APPENDIX E
DATA COLLECTION AND MONITORING PLANS

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Summary of Pallid Sturgeon-Related Studies in the Missouri River Below Fort Peck Dam

and

Fort Peck Flow Modification Biological Data Collection Plan
(Draft 6/20/2001)

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Background

The pallid sturgeon *Scaphirhynchus albus* is a long-lived (> 40 years; Keenlyne and Jenkins 1993) species endemic to the Missouri River, lower Mississippi River, and large tributaries entering these river systems (Bailey and Cross 1954). Extensive habitat alterations have occurred throughout the geographical range of pallid sturgeon, and resulted in the designation of pallid sturgeon as an endangered species in 1990 (Dryer and Sandvol 1993).

One of the few remaining concentrations of pallid sturgeon occurs in the upper Missouri River between Fort Peck Dam and the headwaters of Lake Sakakawea, North Dakota. Individuals in this population also inhabit the lower Yellowstone River in Montana and North Dakota (Bramblett 1996). Similar to pallid sturgeon in other regions, long-term viability of the pallid sturgeon population in the Missouri River downstream from Fort Peck Dam is in jeopardy. It is hypothesized that regulated flows from Fort Peck Dam coupled with a suppressed water temperature regime during the spring and early summer spawning period have failed to provide adequate spawning cues for pallid sturgeon. In addition, cold water releases from Fort Peck Dam have limited the amount of riverine habitat suitable for spawning. As a consequence, natural reproduction and recruitment of pallid sturgeon have not occurred for several years as evidenced by a population comprised of large (e.g., > 1200 mm; > 8 kg; Liebelt 1996, 1998) and presumably old individuals.

The U.S. Army Corps of Engineers (USACE) proposes to modify operations of Fort Peck Dam following specifications outlined in the Missouri River Biological Opinion (U.S. Fish and Wildlife Service 2000). Modified dam operations are proposed to increase discharge and enhance water temperatures during late May and June to provide spawning cues and enhance environmental conditions for pallid sturgeon and other native fishes. In contrast to "normal" cold water releases through the dam, water from Fort Peck Reservoir will be released over the spillway during flow modifications to enhance water temperature conditions. In 2001, the USACE is proposing to conduct a mini-test of the flow modification plan to evaluate structural integrity of the spillway and other engineering concerns. A full-test of the flow modifications is proposed for 2002 when a maximum of 19,000 cfs will be routed through the spillway. Spillway releases will be accompanied by an additional 4,000 cfs released through the dam. The full-test will be followed by two years (2003, 2004) of "normal" dam operations whereby cold water will be released through the dam. All proposed flows are dependent on adequate inflows to Fort Peck Reservoir and adequate water levels in the reservoir.

The USACE contracted with the U.S. Geological Survey (USGS) to facilitate development of a monitoring program that will be used between 2001 and 2004 to examine the influence of the proposed flow modifications on physical habitat and biological response of pallid sturgeon and other native fish species. Components of the monitoring program include: 1) monitoring water temperature and turbidity at several locations downstream from Fort Peck Dam, 2) examining movements by pallid sturgeon, 3) examining movements of paddlefish *Polyodon spathula*, blue suckers *Cycleptus elongatus*, and shovelnose sturgeon *Scaphirhynchus platorynchus*, 4) quantifying larval fish, and 5) examining food habits of piscivorous fishes. Several studies have examined various aspects of pallid sturgeon biology and ecology in the Missouri River downstream from Fort Peck Dam and in the lower Yellowstone River (Clancey 1990, 1991,1992, Tews and Clancey 1993; Tews 1994; Bramblett 1996; Liebelt 1996, 1998, 2000a). In addition, the Montana Department of Fish, Wildlife and Parks (MTFWP) implemented a monitoring plan in 2000 (Liebelt 2000b). Information generated by the MTFWP monitoring plan in 2000, in conjunction with results from earlier studies, provides baseline conditions to which biological responses to flow modifications can be compared.

This first portion of this document provides an overview of the study area and summary of pallid sturgeon - related studies in the Missouri River downstream from Fort Peck Dam. The second portion of this document discusses components of the monitoring plan, and provides the rationale and methods for each monitoring component.

Description of the Study Area

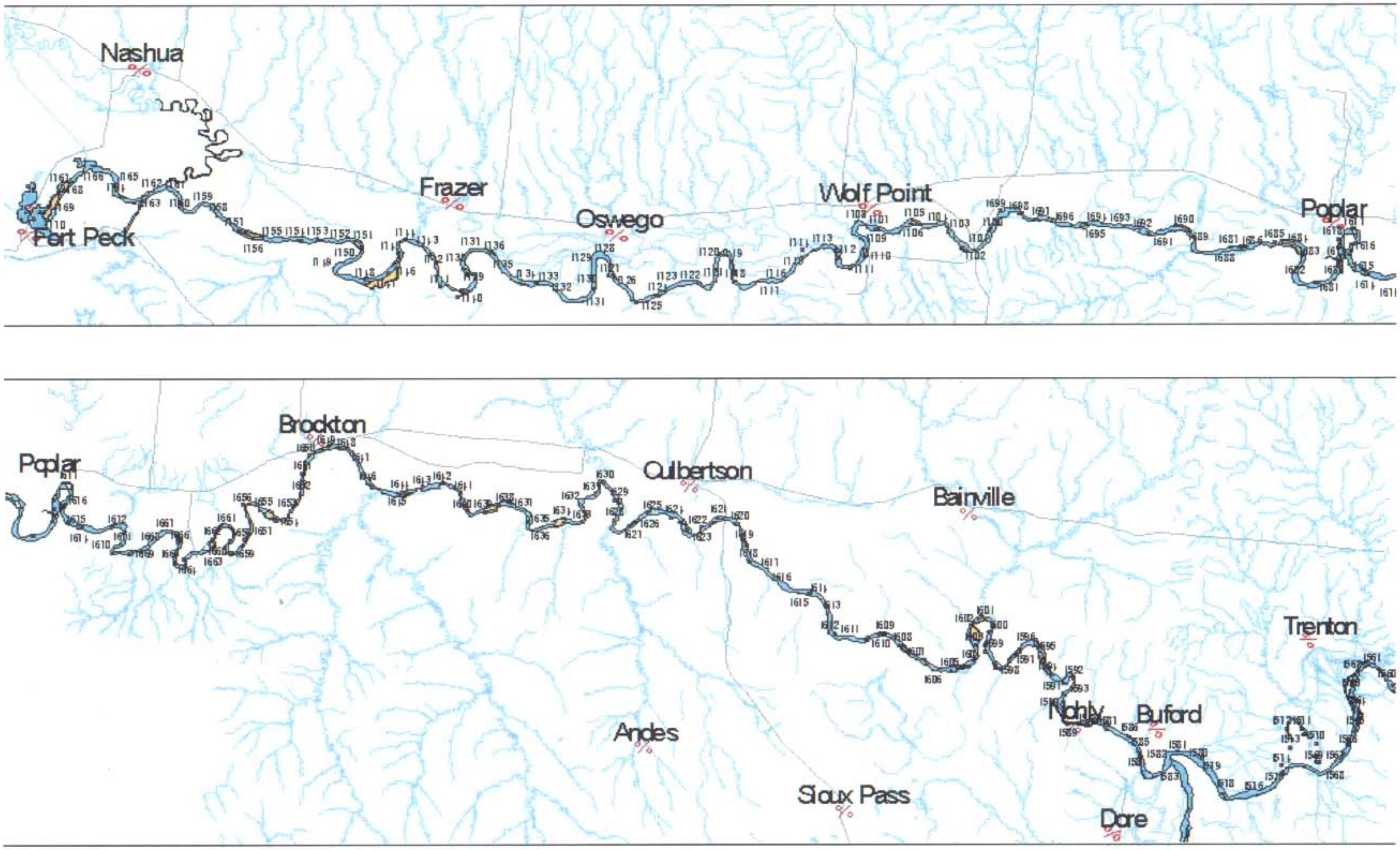
The Missouri River between Fort Peck Dam and the Yellowstone River (Figure 1) was described in detail by Gardner and Stewart (1987) and Tews (1994). Fort Peck Dam is operated as a peaking facility which contributes to daily fluctuations in water levels and atypical seasonal flows (Frazer 1985; Gardner and Stewart 1987; Clancey 1989; Tews 1994). Inputs from tributaries (e.g., Milk River) seasonally augment discharge in the Fort Peck reach. The reach from Fort Peck Dam to Wolf Point is generally characterized as erosional due to altered sediment dynamics. Although this area was likely depositional prior to dam construction (Gardner and Stewart 1987; Bramblett 1996), several areas of gravel and cobble are concentrated between the Milk River and Frazer (Gardner and Stewart 1987; Figure 1). Turbidity is much reduced downstream from the dam, but sediment contributions from the Milk River and other tributaries seasonally elevate turbidity (Gardner and Stewart 1987). The river downstream from Wolf Point is characterized as depositional with numerous shifting sand bars. Despite depositional characteristics, several gravel bars also occur in this reach. For example, Gardner and Stewart (1987) identified 14 gravel areas between Wolf Point and Nohly varying in length from 61 m to 183 m (200 - 600 yards). Liebelt (1996) similarly identified gravel and cobble areas near Nohly.

Hypolimnetic releases (cold water drawn from about 57 m below the surface; Gardner and Stewart 1987) through Fort Peck Dam have significantly altered the thermal regime of the Missouri River downstream from Fort Peck Dam. For example, Gardner and Stewart (1987) found mean water temperature between June and September was 19.4° C in the Missouri River upstream from the reservoir, 11.4° C downstream from the dam, 14.9° C at Wolf Point, and 16.1° C near Culbertson. Thus, although water temperature increases longitudinally downstream from the dam, mean temperature remains suppressed 3.3° C - 8.0 ° C below ambient conditions upstream. The suppressed water temperature regime in the Fort Peck reach provides the primary impetus for the Fort Peck flow modification plan.

The Yellowstone River joins the Missouri River about 200 miles downstream from Fort Peck Dam (Figure 1). In contrast to the Missouri River, the lower 71 miles of Yellowstone River exists in a relatively natural state and is characterized by natural discharge, temperature, and sediment regimes (White and Bramblett 1993). Gravel substrates are common in the upper reaches of the lower Yellowstone River; whereas, sand is more common in the lower reaches (White and Bramblett 1993; Bramblett 1996). A diversion dam is located 71 miles upstream from the mouth.

The Missouri River downstream from the confluence of Yellowstone River regains some semblance of natural conditions due to inputs from the Yellowstone River (Bramblett 1996). Sandbars are common in this reach, and depth can exceed 11 m (Tews 1994). Lotic conditions of the Missouri River downstream from the Yellowstone River are dependent on water levels in

Figure 1. Missouri River below Fort Peck Dam.
The Yellowstone River enters the Missouri River at river mile 1582.



Lake Sakakawea, and vary from about 15 miles at full pool to greater than 31 miles at lower water levels (Tews 1994; Bramblett 1996).

Collections and Sightings of Pallid Sturgeon

Pallid sturgeon have been collected at more than 280 locations in the Fort Peck reach and lower Yellowstone River (Table 1). Capture locations are differentially distributed among three areas representing the Missouri River between Fort Peck Dam and the Yellowstone River (4.5%), the Yellowstone River (24.0 %), and Missouri River downstream from the Yellowstone River confluence (71.5 %). The disproportionate number of pallid sturgeon collected in the three areas is probably attributable to several factors including variations in sampling intensity among areas, differences in habitat suitability among areas, and differences in sampling related to specific study objectives. For example, concentrations of pallid sturgeon in the Yellowstone River confluence area during fall and spring are targeted for brood stock and propagation efforts (Krentz 2000).

Most collections (or sightings) of pallid sturgeon in the Missouri River upstream from the Yellowstone River occurred just below Fort Peck Dam during winter. The number of pallid sturgeon sightings below the dam has varied from year to year (Tews 1994): 1988 (4), 1989 (5), 1990 (2), 1991 (21), 1992 (0), and 1993 (3). The number of different pallid sturgeon observed below the dam during this time period varied from two to three. In recent years, Liebelt (1998) similarly reported three pallid sturgeon were caught by SCUBA below the dam. In addition to collections near the dam, pallid sturgeon have also been sampled or caught by anglers in other areas of the Missouri River between Fort Peck Dam and the Yellowstone River. One pallid sturgeon was caught by an angler near Poplar/Brockton on May 19, 1990 (Table 1). The angler also reported that in past years three other pallid sturgeon were caught in this area during spring (Clancey 1991). Tews and Clancey (1993) reported that a pallid sturgeon was caught by an angler near Culbertson (river mile 1623) in July 1992 (Table 1). A hatchery-reared juvenile pallid sturgeon was recaptured near Nohly in 1999 (river mile 1589.1; Table 1; Liebelt 2000a)

Pallid sturgeon collections in the Yellowstone River occurred primarily during April (28 collections), May (22 collections) and June (10 collections; Table 1). Although pallid sturgeon have been located throughout the lower Yellowstone River, most collections have occurred in the lower 10 miles of the river.

In the Missouri River between the Yellowstone River and Lake Sakakawea, pallid sturgeon have been collected primarily during April (44 collections), September (89 collections), and October (44 collections; Table 1). A total of 25 pallid sturgeon collections have occurred in this area between May and August.

Table 1. Date, location (river mile), length (mm), and weight (kg) of pallid sturgeon collected and observed in the lower Yellowstone River and Missouri River between Fort Peck Dam and the headwaters of Lake Sakakawea. River miles delineate collection locations in the Missouri River upstream from the Yellowstone River confluence (river mile 1582-1770), in the Missouri downstream from the Yellowstone River confluence (river mile < 1582), and in the Yellowstone River (river mile 0-86; Y designates Yellowstone River). Collections records are based on field sampling and angler catches compiled from Clancey (1990, 1991, 1992), Tews and Clancey (1993), Tews (1994), Liebelt (1996, 1998, 2000a), and the U.S. Fish and Wildlife Service pallid sturgeon data base (Steve Krentz, personal communication).

