18	14	4	82	86	96

SWRCB-14	14.1	19		14	13	16	86	87	84
	14.2	15		15	14	14	85	86	86
	14.3	25		68	59	35	32	41	65
	14.4	25		21	24	22	79	76	78
	14.5	20		3	3	0	97	97	100
	14.6	30		41	39	41	59	61	59
	Mean	22	73	27	25	21	73	75	79
	Std Dev.	5	18	24	21	15	24	21	15
SWRCB-15	15.1	20		5	5	0	95	95	100
	15.2	27		7	6	5	93	94	95
	15.3	12		12	10	6	88	90	94
	15.4	37		0	0	0	100	100	100
	15.5	17		0	0	0	100	100	100
	Mean	23	74	5	4	2	95	96	98
	Std Dev.	10	32	5	4	3	5	4	3
SWRCB-16	16.1	14	46	28	28	21	72	72	79
	16.2	25	82	59	62	63	41	38	37
	16.3	25	82	66	72	56	34	28	44
	16.4	22	72	57	50	37	43	50	63
	16.5	40	131	47	47	49	53	53	51
	16.6	25	82	56	59	65	44	41	35
	Mean	25	83	52	53	49	48	47	52
	Std Dev.	8	28	13	15	17	13	15	17