Month	Day	Year	Location or River mile	Fork length (mm)	Weight (kg)
3	10	89	1769	1483	15.0
3	10	89	1769	1537	24.0
3	21	89	1770	1321	13.2
2	10	90	1770	1494	20.0
5	19	90	Poplar/Brockton	1746	
9	13	90	1577	1379	15.0
9	13	90	1577	1397	15.9
9	14	90	1575	1455	17.7
9	17	90	1575	1448	18.1
1	26	91	1769	1240	12.7
2	2	91	1769	1247	10.4
5	31	91	1577	1356	23.0
6	5	91	1577	1479	19.1
6	11	91	71Y		8.6
7	18	91	86Y	1341	11.4
9	22	91	1564	1320	17.0
9	23	91	1576	1480	22.7
9	23	91	1575	1220	13.4
9	24	91	1546	1465	28.6
9	24	91	1546	1207	10.2
10	10	91	1577	1311	11.8
4	10	92	1574	1567	22.2
6	17	92	2Y	1336	12.7

Month	Day	Year	Location or River mile	Fork length (mm)	Weight (kg)
7	14	92	1623		
8	15	92	1560		
9	15	92	1568	1600	24.5
9	30	92	1573	1242	10.6
9	30	92	1573	1478	18.4
9	30	92	1573	1463	
9	30	92	1573	1090	6.8
9	30	92	1573	1524	22.2
9	30	92	1573	1402	15.9
9	30	92	1573	1463	19.7
9	30	92	1573	1481	19.7
10	6	92	1573	1334	12.2
10	6	92	1573	1336	14.7
10	6	92	1573	1539	19.5
10	6	92	1573	1303	12.7
10	7	92	1568	1359	10.8
10	7	92	1570	1359	14.1
10	8	92	1573	1463	19.0
10	8	92	1573	1399	15.8
10	8	92	1573	1338	12.9
10	19	92	1573	1366	16.1
10	19	92	1573	1402	16.6
10	19	92	1573	1308	10.8
10	19	92	1573	1407	13.6
10	19	92	1573	1415	17.0
10	21	92	1566	1486	19.3
10	21	92	1568	1445	14.3
10	21	92	1568	1265	11.6
10	22	92	1574	1359	12.2
10	22	92	1574	1123	8.4

Month	Day	Year	Location or River mile	Fork length (mm)	Weight (kg)
10	22	92	1574	1389	13.6
10	27	92	1573	1478	17.9
10	27	92	1573	1341	13.6
10	29	92	1573	1422	15.6
3	20	93	1770	1524	17.4
4	15	93	1566	1385	13.8
4	15	93	1566	1514	20.2
4	22	93	0.5Y	1373	15.0
4	23	93	0.5Y	1566	28.1
4	24	93	2Y	1365	14.5
4	25	93	9Y	320	4252
4	27	93	9.5Y	1317	12.5
5	16	93	3Y		
5	21	93	71Y		
5	30	93	9Y		
9	9	93	1577	1305	12.7
9	10	93	1580	1280	11.3
9	11	93	1580	1525	29.9
9	11	93	1576	1515	23.6
9	12	93	1577	1371	14.1
9	14	93	1580	1379	18.6
9	14	93	1574	1410	17.5
9	14	93	1564	1425	12.4
9	16	93	1580	1292	10.8
9	28	93	1573	1525	20.6
9	28	93	1573	1430	16.8
9	28	93	1573	1325	15.9
9	28	93	1574	1519	18.4
9	29	93	1573	1400	14.5
9	29	93	1573	1275	12.0

Month	Day	Year	Location or River mile	Fork length (mm)	Weight (kg)
10	5	93	1569	1143	16.8
4	27	94	1579	1525	
4	29	94	7Y	1295	
4	30	94	10.5Y	1405	17.2
5	15	94	9Y		
5	18	94	67.1Y	1384	18180
5	21	94	71Y		
6	5	94	1580	1294	11.6
6	8	94	69.8Y	1094	8.2
6	14	94	70Y	981	3.8
6	14	94	5.5Y	1450	14.7
6	15	94	5.5Y	1366	12.2
6	15	94	5.5Y	1373	13.8
6	15	94	5.5Y	1240	10.4
6	16	94	7.5Y	1346	11.3
6	16	94	6.5Y	1219	10.0
8	11	94	1521		
8	11	94	1521		
8	11	94	1521		
8	12	94	1521		
9	7	94	1575	1358	12.5
9	7	94	1579	1613	32.0
9	21	94	1580	1638	34.5
9	22	94	1577	1625	
9	22	94	1576	1489	22.7
9	22	94	1577	1409	16.8
9	22	94	1575	1300	10.4
9	22	94	1575	1488	20.0
9	22	94	1575	1388	13.8
9	22	94	1575	1300	14.5

Month	Day	Year	Location or River mile	Fork length (mm)	Weight (kg)
9	23	94	1575	1413	20.2
9	23	94	2Y	1222	8.8
9	24	94	1564	1363	20.7
9	24	94	1564		
9	24	94	1564	1425	17.5
9	24	94	1556	1388	14.5
9	25	94	1564	1444	18.2
9	25	94	1564	1456	22.5
9	25	94	1564	1405	12.7
9	25	94	1564	1345	17.0
9	25	94	1564	1310	15.0
9	25	94	1564	1456	22.0
9	26	94	1564	1356	18.2
9	26	94	1564	1275	
9	26	94	1559	1406	21.1
9	26	94	1554	1450	18.2
9	26	94	1554	1350	15.4
9	27	94	1564	1356	13.6
9	27	94	1564	1363	12.7
9	27	94	1564	1245	10.0
9	27	94	1564	1263	11.8
9	27	94	1564	1300	12.7
9	27	94	1564		
9	28	94	1578	1315	12.3
9	28	94	1575	1459	29.7
9	28	94	1575	1325	12.5
9	28	94	1575	1500	23.4
9	28	94	1575		
9	28	94	1575	1381	16.1
9	28	94	1574	1181	12.5

Month	Day	Year	Location or River mile	Fork length (mm)	Weight (kg)
10	5	94	1578	1495	23.1
10	5	94	1575	1524	24.9
10	5	94	1575	1312	11.3
10	6	94	1574	1319	13.2
10	6	94	1575	1315	14.1
11	15	94	1564	1280	12.5
11	15	94	1564		
11	15	94	1564		
11	16	94	1575	1375	14.5
4	24	95	3Y	1430	18.1
4	24	95	1579	1475	21.8
4	26	95	4Y	1500	21.3
4	26	95	4Y	1630	26.8
4	27	95	9.5Y	1412	17.5
4	27	95	9Y	1490	22.2
5	18	95	5Y	1353	14.1
5	31	95	10Y	1400	16.3
5	31	95	10Y	1204	10.4
5	31	95	10Y	1475	23.6
8	24	95	1579	1306	14.5
8	24	95	1579	1346	17.0
8	24	95	1579	1477	20.0
9	29	95	1579	1384	14.7
9	29	95	1579	1412	15.4
9	29	95	1578	1365	15.6
10	2	95	1566	1170	14.1
10	10	95	1579	1330	13.6
10	10	95	1579	1340	15.9
10	11	95	1577	1399	18.1
10	11	95	1577	1410	16.6

Month	Day	Year	Location or River mile	Fork length (mm)	Weight (kg)
10	12	95	1579	1507	27.2
10	12	95	1579	1550	29.0
2	18	96	1770	1552	23.1
3	19	96	1770	1522	23.1
3	20	96	1770	1319	13.6
5	1	96	5Y	1277	14.1
5	13	96	1577	1503	26.3
5	13	96	5Y	1467	18.6
5	14	96	9.5Y	1450	18.6
5	15	96	9.5Y	1377	15.2
8	28	96	1578	1452	16.3
8	28	96	1578	1320	12.7
8	28	96	1578	1398	16.8
8	28	96	1574	1432	18.1
9	17	96	1577		
9	19	96	1578	1453	
9	20	96	1564.5		
9	20	96	1564.5		
9	24	96	1582	1335	11.8
9	25	96	1577	1356	11.8
10	16	96	1579.5		
9	25	96	1578	1545	24.9
4	22	97	0.5Y	1424	19.4
4	23	97	0.5Y	1527	15.4
4	23	97	0.5Y	1470	24.5
4	24	97	6Y		29.9
4	25	97	6Y		15.4
4	26	97	6Y	1390	17.2
4	26	97	6Y		16.3
4	26	97	6Y	1442	17.7

Month	Day	Year	Location or River mile	Fork length (mm)	Weight (kg)
4	27	97	6Y		27.2
4	27	97	6Y		
4	27	97	6Y		18.6
5	30	97	1581.5		
8	3	97	1552.5		16.3
8	17	97	1552.5		29.5
9	16	97	1578		20.9
9	21	97	1556.4		15.9
9	23	97	0Y		27.2
9	23	97	0Y		24.0
9	24	97	1576.5		15.9
9	25	97	0Y	1438	17.0
9	25	97	0Y		23.1
10	15	97	0Y		21.8
10	15	97	0Y		23.6
10	21	97	1581.5	1350	13.2
10	21	97	1581.5	1425	17.4
10	21	97	1581.5	1456	19.1
10	21	97	1581.5	1547	21.4
4	14	98	0Y	1435	15.0
4	15	98	0.5Y	1375	
4	16	98	0.5Y	1450	20.9
4	20	98	1578		
4	20	98	1578		
4	21	98	0Y	1165	11.3
4	22	98	1578		
4	28	98	5Y	1413	21.8
8	6	98	1582		
8	11	98	1581		
8	11	98	1578		

Month	Day	Year	Location or River mile	Fork length (mm)	Weight (kg)
9	20	98	1554		
9	22	98	1581.5	1328	12.2
9	29	98	1564		11.4
9	30	98	1573	1600	29.5
10	5	98	1578	1365	14.1
10	6	98	1581.5	1550	29.5
4	12	99	1581.5	1365	14.1
4	13	99	1581.5	1296	13.6
4	13	99	1581.5	1403	14.1
4	13	99	1581.5	1356	17.7
4	13	99	1581.5	1500	23.2
4	14	99	1581.5	1397	15.4
4	14	99	1581.5	1546	22.7
4	14	99	1581.5	1365	16.3
4	14	99	1581.5	1553	23.1
4	15	99	1581.5		21.3
4	15	99	1581.5		13.6
4	15	99	1581.5		
4	15	99	1581.5	1476	23.1
5	4	99	3Y	303	0.0867
5	4	99	3Y		
5	5	99	14.5Y	1450	16.3
5	5	99	11.1Y	337	0.1276
5	19	99	5.2Y	1245	10.0
5	19	99	Fairview bridge in Yellowstone River		
5	20	99	1589.1		
7	7	99	8.5Y	447	0.2783
7	16	99	1552.2		

Month	Day	Year	Location or River mile	Fork length (mm)	Weight (kg)
8	4	99	1554	1429	18.2
8	26	99	1581.5	1445	19.0
4	11	00	1581.5	1580	25.0
4	11	00	1581.5	1521	25.0
4	11	00	1581.5	1352	12.7
4	11	00	1581.5	1515	22.7
4	11	00	1581.5	1367	12.3
4	11	00	1581.5	1520	20.9
4	12	00	1581.5	1448	14.1
4	12	00	1581.5	1308	12.3
4	12	00	1581.5	1468	20.4
4	12	00	1581.5	1444	14.5
4	12	00	1581	1293	11.4
4	13	00	1581.5	1516	25.9
4	13	00	1581.5	1578	24.1
4	13	00	1581.5	1060	5.3
4	13	00	1581.5	1461	17.7
4	13	00	1581.5	1295	15.0
4	17	00	1581.5	1404	16.3
4	18	00	1581.5	1469	19.1
4	18	00	1581.5	1278	12.7
4	18	00	1581.5	1425	20.4
4	18	00	1581.5	1223	13.2
4	18	00	1581.5	1262	10.0
4	18	00	1581.5	1542	27.7
5	3	00	5.4Y	1482	19.5
5	28	00	72Y	1320	13.2

Catch Rates of Pallid Sturgeon

In 1990, the MTFWP initiated standardized sampling of pallid sturgeon in the Missouri River and lower Yellowstone River. Clancey (1992) established nine study sections (Table 2) that have subsequently been used during recent pallid sturgeon studies (e.g., Tews 1994; Liebelt 1996, 1998, 2000a). Sections 1-5 represent sampling areas in the Missouri River between Fort Peck Dam and the Yellowstone River. Sections 6 and 7 represent sampling areas in the Missouri River between the Yellowstone River and Lake Sakakawea. Sections 8 and 9 represent sampling areas in the lower 71 miles of the Yellowstone River.

Table 2. Sections, river miles, and descriptions of study areas for the Missouri River below Fort Peck Dam and the Yellowstone River.

Study section	River miles	Description
1	1770-1761	Fort Peck Dam to Milk River
2	1761-1708	Milk River to Wolf Point
3	1708-1683	Wolf Point to Redwater River
4	1683-1630	Redwater River to Big Muddy River
5	1630-1582	Big Muddy River to Yellowstone River
6	1582-1553	Yellowstone River to Highway 85 bridge
7	1553-1530	Highway 85 bridge to Lake Sakakawea
8	71-30	Yellowstone River from Intake to Highway 23 bridge
9	30-0	Yellowstone River from Highway 23 bridge to mouth

Catch rates of pallid sturgeon at standardized sampling sites varied greatly among different study sections (Table 3). Between 1990 and 1996, highest catch rates occurred in section 6 of the Missouri River downstream from the Yellowstone River (0.3 - 0.9 pallid sturgeon/h) and in sections 8 and 9 of the Yellowstone River (0 - 0.2 pallid sturgeon/h; Table 3). In sections 1-5 of the Missouri River between Fort Peck Dam and the Yellowstone River, no adult pallid sturgeon were reported during standardized sampling. Liebelt (2000a) reported catch rates for 1999 standardized sampling varied between 0.06 pallid sturgeon/net (Yellowstone River sections combined) and 0.12 pallid sturgeon/net (all Missouri River sections combined). Although Liebelt (2000a) reported that all pallid sturgeon in Missouri River sections were captured at river mile 1583.5 (1.5 miles upstream from the Yellowstone River confluence), subsequent examination of the pallid sturgeon data base maintained by the U.S. Fish and

Wildlife Service (Steve Krentz) indicated these individuals were collected at river mile 1581.5 (downstream from the Yellowstone River confluence). Thus, the catch rate of 0.12 pallid sturgeon/net reported for Missouri River sections during 1999 probably represents the catch rate for section 6. For the Yellowstone River and Missouri River downstream from the Yellowstone River, Krentz (2000) reported catch rates of 0.47 pallid sturgeon/h (Fall 1997), 0.62 pallid sturgeon/h (Spring 1998), and 0.41 pallid sturgeon/h (Spring 1999).

Table 3. Catch rates (number/h) of pallid sturgeon sampled in study sections of the Missouri River and lower Yellowstone River. Number of pallid sturgeon sampled, total number of sampling hours, and total number of net drifts are listed in parenthesis. See Table 2 for Study section descriptions.

	Study sections			
Study period	1 - 5	6	8 - 9	Reference
1990-1993	0	0.9	0.15	Tews (1994)
	(0, 41.6, 329)	(46, 52.7, 427)	(4, 26.9, 249)	
1994	0	0.5	0.2	Liebelt (1996)
	(0, 12.9, 91)	(9, 16.5, 106)	(1, 6.1, 41)	
1995	0	0.6	0.1	Liebelt (1996)
	(0, 14.5, 97)	(12, 19.7, 125)	(1, 12.3, 71)	
1996	0	0.3	0	Liebelt (1998)
	(0, 9.2, 218)	(7, 23, 151)	(0, 4, 32)	

Although catch rates of pallid sturgeon vary among study sections, all study sections have not been sampled with the same intensity (Table 3). For example, between 1990 and 1996, sampling intensity averaged 24 net drifts/section/year (sections 1-5), 122 net drifts/section/year (section 6), and 26 net drifts/section/year (sections 8-9). Given the greater length of river encompassed by sections 1-5, these results suggest sections 1-5 have been under-sampled relative to the other study sections.

Movements of Pallid Sturgeon

Movements of pallid sturgeon in the Missouri River and lower Yellowstone River have been examined via telemetry and summarized by several investigators (Clancey 1990; Tews and Clancey 1993; Tews 1994; Bramblett 1996). Pallid sturgeon used in telemetry studies included individuals originally collected and fitted with transmitters in the Fort Peck tailwaters and individuals collected and fitted with transmitters in other downstream areas.

Clancey (1990) reported movements of three pallid sturgeon originally tagged in the Fort Peck tailwaters during March 1989. Two of the three pallid sturgeon tagged in this study exhibited downstream movements after being tagged. For example, one individual was relocated downstream from the Milk River between late March and May. This individual was subsequently relocated at river mile 1736 (river miles are approximate) on June 5 and river mile 1732 on June 14. The second pallid sturgeon exhibiting downstream movement was relocated downstream from the Milk River between late March and April, and also relocated on May 5 (river mile 1749), May 16 (river mile 1722), May 23 (river mile 1694), May 24 (river mile

1689), and June 14 (river mile 1662). Pallid sturgeon moving downstream were located on the north side of the river where turbid inflows from the Milk River increased turbidity in the Missouri River (Clancey 1990). The transmitter on the third pallid sturgeon tagged in the Fort Peck tailwater did not function; however, this individual was subsequently caught twice in the tailrace, once by an angler (April 28) and once by gillnet (August 25).

More comprehensive reports of the spatial and temporal dynamics of pallid sturgeon movements throughout the Missouri River and lower Yellowstone River were provided by Tews and Clancey (1993), Tews (1994), and Bramblett (1996). Bramblett (1996) partitioned the movement periods of pallid sturgeon into four seasons corresponding to spring (March 20 - June 20), summer (June 21 - September 22), Fall (September 23 - December 20), and winter (December 21 - March 19). During spring, 75% of the locations occurred in the lower 28 km of the Yellowstone River and 15% of the locations occurred in the Missouri River downstream from the Yellowstone River confluence. Only one pallid sturgeon originally tagged at the dam was relocated at the dam. Relocations of pallid sturgeon in summer were similar to spring except 39% of the locations occurred in the Missouri River downstream from the Yellowstone River confluence. Four relocations of pallid sturgeon in the Missouri River upstream from the Yellowstone River occurred in summer, and except for the individual that resided at the dam, individuals occurred as far upstream as river mile 1714 (near Wolf Point). During Fall, 96% of all observations occurred in the Missouri River downstream from the Yellowstone River. One pallid sturgeon during Fall was relocated near river mile 1659 (near Brockton). During winter, all observations of pallid sturgeon locations occurred in the Missouri River downstream from the Yellowstone River.

Tews (1994) and Bramblett (1996) provided summaries of the pallid sturgeon movement patterns. For individuals originally tagged near the Yellowstone River confluence, four general movement patterns were identified: 1) movement from the Missouri River to the Yellowstone River in April and May, 2) residency in the Yellowstone River during May, June, and July, 3) movement into the Missouri River/Yellowstone River confluence in late summer, and 4) little movement during winter. In contrast, pallid sturgeon tagged in the Fort Peck tailrace exhibit different movement patterns. These individuals either move downstream in April or reside year-round in the tailrace.

Larval Fish Sampling

Larval fish have been sampled at several sites and areas in the Missouri River downstream from Fort Peck Dam to examine reproductive success of pallid sturgeon and other native fishes. Several studies reported larval sturgeon as *Scaphirynchus sp.*, but positive identifications to date indicate larvae were shovelnose sturgeon (M. Ruggles, MTFWP). In 1978, the MTFWP sampled larval fishes in the Missouri River just upstream from the Milk River confluence, but no larval sturgeon were collected (Needham 1979). Gardner and Stewart (1987) collected 339 samples between 1979 and 1982, but did not find any *Scaphirynchus* larvae. Clancey (1991) sampled larvae in river section 9 (see section descriptions in Table 2), but sampling was unsuccessful. Tews and Clancey (1993) sampled larvae on three dates (June 21, July 15, July 16) in section 9, but no sturgeon eggs or larvae were collected. Liebelt (1996) collected 87 samples in 1995 from three sections (2, 3, 5) on four sampling dates (6/23-6/29, 7/8-7/14, 7/21-7/28, 8/2-8/10); four *Scaphirynchus* larvae were collected in section 5 (near Nohly, river mile 1589). In 1995, 176 larval samples were collected on eight dates (5/18, 5/30-6/1, 6/15-6/16, 6/27-6/29, 7/11-7-13, 7/20, 7/26-7/28, 8/2-8/10) in sections 5, 6, and 9 (Liebelt 1996). Twenty-two *Scaphirynchus* larvae were collected, and distributed among section 6 (12 individuals), section 9 (9 individuals), and section 5 (1 individual). In 1996, 250 larval samples were collected in sections 1-5, 6, and 9 on six sampling dates (5/30-6/6, 6/12-6/21, 6/25-7/2, 7/9-7/12, 7/19-7/26, 7/28-8/7). Three *Scaphirynchus* larvae were collected in section 9 (Liebelt 1998). In 1999, larvae were sampled on eight dates (5/19, 5/20, 6/7, 6/14, 6/29, 6/30, 7/15, 7/16) in section 5 (14 samples), section 6 (4 samples), and section 9 (38 samples; Liebelt 2000a). Only one *Scaphirynchus* larvae was collected during 1999, and this individual was collected in section 5.

Existing Pallid Sturgeon Monitoring Program

In 2000, the MTFWP implemented a monitoring plan supported by the Western Area Power Administration (WAPA) designed to collect baseline information and evaluate the influence of modified flow releases on pallid sturgeon and other native fishes in the Missouri River downstream from Fort Peck Dam (Liebelt 2000b). The WAPA-supported monitoring plan includes larval fish sampling, and sampling and habitat quantification of pallid sturgeon and other native fishes. The monitoring plan includes 8-10 fixed sites located between the Fort Peck tailwaters (river mile 1765.8) and Poplar River (river mile 1679; Figure 1). Larval fish and older life stages of pallid sturgeon and other fishes are sampled 1-2 times/month at each site between May and August. One to three samples are collected at each site during each sampling interval.

Fort Peck Flow Modification Physical and Biological Data Collection Plan

The Fort Peck Flow Modification Physical and Biological Data Collection Plan (presented in the next section) will be implemented during 2001, 2002, 2003 and 2004 to examine the influence of modified dam operations on physical habitat characteristics, and to evaluate biological response by pallid sturgeon and other native fishes to modified dam operations. Components of the Data Collection Plan include: 1) monitoring water temperature and turbidity at several locations downstream from Fort Peck Dam, 2) examining movements by pallid sturgeon, 3) examining movements of paddlefish, blue suckers, and shovelnose sturgeon, 4) quantifying larval fish, and 5) examining food habits of piscivorous fishes. The Data Collection Plan augments the existing WAPA-supported monitoring plan, and includes several monitoring components not addressed in the WAPA-supported monitoring plan. Information obtained from monitoring activities between 2001 and 2004 will be used to direct future pallid sturgeon monitoring activities.

1. Water temperature and turbidity

Objective: Determine the influence of modified dam operations on water temperature and turbidity in the Missouri River downstream from Fort Peck Dam

Success Criteria: The Missouri River Biological Opinion (USFWS 2000) mandates that a minimum water temperature of 18°C (64.4°F) be established and maintained at Frazer Rapids (river mile 1746) via spillway releases.

Rationale: Spawning by pallid sturgeon is thought to occur as water temperature approaches 18°C (USFWS 2000). In addition to this water temperature requirement, pallid sturgeon larvae require an extensive length of free-flowing riverine habitat to complete their 8-13 day larval drift period (Kynard et al. 1998). Existing conditions in the Missouri River downstream from Fort Peck Dam do not fulfill these requirements. Inadequate water temperatures inhibit spawning, and the length of riverine habitat available for larval drift dynamics is insufficient between spawning areas and the headwaters of Lake Sakakawea. Increasing water temperature to 18°C at Frazer Rapids will not only improve suitability for spawning in the upper reaches of the river, but also significantly increase the length of riverine habitat available to drifting larvae. An assessment of water temperature is needed to characterize the influence of spillway releases and tributary inputs on the longitudinal water temperature regime of the Missouri River downstream from Fort Peck Dam. In addition, water temperature data collected during the study will be used by the USACE to develop water temperature/discharge models for the Missouri River below Fort Peck Dam.

Turbidity is an important water quality variable influencing the distribution and habitat use of pallid sturgeon. Pallid sturgeon are predominantly found in highly turbid waters (Bailey and Cross 1954), and there is evidence suggesting pallid sturgeon prefer areas of high turbidity in the Missouri River (Erickson 1992). In addition to altered discharge and thermal regimes, reduced turbidity in the Missouri River downstream from Fort Peck Dam (Dieterman et al. 1996; Young et al. 1997) may inhibit use of this area by pallid sturgeon. Modified dam operations will likely increase turbidity in the Missouri River downstream from Fort Peck Dam and enhance suitability of this reach for pallid sturgeon. An assessment of turbidity is needed to quantify the influence of modified dam operations on turbidity.

Design and

Analysis: Continuous recording (1-h intervals) water temperature loggers will be installed at several locations in the Missouri River and tributaries during 2001, 2002, and 2003 (Table 4). Data collected in the Missouri River near Landusky (upstream from Fort Peck Reservoir) will characterize the natural thermal regime of the Missouri River, and provide estimates of ambient water temperature conditions that would be expected below Fort Peck Dam under natural conditions. At all mainstem Missouri River sites below the Milk River, a water temperature logger will be positioned near the right and left bank to characterize lateral variations in water temperature across the river channel. This will be most prevalent at locations downstream from tributaries. Water temperature loggers will be positioned in the lower 0.25 m of the water column to maintain consistency with previous monitoring studies. At all Missouri River sites, a water temperature logger will also be positioned in a mid-water column location to characterize vertical variations in water temperature. Water temperature loggers will be installed by April 15 and retrieved October 15. Water temperature data will be downloaded from each logger at monthly intervals. Deployment locations will be recorded with a GPS unit (latitude, longitude).

Continuous recording (1-h intervals) turbidity loggers (turbidity recorded as nephelometric turbidity units; NTU) will be installed during 2001, 2002, and 2003 at four sites. The sites will be located near Frazer Rapids (river mile 1746), Nohly (river mile 1589), in the lower three miles of the Yellowstone River, and at one additional site (to be determined). Turbidity loggers will be positioned mid-stream (where logistically feasible) at a mid-water column location. Turbidity loggers will be deployed by May 1 and retrieved by August 1.

Table 4. Approximate river and tributary locations where water temperature loggers will be deployed during 2001, 2002, and 2003.

River	Location or river mile	River	Location or river mile
Missouri River	Landusky	Missouri River	1724.6
Musselshell River	Mosby	Missouri River	1701.5
Missouri River	1765.2	Redwater Creek[b]	
Spillway[a]		Missouri River	1680.0
Milk River[b]		Poplar River[b]	
Beaver Creek[c]		Missouri River	1653.1
Missouri River	1759.9	Big Muddy Creek[b]	
Missouri River	1757.5	Missouri River	1630.0
Missouri River	1751.5	Missouri River	1620.9
Missouri River	1746.0	Yellowstone River	Lower 3 miles
Missouri River	1741.5	Missouri River	1576.4
Prairie Elk Creek[b]			

a - temperature logger will be placed downstream from plunge pool
b - temperature logger will be placed upstream from any backwater effects of the Missouri River
c - tributary to Milk River

Major equipment needs and specifications:

35 water temperature loggers

(Optic StowAway, -5°C – 37°C, Part No. WTA32-05+37, Onset Computer Corporation)

2 optic shuttles

(Part No. DTA128B, Onset Computer Corporation)

2 optic base stations

(Part No. DSA, Onset Computer Corporation)

3 turbidity loggers "Sondes"

(Part No. 6920 Sonde with self-cleaning turbidity sensor, 6067 attachment cable, YSI Incorporated)

2. Movements of pallid sturgeon

Objective: Examine movements of pallid sturgeon inhabiting the upper Missouri River adjacent to Fort Peck Dam

Rationale: In 2000, the U.S. Fish and Wildlife Service initiated a USACE-supported pallid sturgeon telemetry study designed to evaluate the influence of modified flow releases from Fort Peck Dam on movements of pallid sturgeon. A detailed study plan for this research is presented by the USFWS (2001), and briefly summarized as follows. Ten pallid sturgeon (2 females, 8 males) originally collected from the confluence area of the Missouri River and Yellowstone River were spawned in 2000, surgically implanted with combined acoustic/radio transmitters (CART tags), and released during Fall 2000. Movements of these individuals, in conjunction with additional pallid sturgeon tagged in subsequent years, will be monitored for several years to evaluate the influence of modified flow releases from Fort Peck Dam on movement patterns and behavior. In addition to traditional field-based tracking methods, the USFWS will use shore-based fixed logging stations to monitor movements of pallid sturgeon. Fixed logging stations will be positioned during Spring 2001 at three locations: 1) in the Missouri River downstream from the Yellowstone River (near river mile 1578, 4 miles downstream from the Yellowstone river confluence), 2) in the Missouri River upstream from the Yellowstone River confluence (near river mile 1589, 7 miles upstream from the Yellowstone River confluence), and 3) in the lower 2 miles of the Yellowstone River. If pallid sturgeon movements range upstream to the fixed logging station located at river mile 1589 (Missouri River upstream from the Yellowstone River) during the full-test, the movement will be considered a positive response to the Fort Peck flow modifications (USFWS 2001).

The sample population of pallid sturgeon used in the existing USFWS study does not include individuals currently residing in the Missouri River upstream from the Yellowstone River confluence. Thus, inclusion of individuals from the upper reaches of the river will expand the inference population, and provide a better understanding of pallid sturgeon movements and movement patterns. In addition, use of these individuals will expand the baseline information on use by pallid sturgeon of the upper Missouri River between Fort Peck Dam and the Yellowstone River. Results will be compared to those from Clancey (1990) who found pallid sturgeon tagged near the dam tended to move downstream during spring and early summer.

The locations of fixed logging stations in the USFWS study are concentrated in the lower reaches of the Missouri River and Yellowstone River. Additional fixed logging stations are needed in the upper reaches of the river to better quantify movements of pallid sturgeon between Fort Peck Dam and the Yellowstone River.

***Design and analysis*:** Pallid sturgeon often reside in the tailwaters of Fort Peck Dam during winter, and can be captured by SCUBA. In March 2001, SCUBA will be used to collect a maximum of 10 pallid sturgeon, if available, from the tailwaters of Fort Peck Dam. Individuals will be implanted with CART tags identical to those used in the USFWS study. Movements by these individuals will be monitored by boat every 3-4 days after initial tag implantation, and continue through early July in collaboration with the USFWS study. Two additional fixed logging stations will be acquired in Spring 2001, and positioned in the Missouri River near river mile 1620 (near Culbertson) and river mile 1702 (near Wolf Point). These stations will also be used during the full-test (2002) and subsequent years. Five additional fixed logging stations will be acquired in 2002. Following radio tracking protocols outlined in the USFWS study plan (USFWS 2001), data logging stations will be checked prior to initiation of boat tracking to facilitate detection of riverine reaches or areas where pallid sturgeon are likely to occur. Attributes measured at pallid sturgeon locations will follow those outlined by the USFWS study (USFWS 2001). In addition to relocating pallid sturgeon, drifting trammel nets (22.9 m x 1.8 m, 2.54 cm inner mesh, 15.2 cm outer mesh) will be fished over pallid sturgeon locations to sample for individuals potentially aggregated with radio tagged pallid sturgeon.

Data collected from pallid sturgeon tagged below Fort Peck Dam will be used to determine use of the upper reaches of the Missouri River prior to the full-test. The statistical component of the USFWS study is currently being developed (USFWS 2001), and will be expanded to include pallid sturgeon tagged below the dam if these individuals relocate to the lower reaches of the river.

Major equipment needs:
(all items listed below, except trammel nets, will be acquired through Lotek Wireless Incorporated)
10 CART 32_1s transmitters
3 W7AS data logging receivers
5 ultrasonic upconverters
5 omnidirectional hydrophones
5 baffles
3 antenna switch boxes
1 handheld antenna
5 Yagi antennas
16 50 ohm terminators
2 Environmental enclosure kits

20 B and C connectors
1 Crimp tool for connectors
Coaxial cable (1000 ft)
Trammel nets (22.9 m x 1.8 m, 2.54 cm inner mesh, 15.2 cm outer mesh, several suppliers)

3. Movements of paddlefish, blue sucker, and shovelnose sturgeon

Objective: Examine the influence of Fort Peck Dam operations on directional movements of native Missouri River fishes

Rationale: The reproductive characteristics of several native Missouri River fishes including paddlefish, blue sucker, and shovelnose sturgeon are similar to those exhibited by pallid sturgeon. For example, paddlefish, blue sucker, and shovelnose sturgeon are migratory during the spawning season, respond to discharge and thermal regimes as cues for spawning migrations, and spawn in gravel substrates (Breder and Rosen 1966; Needham 1979; Berg 1981; Penkal 1981; Moss et al. 1983; Hurley et al. 1987; Gardner and Stewart 1987; Bramblett 1996; Pflieger 1997). Collections of larvae and juveniles by Liebelt (1996) indicate that paddlefish, blue sucker, and shovelnose sturgeon exhibit some degree of spawning success under existing operations of Fort Peck Dam; however, there is evidence to suggest that spawning may occur primarily in tributaries (Needham 1979; Needham and Gilge 1983; Gardner and Stewart 1987; Liebelt 1996) where discharge and thermal regimes are more similar to natural conditions. This hypothesis similarly applies to pallid sturgeon for which spawning conditions are more suitable in the Yellowstone River than in the Missouri River. Minimal or lack of spawning by paddlefish, blue sucker, and shovelnose sturgeon in the mainstem Missouri River downstream from Fort Peck Dam probably reflects the decreased suitability of the river resulting from hypolimnetic releases and the unnatural discharge regime. Clancey (1989) hypothesized that high discharges in the Missouri River relative to the Milk River may promote spawning in the Missouri River; whereas, high discharges in the Milk River relative to the Missouri River may promote spawning in the Milk River. Given these considerations, the information gained by examining behavior and movement responses in paddlefish, blue sucker, and shovelnose sturgeon will complement that obtained for pallid sturgeon, and provide a better understanding of how native fishes respond to modified discharge releases. In addition, the use of paddlefish, blue sucker, and shovelnose sturgeon is warranted due to the limited population size of pallid sturgeon in the Missouri River downstream from Fort Peck Dam, and the difficulty of procuring sufficient numbers of pallid sturgeon for research needs.

Design and analysis: Twenty paddlefish, blue suckers, and shovelnose sturgeon will be collected during fall 2001 and 2002, and surgically implanted with CART tags. CART tags used will be fully compatible with shore-mounted data logging stations used for recording movements of pallid sturgeon (described earlier).

Individuals implanted with transmitters will be tracked between May 1 and June 30 during 2002 (full-test) and 2003 (no-test). Implementation of spillway releases during the full-test will likely not occur until late May. Thus, tracking during early May will provide an initial location of individuals prior to spillway releases. Locations will be monitored every 1-4 days to provide detailed information on fish locations and movements prior to and in response to the full-test (2002) or no test releases (2003). Fish tracking will be conducted primarily by boat, and locations determined via triangulation (Winter 1996). Information from shore-mounted logging stations will also be used to supplement movement data collected in the field. Data collected at all locations where individuals are observed will include: date, time of day, latitude, longitude, river mile (or distance up tributary if applicable), water temperature, turbidity, depth, velocity, and substrate type.

Two hypotheses will be tested to evaluate the influence of dam operations on movements of paddlefish, blue sucker, and shovelnose sturgeon:

Hypothesis 1: The frequency of upstream fish movements will be greater during the full-test (2002) than no-test year (2003).
A Chi-square test will be used to compare the proportion of directional movements of individuals (upstream, downstream, none) between years of different dam operations (full-test, no-test). An analysis will also be conducted to compare directional movements before the spillway is operating (early May) and during spillway operation (late May through June).

Hypothesis 2: The frequency of fish observations in the Missouri River will be greater than in the tributaries during the full-test (2002) than no-test year (2003).
A Chi-square test will be used to compare the proportion of observations in different habitats (Missouri River, tributaries) between years of different dam operations (full-test, no-test).

Major equipment needs:
60 CART tags (exact size to be determined, Lotek Wireless Incorporated)
Telemetry receivers and fixed logging stations as described in monitoring component 2 (above)
Trammel nets, experimental gill nets, hoop nets, and boat electrofishing apparatus (several suppliers carry these items)

4. Larval fish sampling

Objective: Examine the influence of Fort Peck Dam operations on spawning success and larval fish abundance

Rationale: The naturalized discharge and temperature regime resulting from the full-test is expected to enhance spawning success of fishes in the Missouri River downstream from the Fort Peck spillway (e.g., Needham 1979; Gardner and Stewart 1987). Therefore, a temporally intensive larval fish sampling regime is necessary to adequately quantify spawning success. Although larval fish are currently sampled under the existing WAPA-supported monitoring plan (Liebelt 2000b; Appendix 1), funding constraints limit the frequency at which larval fish are sampled (e.g., 1-2 times/month). This study will augment the existing larval fish sampling program, and provide a better understanding of spawning dynamics and the temporal distribution of larval fish in response to changes in operations of Fort Peck Dam.

Design and analysis: Larval fish will be collected during 2001, 2002, and 2003 at sites located immediately downstream from the spillway (river mile 1762), immediately downstream from the Milk River (river mile 1761), near Wolf Point (river mile 1701-1711), Nohly (river mile 1583 - 1592), and in the lower Yellowstone River (river mile 0-3). Water contributions from the Milk River and spillway remain closely associated with the north (Milk River) and south (spillway) banks of the river channel for several miles downstream (Gardner and Stewart 1987); therefore, larvae collected from these sites will quantify spawning success specific to each area. Samples will be collected every third day at each site between May 15 and July 31. A minimum of three replicates will be collected at each site. At sites immediately downstream from the Milk River and spillway, each replicate will be comprised of two samples, each sample collected from the right and left sides of the boat. For the Wolf Point, Nohly, and Yellowstone River sites, each replicate will be comprised of four samples: two samples (right and left side of the boat) collected from the left and right shorelines. Drift nets (0.5-m-diameter, 750 μm mesh) will be fished on the bottom for 15 minutes when possible (e.g., when detrital loads are low). Larval drift nets will be fitted with a velocity meter for use in calculating water velocity and volume of water sampled. Larval fish abundance will be expressed as density (number/m^3). Larval sturgeon collected in the samples will be sent to Dr. Darrel Snyder (Larval Fish Laboratory, Colorado State University) for species identification.

A three-way analysis of variance will be used to compare densities of larval fish among years (2001, 2002, 2003), sampling periods (May 15-July 31), and among sites (downstream from spillway, downstream from Milk River, Wolf Point, Nohly). The Yellowstone River site will be analyzed individually using a two-way analysis of variance (year x sampling period) because this site will not be directly influenced by the Fort Peck modified flow releases. Nonetheless, intensive larval sampling in the lower Yellowstone River is needed due to its potential suitability as a spawning area for pallid sturgeon (Bramblett 1996).

Constraint: The temporally intensive larval sampling regime will provide a thorough evaluation of the influence of modified flow regimes on spawning success and larval abundance of most species; however, the limited number of spawning female pallid sturgeon in the Missouri River below Fort Peck Dam significantly reduces the likelihood that pallid sturgeon larvae will be collected. Therefore, the absence of larval pallid sturgeon cannot be used to indicate a "lack of spawning response" by pallid sturgeon to the flow modifications.

Major equipment needs:
(several suppliers carry these components)
4 0.5 meter nets (750 µm mesh)
4 0.5 meter net rings and bridles
4 collecting buckets (3 ½ inch diameter, 750 µm mesh)
3 water velocity meters for nets (Model 2030R, General Oceanics, Incorporated)

5. Food habits of piscivorous fishes

Objective: Examine the food habits of piscivorous fishes in the Missouri River downstream from Fort Peck Dam

Rationale: The USACE held a series of public scoping meetings in Montana during Fall 2000 at which the public was invited to express their thoughts and concerns regarding the proposed flow modifications at Fort Peck Dam. Officials from the USACE were informed by local landowners in the region that young-of-the-year sturgeon have been observed in the stomach contents of sport fish (primarily walleye *Stizostedion vitreum* and northern pike *Esox lucius*) caught in the Missouri River. The observations by local landowners of sturgeon in the diet of large piscivorous fishes occurred during and after observations of "hundreds" of small sturgeon in some tributaries to the Missouri River.

Previous food habit studies on potential predators in the Missouri River below Fort Peck dam have not documented piscivory on young-of-the-year sturgeon. For example, Gardner and Stewart (1987) found the diet of sauger *Stizostedion canadense* included goldeye *Hiodon alosoides*, flathead chub *Platygobio gracilis*, fathead minnow *Pimephales promelas*, white sucker *Catostomus commersoni*, sauger, and freshwater drum *Aplodinotus grunniens*. Food habits of burbot *Lota lota* included fathead minnow, emerald shiner *Notropis atherinoides*, white crappie *Pomoxis annularis*, goldeye, burbot, shorthead redhorse *Moxostoma macrolepidotum*, and sauger (Gardner and Stewart 1987). The diet of shovelnose sturgeon below Fort Peck dam is comprised primarily of aquatic invertebrates (Gardner and Stewart 1987; Liebelt 2000), but may include cyprinids (Liebelt 2000a). Sheik et al. (1998) reported that white crappie in a backwater of the Missouri River in North Dakota consumed fishes. In backwater habitats of the Missouri River downstream from the Yellowstone River, Moon et al. (1998) found goldeye consumed larval fishes; however, larval fish occurred in only 2.5% of the stomach and composed less than 0.1% by number of the total items found in the diet. The opportunistic behavior of predatory fishes poses the possibility that young-of-the-year sturgeon, if available, could be consumed. According to reports received at public scoping meetings, the incidence of sturgeon in the diet is very sporadic which may partially account for the fact that piscivory on sturgeon has not been reported in earlier food habit studies.

Design and analysis: The food habits of potential piscivores including walleye, sauger, northern pike, burbot, goldeye, channel catfish, freshwater drum, and shovelnose sturgeon will be quantified during 2001 and 2002. A minimum of 30 individuals from each species will be collected each month between late June and August. Individuals will be collected from two different areas representing the Missouri River above and below the Yellowstone River confluence. An independent examination of predator food habits in each area is necessary because susceptibility of young-of-the-year sturgeon to predators may vary between areas due to differences in turbidity and abundance of young-of-the-year sturgeon between areas. Predators will be sampled from all available habitats using a variety of gears (e.g., electrofishing, seining, trammel netting, gill netting). Stomach contents of predator fishes will be removed either by dissection (lethal) or by flushing the stomach with a gastric lavage (non-lethal). Young-of-the-year sturgeon found in the diet will be shipped to Dr. Darrel Snyder (Larval Fish Laboratory, Colorado State University) for species identification. The diet of piscivorous fishes will be quantified by the presence/analysis of sturgeon, frequency of occurrence of sturgeon and other taxa, and percent composition by number of sturgeon and other taxa (Bowen 1996).

Major equipment needs:
Trammel nets, experimental gill nets, hoop nets, and boat electrofishing apparatus (several suppliers carry these items)

Contractor Responsibilities and Deliverables

The contractor will purchase all equipment and conduct all tasks in accordance with methods and equipment specified in the five monitoring components listed above. For the water temperature monitoring component, the USACE will purchase 35 water temperature loggers and deliver these to MTFWP for their use in water temperature monitoring. The additional 35 water temperature loggers purchased for the Data Collection Plan will be used as necessary by MTFWP such as to replace loggers damaged by river conditions and to increase the number of water temperature collection sites. The equipment used for tracking movements of pallid sturgeon as listed on page 23 will be furnished to MTFWP by the USFWS.

Progress reports including research data and analyses will be submitted to the USACE and WAPA on a quarterly basis (March 31, June 30, September 30, December 1). In addition, monthly activity reports will be prepared and submitted to the USACE and WAPA. A final project report will be submitted to the USACE and WAPA by March 31, 2005.

Quality assurance representatives from the USACE will periodically accompany MTFWP during monitoring activities to perform quality assurance inspections during the course of the monitoring program. The MTFWP will provide the quality control for their monitoring activities. The MTFWP shall submit, through WAPA to the Omaha District USACE, a quality control plan that includes as a minimum data collection procedures and processes, personnel qualification, training, and safety.

Confidentiality: All data collected, analysis of data, etc. performed under this agreement is the property of the USACE, and is considered provisional until accepted by the Omaha District USACE. Neither WAPA nor the MTFWP will publish, report, or in any way disseminate information generated under this agreement without permission from the Omaha District USACE.

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Montana Department of Fish, Wildlife and Parks

Proposal for Monitoring the Missouri River Fisheries and Habitat Parameters Before, During, and After Fort Peck Spillway Releases (J. E. Liebelt, 2000)

Introduction:

Tentative plans are to release 15,000 cfs to 20,000 cfs from the Fort Peck Spillway into the Missouri River during May/June in 2001. The purpose is to mimic historical natural hydrograph events to some degree. It is surmised releases from the spillway will increase downstream water temperatures, thereby aiding reproduction of warmwater fish species and also increase available habitat by filling side channels and backwater nursery areas. Other possible benefits from increased flows may be scouring of the river channel, establishment of woody vegetation such as cottonwoods along the river bank, and sloughing and erosion of river banks. This provides nutrients and sediments that are important to the overall health of a river system and which would normally occur during a natural hydrograph. Sandbars created or added to by the increased sediment load will provide additional habitat for shorebirds and other wildlife after the water recedes.

Establishment of baseline information prior to spillway releases is necessary in order to determine and measure possible benefits to the fisheries community and river habitats needed by various fish species to survive and prosper. Sustained spillway releases in the past, as in 1975, 1976, and 1997, resulted in major migrations of fish into the spillway and immediate river areas as well as emigration of fish from Fort Peck Reservoir.

A combination of methods designed to sample fish relative to various flow and habitat conditions is needed to collect meaningful baseline data. It is felt a modified Benthic Fish Sampling system would provide the best means of collecting information before, during, and after spillway discharges occur.

Methods:

Seven sites/areas have been selected for monitoring the effects of spillway discharge. A combination of drift nets, stationary gill nets, benthic trawl, bag seine, hoop net, electrofishing, and larval sampling will be used to gather data. Sites selected (see maps) are: Anderson Island (RM 1765.8), Spillway (RM 1762.8), Milk River confluence (RM 1761.0), Nickels rapids (RM 1757.5), Grandchamps/Frazer rapids (RM 1741.5), Wolf Point (RM 1701.5), Poplar/Redwater (RM 1679-1681). Sampling areas were selected based on proximity to the spillway, accessibility, potential influence of spillway discharges, and habitat considerations.

The Anderson Island area is upstream from the spillway confluence and will serve as a control site since this area will not be directly influenced by spillway discharges. The Milk River confluence area is about 1.5 miles downstream across from the spillway confluence and should be monitored in order to compare possible changes in fish species composition and numbers before, during, and after discharges occur. The Milk River attracts large numbers and species of fish during the spring, particularly in "good" water years and may provide comparisons between "natural" river flows and river flows during spillway discharges. The Nickels rapids area, about 5.3 miles below the spillway, has a number of interesting physical features. There is a small rapids area, large boulders, woody snags, a relatively long, deep run and side channels. Also, this area should be strongly affected by the warmer water temperatures from the spillway discharges. The Grandchamps/Frazer rapids area, over 20 miles downstream from the spillway, also has interesting habitat features including a deep, boiling run below the rapids which should concentrate fish and provide comparisons with upstream sampling sites. There are also side channels in the area, which under higher flows, will provide additional habitat for fish. The Wolf Point area, some 60 miles downstream from the spillway, may show subtle changes in fish numbers and composition in response to the increased flows and water temperatures from the spillway. The Poplar/Redwater area, about 83 miles downstream from the spillway, will serve as the lower control site. The spillway discharge should be well mixed by the time the river reaches this area and a more natural state, relative to water temperatures, should prevail.

Temperature loggers have been installed at all proposed sampling sites and are programmed to record water temperatures at one hour intervals. Additional loggers have also been installed in the Spillway Channel (surface, 6-feet, 12-feet depths), the Milk River near the confluence (RM 3), Nohly Bridge (RM 1589), and the lower Yellowstone River (RM 10). This will provide additional support data concerning temperature comparisons among the rivers.

One other consideration regarding spillway releases should be addressed: Emigration of Fort Peck Reservoir fish directly into the Missouri River. It is suspected relatively large numbers of fish including walleye, chinook salmon, lake trout, cisco, and other species, are drawn to the discharge and find their way to the spillway channel and Missouri River. Walleye tagged in the reservoir were caught in the Missouri River after the 1975, 1976, and 1997 spillway releases. After the 1997 releases, adult chinook salmon were observed spawning in a side channel of the Missouri River several miles upstream from the spillway confluence during October. There is little doubt they emigrated from Fort Peck Reservoir. Lake trout and large numbers of cisco were also observed and caught by fishermen in the Aspillway hole≅, immediately below the spillway during and after discharges were terminated in 1997. This emigration could be ignored but would result in a **major** data bias relative to species composition and numbers of fish captured during and after releases.

An electrical grid or other type of barrier system (strobe lights, sonic, or combination) in the reservoir spillway channel should be installed to deter fish emigration from the reservoir. The Corps of Engineers and/or Western Area Power Administration should be responsible for the installation and maintenance of a barrier system. The concrete-lined channel is approximately 1,000 feet wide and about 12 feet deep at the present reservoir level of 2234 msl (end of May, 2000).

Sampling procedure and schedule:

Site 1 - Anderson Island

Sample one to two times per month; May through August

Gear: 3-drift trammel nets
- 3-bottom trawls
- 2-bag seines
- 2-electrofish runs
- 2-hoop nets
- 1-stationary experimental gill net if suitable site found
- 2-larval samples

Site 2 - Spillway Channel and Missouri River (Right Bank)
Sample one to two times per month; May through August

Spillway - pre discharge
Gear: 2-stationary experimental gill nets
2-electrofish runs
2-bag seines

Spillway - discharging:
Gear: 2-stationary experimental gill nets
3-electrofish runs
2-hoop nets
3-drift trammel nets
2-larval samples
Seining and trawling are not possible with spillway discharging

Spillway - post discharge
Gear: Same as pre discharge

Missouri River - Right bank immediately below spillway confluence
Gear: 1-stationary experimental gill net if suitable site found
2-electrofish runs
1-hoop net
2-bag seines
3-drift trammel nets
2-larval samples
3-bottom trawls

Site 3 - Milk River and Missouri River - Left bank below confluence
Sample one to two times per month; May through August
Milk River above confluence:
Gear: 1-stationary experimental gill net
2-electrofish runs

Missouri River below Milk River confluence:
Gear: 1-stationary experimental gill net if suitable site found
2-electrofish runs
1-hoop net
2-bag seines
3-drift trammel nets
2-larval samples
3-bottom trawls

Site 4 - Nickels Rapids

Sample one to two times per month; May through August

Gear: 3-drift trammel nets
3-bottom trawls
2-electrofish runs
1-hoop net
2-bag seines
2-larval samples
1-stationary experimental gill net if suitable site found

Site 5 - Grandchamps/Frazer Rapids

Sample one to two times per month; May through August

Gear: Same as Sites 3 and 4

Site 6 - Wolf Point; Site 7 - Poplar/Redwater

Sample once each month; May through August

Gear: Same as Sites 3,4,5

Sampling protocol and gear:

Protocol

All fish captured by drift netting, stationary experimental gill nets, hoop nets, electrofishing and trawling will be identified, weighed and measured; shovelnose sturgeon and blue sucker will be tagged with numbered cinch tags. Any pallid sturgeon captured will be treated according to guidelines and protocol relative to pallid sturgeon. Electrofishing will not be used to sample fish if concentrations of sturgeon/paddlefish are present in the sampling area in order to avoid possible physical damage to the fish.

Fish captured by seining will be identified and counted. A sample may be weighed and measured if needed.

Larval fish samples will be transferred to glass jars and preserved in 10 percent formalin/phloxine-B dye. Sorting of larval fish, eggs, and aquatic invertebrates will be done later at Fort Peck. Fish will be identified to family/genus/species using larval fish keys and unknown specimens will be sent to the larval fish laboratory at Colorado State University for species ID.

Gear

1. Trammel nets: 75-feet x 6-feet with 1-inch bar inner mesh 6-inch bar outer mesh. Nets will be drifted with the aid of one or two boats, depending on current velocities, for up to 10 minutes. All drifts will be timed using a stopwatch.

2. Stationary experimental gill nets: 125-feet x 6-feet with five 25-foot panels, one each of 3/4-, 1-, 1 1/4-, 1 1/2-, 1 3/4-, 2-inch bar mesh. Nets will be fished for varying times depending on location and river conditions.

3. Hoop nets: 3 1/2-feet mouth diameter, 1-inch bar mesh; will be fished overnight unless location or river conditions require earlier removal.

4. Bottom trawl: 2-feet x 6-feet frame x 15-feet long equipped with rubber rock hopper gear; 1/8-inch outer chafe net and inner liner with 6 1/2-inch cod end diameter. Trawl will be pulled downstream by boat for up to four minutes per trawl.

5. Bag seine: 35- x 6-feet with mud line bottom, 3/16-inch knotless Ace mesh and 6- x 6- x 6-foot bag. Seine will be waded along suitable shoreline for approximately 50 yards and landed on shore for examination of catch.

6. Larval nets: 1/2-meter diameter, 4:1, 750-um Nitex mesh, 11-feet long, equipped with 3 1/2-inch diameter collecting bucket with 750-um screen. Paired nets (one on each side of boat), weighted with 10-or 20-pound lead cannonballs, depending on depth and current velocity, are fished near the bottom for five to 30 minutes, depending on debris load.

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1. **Bank Erosion Monitoring during the Mini-Test.** Monitoring will consist of the following tasks if funds are available:

   a. Bank Erosion. Erosion pins and control points have been established at the three previously established sites. Distances will be measured from the pins to the new bank lines to determine erosion rates. The bank line at each site will be mapped from the established control points to determine the total area lost from the test.

   b. General Downstream Areas. Municipal water and irrigation intakes will be monitored to assure that they will function properly. Other areas identified as critical features will be monitored on an as-needed basis.

   c. Water Surface Elevation Profiles. A water surface profile will be surveyed to identify changes in water surface elevations in the reach.

   d. Spillway Exit. The spillway exit will be surveyed to identify scour and bank erosion.

   e. Aerial Photography. A before and after set of aerial photos will be collected for use in identifying bank erosion.

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Least Tern/Piping Plover
Endangered Species Productivity Work Summary

I. Survey Area

The survey area is the Missouri River from Fort Peck Dam (River Mile 1770.0) to the headwaters of Lake Sakakawea (River Mile 1568.1). Two major tributaries, the Milk and Poplar Rivers, join the Missouri from the north along this reach. Toward the east end of the reach at RM 1582.0, the Missouri's longest tributary, the Yellowstone River, joins the river. Since censusing began in 1988, very few piping plovers have been found on this part of the river, averaging just twelve plovers per year. The Missouri is much more important to least terns with a yearly average of 79 adult terns. In contrast to the plovers farther to the west on Fort Peck Lake, most of the piping plover nests on the river are not initiated until late May and early June. For least terns the majority of nests on the river are initiated during the first three weeks in June.

II. Productivity Surveys

The productivity surveys are conducted on a weekly basis from the last week in May when the plovers first arrive on the nesting grounds through the last week in August when the last of the fledged juvenile terns have departed for the wintering grounds. Surveys to be conducted include nest site surveys, including historically used sites and sites with suitable habitat, surveys for nests, surveys for chicks and fledged juveniles and surveys for banded birds. Nest and chick data will be recorded and inputted into the Threatened & Endangered Species Data Management System (TESDMS). This information will be updated during subsequent site visits throughout the nesting season.

III. Adult Census

A census of adult least terns and adult piping plovers is conducted during the breeding season as a compliance measure for the Biological Opinion. The Adult Census is conducted during the last two weeks in June. All areas of potential habitat need to be censused. This includes areas that were first checked at the beginning of the season that did not yield any birds. The Adult Census is to be conducted in conjunction with the regular productivity survey. The census results will be tabulated into the TESDMS.

IV. Management Actions

Several management actions are undertaken to increase the productivity of the birds. This includes predator control measures, reducing human disturbance, relocating nests and salvaging eggs.

Anti-predation measures include cages put over plover nests, strobe light systems for tern colonies, construction of electrified fences and predator removal. To reduce human disturbance, access to nesting areas can be restricted through the placement of restriction signs and barricades. To prevent loss due to flooding, nests can be relocated to higher elevations by a number of methods. Eggs can be salvaged for captive rearing purposes if nests cannot be relocated to a higher elevation.

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GOVERNMENT ORDER NO. W59XQ6015339S6
BETWEEN THE U.S. FISH AND WILDLIFE SERVICE AND THE OMAHA DISTRICT U.S. ARMY CORPS OF ENGINEERS

SCOPE OF WORK AND TASK ASSIGNMENTS

Piping Plover and Least Tern Surveys and Productivity Monitoring

PURPOSE AND AUTHORITY

This is a memorandum of understanding (MOU) entered into by and between the U.S. Fish and Wildlife Service (USFWS) and the Omaha District of the U.S. Army Corps of Engineers (Corps). The purpose of this MOU is to establish a scope of work, cost estimate, and responsibilities for the delivery of services to be performed as part of the Corps' responsibilities under the Endangered Species Act of 1973 (ESA), as amended. The accompanying government order purchase request (GO) is to obligate FY 00 funds to finance the continuation of services provided by the USFWS. The GO constitutes an order by the Corps, acting by and through the Contracting Officer, pursuant to the Economy Act, U.S.C. Section 1535, as implemented by the Federal Acquisition Regulation Supplement Subpart 217.5. Each of the parties hereto has the authority and is willing to enter into this MOU and to abide by its terms and conditions.

The Corps received a Biological Opinion (Opinion), concerning the operations of the Missouri River Main Stem System, from the US Fish and Wildlife Service in November 1990. This Opinion concluded that the current operations of the Missouri River would likely jeopardize the continued existence of the interior population of the least tern (*Sterna antillarum*) and the Great Plains population of the piping plover (*Charadrius melodus*). The Opinion provided reasonable and prudent alternatives that, if implemented, would preclude jeopardy to these species. Success of implementing the alternatives and subsequent preclusion of jeopardy, will be based on production, to be measured annually by fledge ratios of both the least terns and piping plovers nesting on the Missouri River. This scope of work for fiscal year 2000 outlines the mission that will be undertaken by the participating agencies to survey populations and enhance and monitor production of both piping plovers and least terns within this region.

SCOPE OF WORK

I. Objectives

A. Conduct annual census to estimate number of breeding pairs of least terns and piping plovers within the Fort Peck Reservoir.

B. Monitor production of least terns and piping plovers nesting on Fort Peck Reservoir and document using standardized Corps methods.

C. Implement alternatives which are fiscally and logistically possible for the enhancement of least tern and piping plover productivity and the survival of young-of-the-year juveniles to flight stage.

II. Participating Agencies or Offices

USFWS, Charles M. Russell National Wildlife Refuge, Lewistown, MT

III. Geo-region Study Area

Fort Peck Reservoir, River Miles 1785.0-1771.0, Reach 1

IV. Breeding Adult Population Census

A. Survey total numbers of adult least terns and piping plovers during the last week of June through the first week of July.

B. Record all counts on Corps standardized census record.

V. Productivity Monitoring

A. Determine distribution of nesting least terns and piping plovers within the reach and record nest or nesting colony locations on US Army Corps of Engineers aerial mosaics or similar imagery.

B. Determine earliest arrival dates and date of initial nesting or breeding activity within the reach. Determine latest nesting activity and date of last observation of both piping plovers and least terns using the habitat within the reach.

C. Conduct productivity monitoring activities on a 7 to 10 day cycle per site, as per permit conditions, and record all nest site and chick survival data in entirety on Corps standardized data cards.

1. Collect nest data.
   a. Determine number of nests initiated, nest initiation dates, number of eggs laid, and number of eggs hatched.
   b. Determine principle causative factor or factors responsible for nest termination.

2. Collect chick survival data.
   a. Determine number of chicks fledged and estimate date of fledging.
   b. Determine principle causative factor responsible for chick mortality.

VI. **Predator Deterrence**

A. Implement predator exclosure cages on piping plover nests where predation is limiting or has historically limited nest success.

   1. Exclosure cage design should be similar to those previously tested on nesting colonies within the Missouri River.
   2. All cage designs, nest success, etc. should be discussed in the final report.

B. Test and implement other forms of predator deterrence or experimental removal (in coordination with USDA-Animal Damage Control office) in areas where predation appears to be limiting least tern and piping plover productivity.

VII. **Other Activities**

A. Assist in developing a database, using GIS and GPS equipment, of island geomorphological characters and their relationship to nesting site locations including, nest elevation, distance to nearest water, distance to vegetation, distance to shallow water feeding areas, distance to riverbank, island topology, etc. Data collected will be used to generate weekly nest site location maps plotted on elevation data and also banked in an arc-info database for comparative analysis.

B. Conduct outreach activities to increase public awareness and knowledge about least terns and piping plovers and the role that they play within the Missouri River ecosystem. These activities should include, but not be limited to, press releases, public service announcements, interviews and/or tours with local media, participation in "awareness" days in the local areas, and daily public relations. These activities should be undertaken in such a manner that all participating agencies and designated missions are spoken of and represented to the highest standard.

C. Provide technical assistance to the Corps for development of better management alternatives and to aid in future planning and local recovery efforts of least terns and piping plovers on the Missouri River.

VIII. Reports

A. Status reports on least tern and piping plover survey and monitoring activities will be entered in the Corps online Data Management System after each days survey during the nesting season. Passwords to the system will be forwarded. Reports will be discontinued when all activity is terminated on the study area.

B. Final report will be due no later than October 15, 200 . Report will be sent to Greg Pavelka, Endangered Species Coordinator for Operations Division, Omaha District. Guidelines for final report format will be forwarded.

IX. Agency Contacts

A. US Army Corps of Engineers

Operations Division

FOR TECHNICAL ASSISTANCE
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B. U.S. Fish and Wildlife Service

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CONTINGENCY PLAN
FOR PROTECTION OF LEAST TERN AND PIPING PLOVER NESTS AND CHICKS

The Corps of Engineers will carry out the following contingency plan for the protection of least tern and piping plover nests and chicks threatened with termination due to natural events or inundation due to poor nest selection under normal system operation, or flood control operations. All efforts will be made to protect nest site viability in the wild prior to collection for captive rearing. Nests will only be collected immediately preceding the inundating release to restrict renesting efforts on unstable habitats. Listed below is a sequential operating plan for nests and chicks threatened by rising water levels. All guidelines are subject to State and Fish and Wildlife Service permit approval and conditions.

NESTS

1. Consult with Reservoir Control Center for water level management options.
    a. Exercise options if available.
    b. If options not available, step 2.

2. Move nest to higher ground that will not be inundated until after the chicks anticipated fledging date.
    a. If successful continue to monitor nest.
    b. If nest cannot be successfully moved, step 3.

3. Elevate nest using a tire or other object if rise in water is expected to be short term.
    a. If successful continue to monitor nest.
    b. If water rise is expected to be long term or if nest cannot be raised, step 4.

4. Evaluate the option of egg removal and captive rearing.
   If option 4 is to be exercised, the US Fish and Wildlife Service and appropriate state agencies will be contacted for coordination and concurrence.

    a. Remove eggs to captive rearing facility to be incubated and raised for release into the wild.
    b. Remove eggs to captive rearing facility to be incubated and raised for research that will aid in meeting the recovery goals of these species.

CHICKS

1. Consult with Reservoir Control Center for water level management options.
   a. Exercise options if available.
   b. If options not available, step 2.
2. Remove chicks and place on adjacent islands within sight of adult birds, if sites unavailable, step 3.

3. Remove chicks to captive rearing facility.
   If option 3 is to be exercised, the US Fish and Wildlife Service and appropriate state agencies will be contacted for coordination and concurrence.

   a. Remove chicks to captive rearing facility to be raised for release into the wild.
   b. Remove chicks to captive rearing facility to be raised for research that will aid in meeting the recovery goals of these species.

CAPTIVE REARING PROTOCOL

CAPTIVE REARING

Captive rearing will be conducted at the Corps of Engineers (Corps) facility at the Gavin's Point Project Office. The facility consists of a main building containing a brooding area, egg handling, incubation, and diet preparation laboratory and an office (see attached facility plans). Outdoor flight pens are attached to the rear of the facility. The building is designed to facilitate the captive rearing of interior least terns and piping plovers in a safe, clean, and healthy environment. The interior walls of the facility are sealed to allow for pressure washing and disinfection of all surfaces. The building and outdoor pens are serviced by raw Missouri River water, treated water, and enclosed sewer.

Visitation protocols are established to limit visitor contact with the birds. Facility technicians are required to wear separate footwear in the brooder area other than that worn outdoors or in the office. Technicians also wear lab coats confined to bird handling areas. Foam alcohol hand creams are used to minimize contamination when handling birds.

Staff from the National Biological Service, Madison Wildlife Health Laboratory were consulted on building design and facility protocols.

COLLECTION

Eggs collected at distances greater than 50 miles from the incubation laboratory at the Gavin's Point Project in Yankton, South Dakota, are placed in a portable incubator to maintain egg viability on route to the lab. Eggs collected within close proximity (less than 50 miles) of the facility, are collected and transported from the field to the laboratory in modified polystyrene or pressed cardboard egg cartons. This allows for the collection operation to be expedited as quickly as possible while maintaining egg viability. Eggs are cleaned, weighed, and candled prior to being placed in the incubator. Any nonviable eggs are removed and sent to the Fish and Wildlife Service (Service) for disposal.

INCUBATION

Viable eggs are placed in a Petersime Model I incubator located in the lab room (see building diagram). Piping plover and least tern eggs are incubated concurrently in the same incubator. The Petersime incubator features a redwood housing, thermostatic thermometer with backup, 150 degree rotational drum egg rack with 2000 egg capacity, paddle fan, and hatcher box. Humidity is controlled by varying the surface exposure of the water pan. Temperature is monitored using the standard dry and wet bulb Fahrenheit thermometers provided by the Petersime Company. Incubator operation settings are set to simultaneously, as closely as possible, meet the requirements of both species.

Dry Bulb Thermometer 99.5 degrees F

Wet Bulb Thermometer 87 degrees F

Relative Humidity 59-60%

Eggs are individually identified by writing a coded number on each shell with a nontoxic felt tipped pen. Eggs are candled and weighed Tuesday, Friday, and Sunday of each week. Weighing allows monitoring of embryo weight loss during the incubation period. Proper humidity regulation should result in 10-10.5 percent fresh egg to hatch weight loss for piping plovers and 11-13 percent fresh egg to hatch weight loss in least terns. Candling enables data to be collected on embryo development and allows observers to accurately determine time to remove eggs from the rotating drum. A second Petersime incubator is used to hatch eggs. Once membrane crowning is observed in the air cell, eggs are to be removed from the incubation incubator and placed in the hatcher incubator. This allows for sufficient time prior to the embryo penetrating the membrane into the air cell, at which time the unhatched chick is susceptible to suffocation if the egg is continually rotated. Humidity within the hatching incubator are to be increased to 65-70 percent. Expected pip to hatch times are 12 to 48 hours for piping plovers and 12-24 hours for least terns. Birds are to be allowed to dry off and then be individually identified with a colored plastic leg band prior to placing them in the brooder box.

BROODING AND FEEDING

After 10 to 12 hours in the hatcher box, or when chicks are completely dried off and are able to stand, the hatchlings will be removed from the hatcher and weighed to determine hatching weight prior to being placed in the brooder box. Every effort will be made to segregate chicks from like broods into individual brooders to prevent any implications that may arise from cross-sibling imprintation. Brooder boxes will be constructed of 7/16ths AC plywood with the smooth side turned in to prevent any injuries from splinters. Box interiors will be sealed with a food grade polyurethane to reduce bacterial contamination and aid in box sanitation. Boxes will be built in 4' X 8' complexes with each individual box being 2' X 2' square and 16 inches high.

Brooder floors will be covered with indoor/outdoor carpeting which will in turn be covered with sand to protect the young birds' feet. Least tern brooders will be provided with a sand simulated nest bowl and an attending adult decoy. Piping plover brooders will have a brood pouch constructed of terry cloth towel for brooding security. Brood boxes will be covered with a fabric top and will be heated with incandescent light bulbs with brooder hoods.

Boxes will be heated to 95-98 degrees F for three to five days with the temperature slowly being decreased as birds began to feather and thermoregulate themselves. Hatchlings will be kept in the brood boxes until their feather tracts are fully feathered (approximately 12-14 days) and they are able to fully thermoregulate. Boxes will be cleaned and disinfected Monday and Thursday of each week using Germacert™ nontoxic disinfectant. Chicks will be weighed during the brooder cleaning to track weight gain and adjust diet to ensure proper nutrition.

Recommended Diets:

Piping Plovers 1-3 days old -	mini meal worms, brine shrimp, blood worms, pinhead crickets, black worms, and fly larvae. Supplement with commercial chick starter.
Piping Plovers 3+ days old -	regular meal worms, brine shrimp, blood worms, wax worms, baby crickets, and locally collected insects. Supplement with a poultry starter for filler.
Least Terns 1-3 days old -	locally seined fish fry 1 to 1.5 centimeters in length.
Least Terns 3+ days old -	endemic forage fish, i.e., shiners, mooneye, fathead minnow, freshwater drum, etc., not to exceed 3-5 cm.

Piping plovers will be fed a complete diet containing items above that are available from a local supplier along with insects trapped on-site nightly. Dry food items will initially be sprinkled on the floor of the brooder box to stimulate the young chicks' pecking behavior. Once chicks become accustomed to foraging, all food will be provided in plastic petri dishes to aid in box sanitation. Piping plover chicks will be provided with an unlimited food supply along with a 50-50 mix of $CaCO_3$ and Petamine™ bird vitamins to meet additional nutritional requirements. Diets will be monitored and adjusted according to a nutritional assay of food items obtained for least tern and piping plover forage.

Least terns will be fed several species of endemic forage fish fry until three days of age at which time they will be switched to a variety of locally seined river forage fish and fathead minnows purchased from a local supplier. Available fish species will be analyzed for thiaminase and a variety of fish will be used as feed so thiamin deficiencies can be avoided. When available fishes nutritional composition is insufficient to meet thiamin requirements, a thiamin supplement will be provided. Fish supplied locally from seines or a supplier will be held at Gavin's Point National Fish Hatchery then placed on ice prior to being fed to the birds. While in the brooder boxes forage for the least terns will be hand fed using a white surgical glove and forceps. All feeding will be conducted in complete background darkness to minimize the association between humans and feed. Once the birds become accustomed to grabbing the fish, fish will be provided in a drop in pan filled with water to train the birds to self feed. Least terns will be fed every two hours from 7:00 a.m. to 9:00 p.m. or more frequently as needed.

Both species will be given unlimited water in shallow petri dishes. Brooder boxes will be rolled outside each day for a minimum of two hours. This will ensure vitamin D is metabolized and that bone development deficiencies are avoided.

All feeding utensils and petri dishes will be disinfected after each feeding. The brooder and laboratory will be disinfected at least once per day with a broad spectrum disinfectant. All personnel feeding or handling chicks or otherwise doing general maintenance in the brooder room or lab will apply foamed alcohol hand cream to prevent cross contamination.

When chicks are 12-14 days old and are able to feed and thermoregulate themselves, they will be transferred to the outdoor flight pen. The outdoor pen is 48 feet by 60 feet and contains 6, 20 feet by 20 feet warm release pens. Three of these pens are designed for plovers and contain 15 feet by 20 feet sand pads and 10 feet by 20 feet beach/pool habitats which gently slope from ½ inch to 6 inches deep. The remaining three pens, designed for terns, contain a 10 feet by 20 feet sand pad but the pool habitat slopes from ½ inch to a maximum depth of 1 foot. The pool habitats are individually contained and receive continuous flow of raw river water.

The outdoor pen's exterior walls and dividers are constructed of a four foot high concrete stub wall. Pen floors and pool bottoms are continuous concrete that abuts an elevated center walkway. Eight foot chain link fencing is attached to the stub wall and is lined with shade netting. Eleven foot high exterior walls support a vinyl coated wire mesh roof which rises to 25 feet at the center, providing opportunity for terns to aerially forage over the pool habitat.

Prior to new broods being placed in pens, the pens will be bleached where possible and sand areas raked and exposed to ultraviolet light.

Food will be provided to the pens from the center walkway access until chicks are fully feathered, self-foraging, and are capable of sustained flight. At this time they will be captured with a drop net and banded for release.

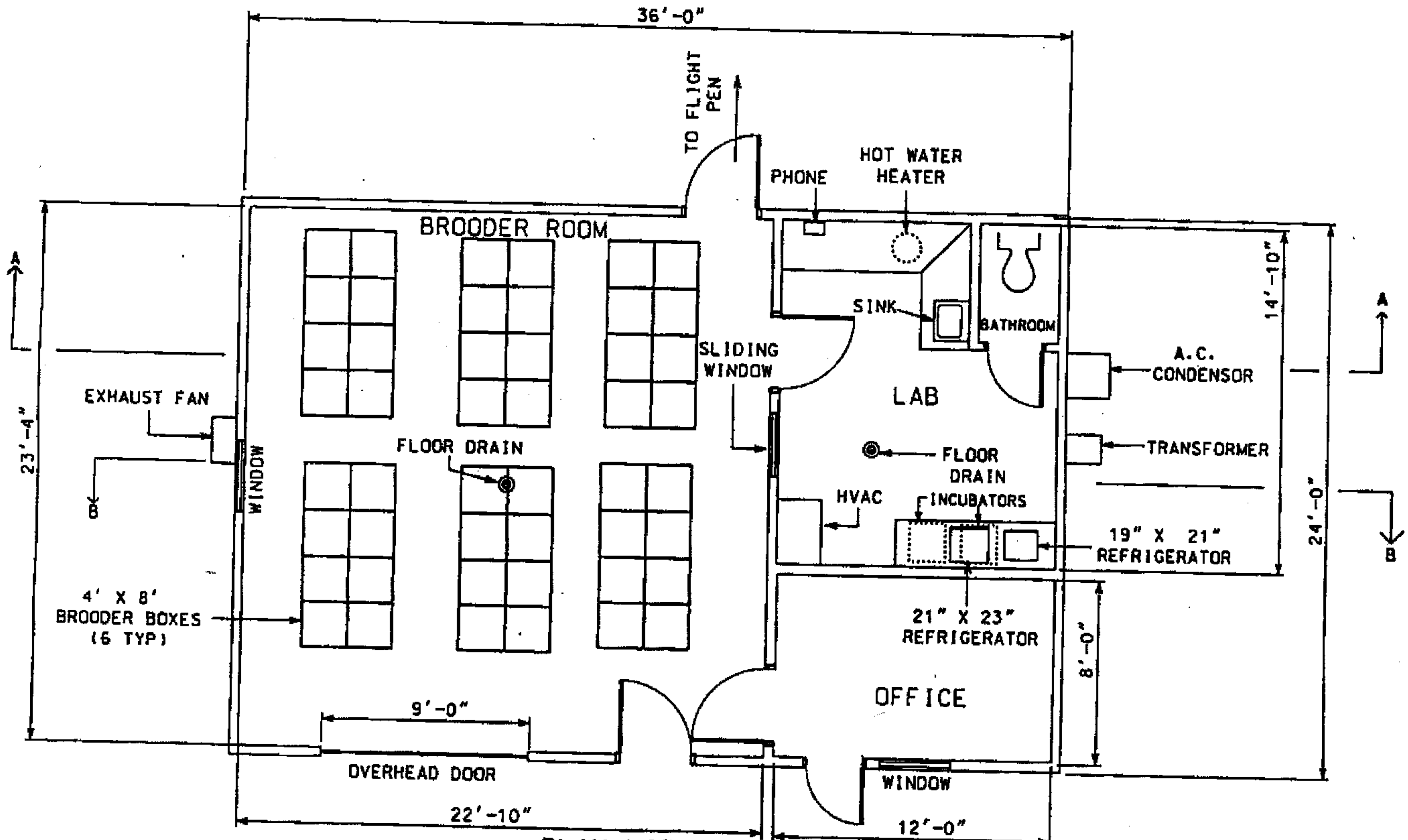
RELEASE AND POST-RELEASE MONITORING

Least terns will be banded with size 1A or 1B steel serially numbered Fish and Wildlife Service bands. Piping plovers will be banded with size 1A or 1B stainless steel serially numbered Service bands. A colored flag (UV stable, Darvic tm plastic manufactured by A.C. Huges) will be applied to the upper leg opposite the Service band.

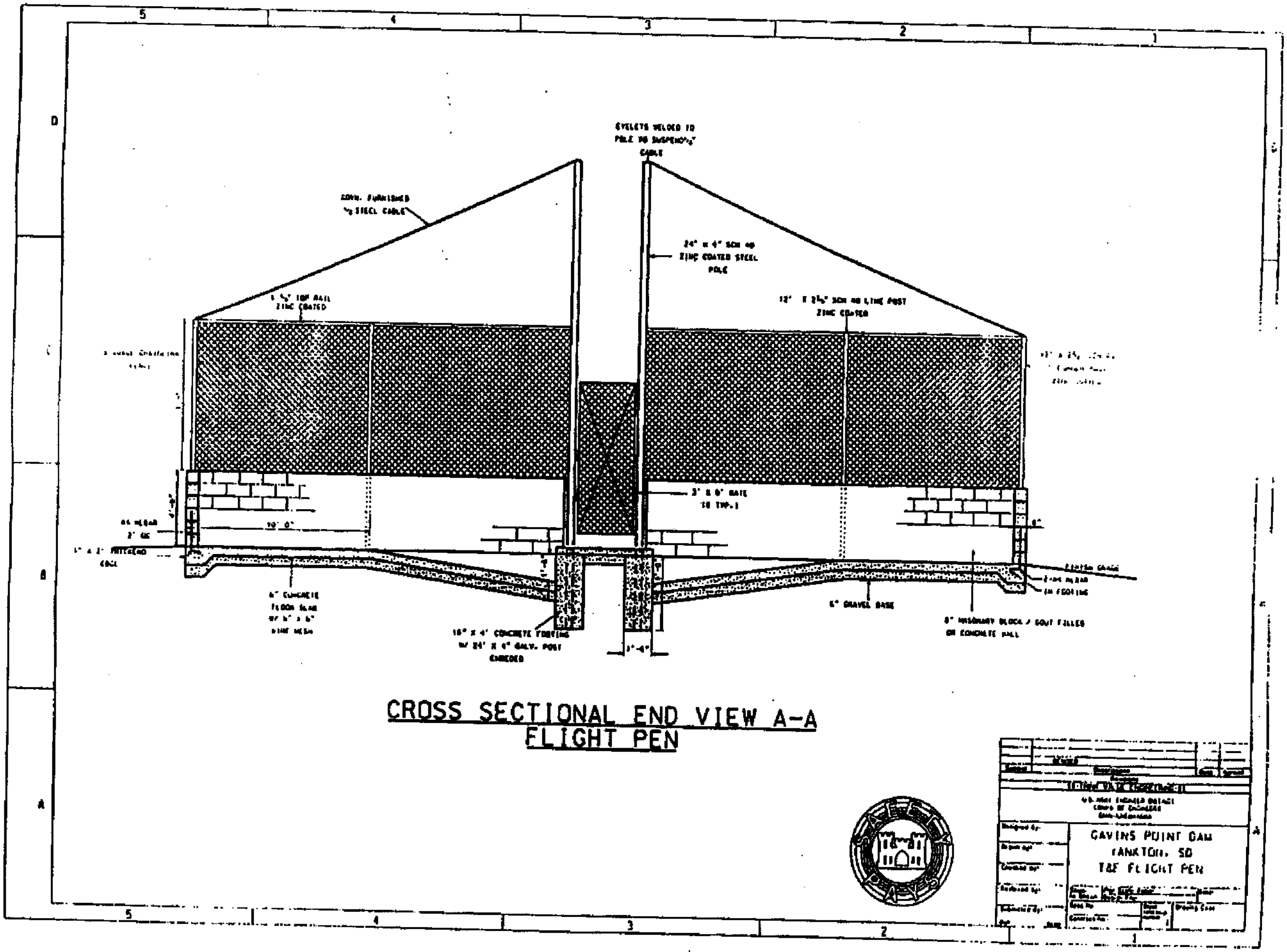
Banded fledglings will be released on sandbar habitat that provides a secure release substrate for a minimum of two weeks post-release. These habitats will be determined to have sufficient elevation to remain exposed during increases in discharges and also will have an available food source for the fledglings. Close coordination with State and other Federal agencies will be undertaken to ensure suitable habitats are located for release sites prior to birds fledging. Many of the constructed sites built by the Corps in previous years below Gavin's Point Dam should provide suitable release substrates.

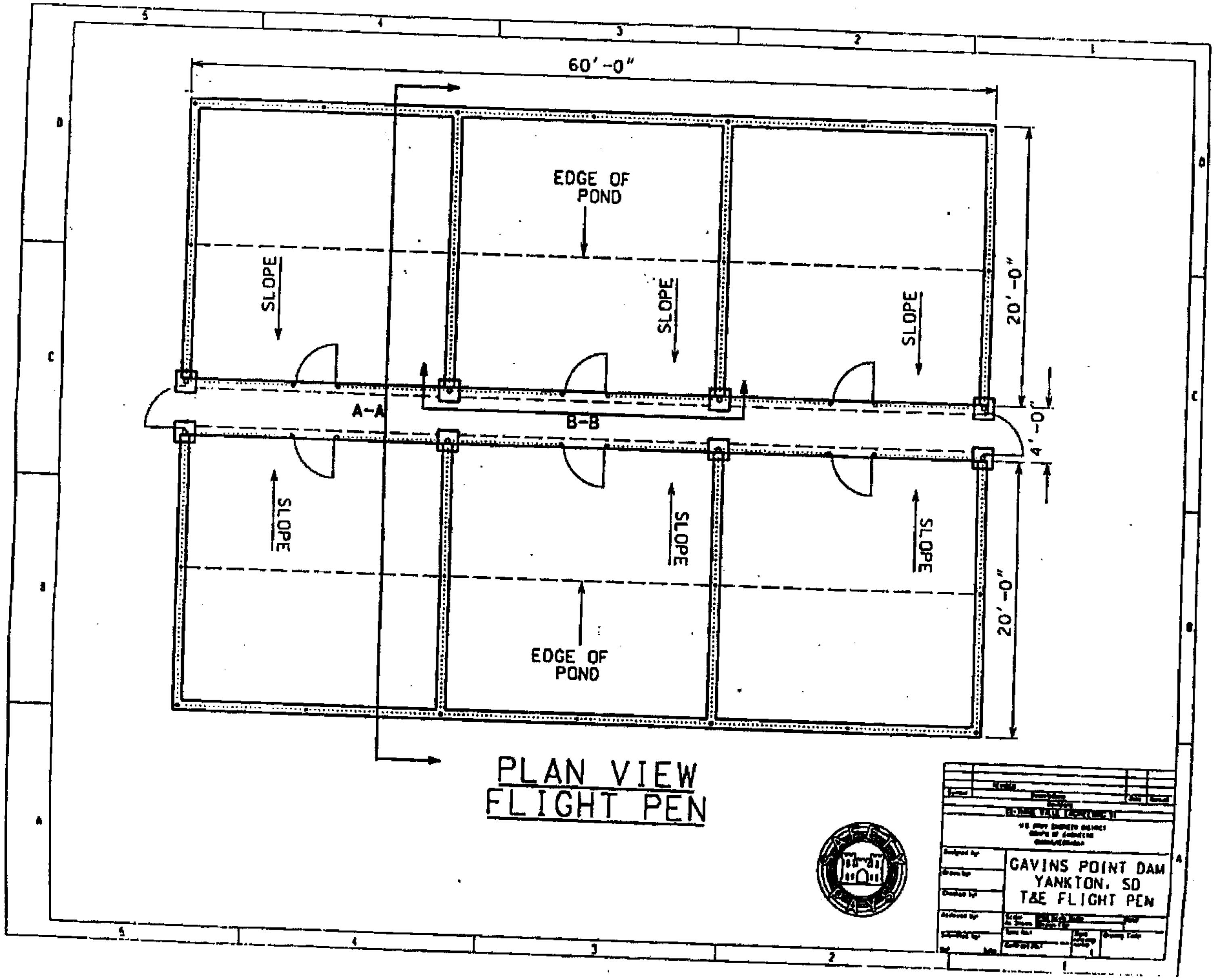
Piping plover chicks of individual broods will be grouped and released onto sandbars with no existing nesting or brooding piping plover adults or released into staging flocks of young-of-the-year flighted piping plover chicks. Least tern chicks of individual broods will be grouped and released near active least tern colonies where young-of-the-year least terns are fledging and beginning to forage for themselves, or released into staging flocks of young-of-the-year flighted least tern chicks.

Least tern and piping plover chicks will be transported to release areas in modified poultry shipping crates. Chicks will be hard-released onto the release areas. Releases will be monitored in conjunction with the Post-Release Survival Study. Efforts will be coordinated through the



PLAN VIEW
CAPTIVE REARING BUILDING


CROSS SECTIONAL END VIEW A-A
FLIGHT PEN
GAVINS POINT DAM
YANKTON, SD
T&E FLIGHT PEN
6" GRAVEL BASE


60'-0"
EDGE OF POND
SLOPE
SLOPE
SLOPE
A-A
B-B
20'-0"
4'-0"
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SLOPE
SLOPE
20'-0"
EDGE OF POND
PLAN VIEW
FLIGHT PEN
GAVINS POINT DAM
YANKTON, SD
T&E FLIGHT PEN

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Scope of Work
Fiscal Year 2004 through Fiscal Year 2008
For the
Fort Peck Flow Modification Biological Data Collection Plan

Background

The U.S. Army Corps of Engineers (USACE) proposes to test operations of Fort Peck Dam following specifications outlined in the Missouri River Biological Opinion (U.S. Fish and Wildlife Service (USFWS 2000). Tests of modified dam operations is proposed to analyze operations which increase discharge and enhance water temperatures during late May and June to provide spawning cues and enhance environmental conditions for pallid sturgeon and other native fishes. In contrast to "normal" cold-water releases through Fort Peck Dam, water from Fort Peck Reservoir will be released over the spillway during flow tests to enhance water temperature conditions. The USACE proposes to conduct a mini-test to evaluate structural integrity of the spillway and other engineering concerns (USACE 2002). A full-test will occur the first year with sufficient storage after the mini-test. The full test consists of a maximum of 19,000 cfs over the spillway. Spillway releases will be accompanied by an additional 4,000 cfs released through the dam. Spillway releases during the full-test are targeted to increase water temperature to a minimum of 18°C (64.4°F) at river mile 1746, 24 miles downstream from Fort Peck Reservoir. All proposed flows are dependent on adequate inflows to Fort Peck Reservoir and adequate water levels in the reservoir.

The original schedule of events for conducting the flow tests called for conducting the mini-test during 2001 and the full-test during 2002. However, insufficient water levels in Fort Peck Reservoir during spring 2001, 2002, and 2003 precluded conducting the mini-test and full-test. Pending adequate water levels in Fort Peck Reservoir, the mini-test is targeted to occur in 2006 and the full-test in 2007, but the tests can occur in any year water is available (William D. Miller, USACE, Omaha District, personal communication).

The USFWS 2000 mandated that the USACE develop a monitoring study that would be used to quantitatively evaluate changes in physical habitat and biological responses of pallid sturgeon and other native fishes to modified dam operations. The monitoring study (outlined in the Scope of Work below) entails collecting physical and biological data in years prior to implementation of flow tests (baseline or pre-treatment data), in years during the mini-test and full-test (treatment data), and at least one year following the full-test (post-treatment data). The Montana Department of Fish, Wildlife, and Parks (MTFWP) implemented the monitoring study in 2001, 2002, and 2003 under a separate agreement with the USACE. The proposed Scope of Work augments data collected during the previous 3 years, and will provide continuity in the monitoring study through at least 2008 (pending adequate water levels for the spillway release).

Scope of Work

The Contractor is responsible for providing all labor, equipment, plant, materials, miscellaneous items, and overhead necessary to accomplish the following tasks: (Any meetings, coordination, reviews, conference calls, etc shall be included in the cost of the tasks.)

Monitoring component 1: Measuring water temperature and turbidity in the Missouri River downstream from Fort Peck Dam. Enhancing water temperature in the Missouri River downstream from Fort Peck Dam is an integral outcome of the Fort Peck spillway releases (USFWS 2000). Thus, seasonal and annual water temperature regimes must be evaluated to determine the influence of spillway releases on water temperatures.

The MTFWP (hereafter the Contractor) will monitor water temperature at established sites (see Braaten and Fuller 2002; Braaten and Fuller 2003) from May through October using continuous-recording water temperature loggers. The Contractor will also monitor turbidity at established sites from May through August using continuous-recording turbidity loggers. Water temperature and turbidity will be monitored from FY2004 through FY2008.

Monitoring component 2: Seasonal use, telemetry, and movements of adult pallid sturgeon in the Missouri River downstream from Fort Peck Dam. The majority of sampling effort expended for adult pallid sturgeon occurs in the Yellowstone River and Missouri River downstream from the Yellowstone River confluence. Conversely, minimal sampling effort for adult pallid sturgeon occurs in the Missouri River upstream from the Yellowstone River confluence. Incidental collections of adult pallid sturgeon (Braaten and Fuller 2003) and occasional movements of adult pallid sturgeon in the Missouri River upstream from the Yellowstone River confluence (D. Fuller, MTFWP, personal observation) suggest this reach of the Missouri River may be used by adult pallid sturgeon more than previously anticipated. A sampling program directed specifically towards adult pallid sturgeon in this river reach is required to more thoroughly address this question.

The Contractor will sample for adult pallid sturgeon in the lower 70 miles of the Missouri River upstream from the Yellowstone River confluence, in the Yellowstone River to the Intake Dam, and in other areas that pallid sturgeons become apparent. Sampling will be conducted from April through September, as this time frame spans the period when adult pallid sturgeon have been caught (Braaten and Fuller 2003) or moved into this reach based on telemetry relocations (D. Fuller, MTFWP, personal observation). Adult pallid sturgeon will be sampled in available habitats using trammel nets, otter trawls, and other gears conducive to the habitats. Sampling will occur from FY2004 through FY2008.

The Contractor will surgically implant radio transmitters in adult pallid sturgeon sampled in any reach. The implanting will be coordinated with and approved by the USFWS. However, transmitters will only be implanted during September as water temperature declines to minimize stress to the individuals. The Contractor must use Combined

Acoustic Radio Transmitters (CART tags; Lotek Wireless, Inc.) to maintain consistency with existing technology used by researchers in this reach of the Missouri River. Pallid sturgeon implanted with CART tags will be tracked via boat at weekly intervals from April through July, and at bi-weekly intervals from August through October in conjunction with other telemetry studies (see Monitoring component 3 below). Adult pallid sturgeon implanted with CART tags will be tracked from FY2004 through FY2008.

Monitoring component 3: Examining flow- and temperature-related movements of paddlefish Polyodon spathula, blue suckers Cycleptus elongatus, and shovelnose sturgeon Scaphirhynchus platorynchus. Similar to pallid sturgeon, seasonal migrations and spawning of native Missouri River fishes including paddlefish, blue suckers, and shovelnose sturgeon are influenced by seasonal changes in discharge and water temperature. Enhanced water temperature and flow regimes resulting from modified spillway releases are anticipated to cue spawning migrations into the Missouri River downstream from Fort Peck Dam, and improve spawning conditions. An intensive telemetry study designed to evaluate discharge- and temperature-related movements in relation to spillway releases is necessary to evaluate biological response.

The Contractor will sample for paddlefish, blue suckers, and shovelnose sturgeon in the Missouri River downstream from Fort Peck Dam, and implant a minimum of 20 individuals from each species with CART tags. The Contractor will also sample in the Yellowstone River up to the Intake Dam. The CART tags will be implanted during September in FY2004 and FY2005. Movements and locations of blue suckers, paddlefish, and shovelnose sturgeon will be determined via boat (and air, if necessary) at weekly intervals from April through July, and at bi-weekly intervals from August through October. In addition to manual tracking, the Contractor will deploy, operate, and maintain a series of six continuous-recording telemetry-logging stations (1 in the Milk River, 5 in the Missouri River) from April through October. The species will be tracked from FY2004 through FY2008.

Monitoring component 4: Quantifying larval fish distribution and abundance. Enhanced water temperature and discharge regimes resulting from the spillway releases are expected to increase spawning success for pallid sturgeon and other native fishes in the Missouri River downstream from Fort Peck Dam. An intensive larval fish sampling program is necessary to quantify changes in spawning success and larval fish densities resulting from the spillway releases.

The Contractor will sample larval fish at selected sites in the Missouri River and adjacent habitats, and in the Yellowstone River (see Braaten and Fuller 2002; Braaten and Fuller 2003) from late May through July. Sampling will be conducted at 2-3 day intervals at each site during this time frame. The Contractor will process the larval fish samples, and perform the identification of larvae. Larval sturgeon sampled may be sent to Dr. Darrel Snyder (Colorado State University) to provide expert identification of larval pallid sturgeon and shovelnose sturgeon. Larval fish will be sampled from FY2004 through FY2008.

Monitoring component 5: Quantify the distribution and abundance of young-of-year sturgeon. The USFWS 2000 (p. 98) presented that there is no evidence to suggest that pallid sturgeon have successfully reproduced in the upper Missouri River including the reach downstream from Fort Peck Dam. In September 2002, two young-of-year (YOY) pallid sturgeon and several YOY shovelnose sturgeons were sampled in the Missouri River downstream from the Yellowstone River confluence (Braaten and Fuller 2003). However, it is not known whether these individuals were spawned in the Missouri River or Yellowstone River. These collections provide the first documented evidence of successful reproduction of pallid sturgeon in recent years. An intensive sampling program specifically targeting YOY sturgeon is necessary to further evaluate successful reproduction by pallid sturgeon and shovelnose sturgeon. This monitoring component is complementary to the larval fish sampling (Monitoring component 4) as it provides another method to quantify spawning success of pallid sturgeon and shovelnose sturgeon under existing flow and temperature regimes, and under modified flow and temperature regimes resulting from spillway releases.

The Contractor will sample for YOY sturgeon at selected sites (Braaten and Fuller 2003) in the Missouri River upstream and downstream from the Yellowstone River confluence, and in the Yellowstone River. The sampling regime will target available habitats including but not limited to outside bends, inside bends, and channel crossover areas. Sampling will be conducted with a beam trawl and/or otter trawl pending otter trawl performance tests in these areas. The Contractor will sample all sites at weekly intervals from early August through mid-September. The Contractor will identify larval sturgeon to species, and supplement species identifications with expert identifications provided by Dr. Darrel Snyder (Colorado State University). The YOY sturgeon sampling program will be conducted from FY2004 through FY2008.

Monitoring component 6: Drift rate, drift behavior, and transport of larval sturgeons in the Missouri River downstream from Fort Peck Dam. The early life history of pallid sturgeon and shovelnose sturgeon is poorly understood, and this is particularly true for the larval life stage. Initial results from laboratory studies suggest larval sturgeon migrate downstream for a period of up to 12-13 days, and move a cumulative distance of about 13 km (Kynard et al. 2002). However, these studies were conducted at low velocities in an experimental stream. Higher velocities (e.g., 0.3 – 0.5 m/s), similar to those found in the Missouri River downstream from Fort Peck Dam, may increase the drift rate of larval sturgeon and increase the downstream drift and migration distance. Additional studies were conducted in 2003 to more thoroughly evaluate drift behavior and drift rate of larval sturgeon at higher velocities. These studies were conducted in the laboratory (USGS, Conte Anadromous Fish Research Center, report in preparation) and in a side channel of the Missouri River downstream from Fort Peck Dam (MTFWP, Fort Peck; USGS, Fort Peck; report in preparation). These studies will be expanded in subsequent years to provide an increased understanding of larval sturgeon drift rates and behavior.

The Contractor will conduct larval sturgeon drift studies in the Missouri River downstream from Fort Peck Dam to quantify drift rate as a function of water velocity.

Studies in FY2004 will be conducted in the main stem Missouri River using larval shovelnose sturgeon. In FY2005, the Contractor will conduct a larval drift study in a side channel of the Missouri River (preferably the same side channel used in 2003) using larval pallid sturgeon. Use of larval pallid sturgeon will be dependent upon approval from the USFWS. If results from the side channel in 2005 (larval pallid sturgeon) are similar to those from 2003 (larval shovelnose sturgeon), it will not be necessary to expand the larval pallid sturgeon studies to the main stem Missouri River. Significant differences between studies may warrant additional studies in the main stem. Additional larval sturgeon drift studies will be conducted in the laboratory by the USGS during FY2004 and FY2005. Thus, the Contractor will coordinate and communicate with the participating USGS entities to facilitate exchange of information and ideas resulting from the similar studies. The U.S. Army Engineer Research and Development Center (CEERD) will be conducting flow modeling measurements in the Missouri River and develop models. The Contractor will also coordinate and communicate with the Corps entities to facilitate exchange of information and ideas. The Contractor will perform a site visit during the CEERD fieldwork.

Monitoring component 7: Food habits of piscivorous fishes. The public has expressed concern that piscivorous fishes in the Missouri River downstream from Fort Peck Dam may feed on larval sturgeon. Food habit studies of piscivorous fishes during 2001 (Braaten and Fuller 2002) and 2002 (Braaten and Fuller 2003) showed that several fish species did consume fish prey, but there was no indication that piscivores consumed larval sturgeon. Studies in 2001 and 2002 were conducted under normal dam releases (e.g., spillway releases did not occur).

During 2007 (or the first year the full-test of spillway releases is implemented), the Contractor will conduct a food habit study of potential piscivores in the Missouri River downstream from Fort Peck Dam that is consistent with earlier studies conducted in 2001 and 2002. The contractor will sample walleyes *Stizostedion vitreum*, saugers *S. canadense*, northern pike *Esox lucius*, goldeye *Hiodon alosoides*, channel catfish *Ictalurus punctatus*, freshwater drum *Aplodinotus grunniens*, shovelnose sturgeon, and bubot *Lota lota*. A minimum of 30 individuals from each species will be sampled in July and August from all available habitat types. Stomach contents will be removed, and identified.

Monitoring component 8: Fort Peck fish barrier. Public concern was expressed about potential loss of game fish particularly walleye via the spillway during operation. Additionally, changes in the river fisheries due to changing habitat may be obscured by passage of fish from the reservoir to the river. Both concerns are addressed by placing a fish barrier to prevent fish from passing through the spillway. To document effectiveness of the barrier, fish will be tagged in the vicinity of the spillway from April through July during the years the spillway will be in operation. The fish will be captured with trap nets and merwin traps, and tagged with t-tags. Additional walleye and pike may be tagged during the annual walleye egg-take in the upper Dry Arm of Fort Peck. Survey crews in the river will report any catch of tagged fish.

Monitoring component 9: Assisting with the larval survival test. The Contractor will provide bedding material (substrate) from the transitional area of the Missouri River/Reservoir headwater areas of Lake Sakakawea (delta-silt) and bedding material (substrate) from ideal rearing areas in this reach. This early life food source will be delivered to the Bozeman Fish Technology in Bozeman, Montana (USFWS). The Contractor will provide insight, advise, and provide River Field support to the USFWS larval testing group.

In addition to this laboratory evaluation of survival, the feasibility of evaluating survival of pallid sturgeon utilizing live cribs in the field within these river/reservoir transitional areas will be explored. The USFWS would have to concur with this field experiment as well as the Pallid Sturgeon Recovery Team. If approved, this study would consist of live cribs being placed at various locations in the headwater areas of Lake Sakakawea. Pallid sturgeon fry (pre- and post-yolk sac absorption) will be held in these cribs to evaluate survival in these areas. Additional cribs further upstream in the river would serve as "controls" for the study. A variety of water quality data (e.g., temperature, dissolved oxygen) would be collected throughout the experiment. (The actual work will be added to the Contract by modification, if it proves to be feasible.)

Monitoring component 10: Investigate the development of a scope of work to determine if "imprinting" exists in pallid sturgeon population located in the Fort Peck Reach. The Contractor will perform necessary research into imprinting, coordinate with the appropriate individual parties, and develop possible investigation methods.
(The actual work may be added to this Contract by modification.)

Monitoring component 11: Assist the USFWS with broodstock collection. The Contractor will schedule time to assist the USFWS with broodstock collection in the spring of each year of the contract.

Scope of Work For Possible Future Work (Do Not Include in Proposal) (This work may be added by modification at a later date, additional details would be provided at that time.)

Background

Questions exists regarding if "imprinting" exists in pallid sturgeon population located in the Fort Peck Reach and about the pallid sturgeon larval survival in the transition area of the Missouri River/Reservoir headwaters of Lake Sakakawea (delta-silt).

Additional Monitoring (Tasks 10 -)

The Contractor may be responsible for implementing or supporting:

- Larval survival test

- Pallid sturgeon imprinting testing

Background

In accordance with the 2000 BiOp (RPA element VI A), the Corps is responsible for producing a portion of the pallid sturgeon to meet annual stocking goals. The Corps' responsibility is referred to as the "Average Annual Shortfall" which has been identified as the pallid sturgeon that have not been produced in culture efforts prior to 2000 because of various limitations (e.g., hatchery facilities). The Corps does not possess the essential facilities to culture these fish to accomplish this requirement. A strategy of enhancing propagation levels at a select few facilities possessing the infrastructure and unique knowledge to propagate and stock pallid sturgeon will fulfill this responsibility. Support for these activities with partnering agencies will be handled through long-term contracts.

Pallid Sturgeon Propagation and Augmentation (Tasks 21-).
The contractor will be responsible for a range of tasks, which may include:

- Pallid sturgeon broodstock collection, sexing and transport
- Egg staging and spawning
- Cryopreservation of genetic material
- Pallid sturgeon incubation and fry shipment
- Pallid sturgeon culture
- Pallid sturgeon tagging
- Pallid sturgeon stocking/distribution
- Annual summary report encompassing all activities

The contractor must adhere to all approved protocols for these task activities (e.g., spawning and stocking guidelines, stocking rates, culture densities, etc.)

Background

In accordance with the 2000 BiOp (RPA element VI B), the Corps is required to design a program to monitor pallid sturgeon populations in the high priority river segments of the Missouri River. This RPA element requires the design of the program have the ability to detect improvements in the warm water benthic fishery and collect habitat characteristic data in conjunction with fishery surveys. The Corps and collaborators have developed a plan and protocols for a population assessment program for pallid sturgeon including the associated fish community. The Corps does not possess the necessary skills to implement this program. Long-term contractual agreements will be utilized with the appropriate agencies to implement this program in the Fort Peck Reach.

Pallid Sturgeon Population Assessment (Tasks 31-)

The contractor will be responsible for a variety of tasks which may include:

- Biological surveys for Sturgeon Sampling Season
- Biological surveys for Fish Community Sampling Season
- Habitat characteristic data collection
- Age/Growth data collection
- General data collection (Datasheet submission, QA/QC)
- Annual summary report

All sampling must be in compliance with Long-Term Pallid Sturgeon and Associated Fish Community Assessment for the Missouri River and Standardized Guidelines for Sampling and Data Collection

Timeline and Deliverables

The Contractor will conduct the study components during the timeframes discussed above and summarized in the table below. The Contractor will submit monthly reports of activities and progress to the USACE, and the monthly report can also be submitted to other state and federal agencies that are involved in studies on the Missouri River. An annual report will be prepared and submitted to the USACE by July 1. The annual report can also be circulated to members of the Upper Basin Pallid Sturgeon Work Group.

See Table 1.

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USACE. 2002. Draft environmental assessment, Fort Peck flow modification mini-test. U. S. Army Corps of Engineers, Omaha District, Omaha, Nebraska.

USFWS 2000. Biological opinion on the operation of the Missouri River main stem reservoir system, operation and maintenance of the Missouri River bank stabilization and navigation project, and operation of the Kansas River reservoir system. U. S. Fish and Wildlife Service, Region 3 (Fort Snelling, Minnesota) and Region 6 (Denver, Colorado).

The monthly reports can be sent by email or letter. The annual report will be in the format of, detail of, and in content of the Summary of 2001 Activities Report dated June 2002 (attached). The field notes and all data supporting the summary will be electrically maintained by the Contractor in a system that is compatible with the Corps. The field notes and supporting data will be made available to the Corps at any time upon request and at completion of the Contract.

References to established sites in the above tasks are defined as the established sites in the Summary of 2001 Activities Report dated June 2002.

All information, data, and reports are the property of the Corps of Engineers. No report can be published without the permission of the Corps of Engineers. The monthly reports and annual report can be circulated to members of the Upper Basin Pallid Sturgeon Work Group and other state federal agencies that are involved in the studies on the Missouri River, but only after all the Contracted Quality Control tasks have been performed on the data in the reports. The parties that the reports are to be provided to must agree to not publish information from the reports without the permission of the Corps of Engineers.

The Contractor shall develop and provide to the Corps working protocols, and procedures for the tasks in the contract that are similar to those used during the monitoring program performed by the Contractor under a separate agreement performed during 2001 thru 2003. These documents will be subject to Corps inspection and revised when needed to assure the requirements of the contract tasks are met. Due to the nature of data collection for physical responses, a general scope of work is provided without specific details on how to accomplish these tasks. The methods used shall be of sufficient quality to provide defendable data. The Contractor is expected to adjust to changing conditions discovered during the activities and develop revised methods that will maintain the quality of the data. The Government will be in formed of revisions to the established protocols and methods. The Government can specify changes to the protocols and methods.

The Contractor will allow complete inspection/review of all Contractor tasks activities by the Corps and provide all necessity support and equipment to allow the Corps to accompany the Contractor during the accomplishment of the contract tasks.

The Contractor will establish and conduct a Quality Control Program for the contract tasks. The Contractor will submit a detailed Quality Control Plan for approval, which addresses the process for reviewing the protocol for each task at the start of each task session and at monthly intervals during the task. The Quality Control Plan should also include all the Quality Control procedures previously included in the FY01 and FY02 Data Collection Plans.

Payment request will be made monthly by invoice sent to the attention of Mr. Mark Drobish, CENWO-OD-TT.

Contract is for a five year time period from NTP, but the contract may be extended by contract modification depending on the timing of the test flows.

If not stated otherwise in the Contract, the Contractor will follow established MTFWP procedures.

The Contractor shall summit their proposal in the following format to allow cost comparison with the Government. See table enclosed.

The contractor shall submit their proposal in the following format to allow cost comparison with the Government. Monitoring Component Cost Table.

	Monitoring Component									
FY Element/ Tasks	1 Temperature/ turbidity	2 Pallid sturgeon sampling/ telemetry	3 Native species telemetry	4 Larval fish	5 Young-of-year sturgeon	6 Larval drift	7 Food habits	8 Fish barrier	9 Broodstock collection	Totals
2004										
Labor										
Plant										
Equipment										
Overhead										
2005										
Labor										
Plant										
Equipment										
Overhead										
2006										
Labor										
Plant										
Equipment										
Overhead										
2007										
Labor										
Plant										
Equipment										
Overhead										
2008										
Labor										
Plant										
Equipment										
Overhead										

Table 1. Timeline table for conducting monitoring components associated with the Fort Peck Data Collection Project.

	Monitoring Component										
Month	1	2	3	4	5	6	7	8	9	10	11
Jan											
Feb											
Mar											
Apr		X	X					X			X
May	X	X	X	X				X		X	X
Jun	X	X	X	X		X		X	X	X	
Jul	X	X	X	X			X	X	X	X	
Aug	X	X	X		X		X				
Sep	X	X	X		X						
Oct	X	X	X								
Nov											
Dec											
Fiscal Years	2004 – 2008	2004 – 2008	2004 – 2008	2004 – 2008	2004 – 2008	2004, 2005	2006	2005 – 2006	2004 – 2005	2004 – 2005	2004 – 2008

SCOPE OF WORK

Interactions Between River Transport Processes, Drift Behavior, and Habitat Use Of Larval Pallid Sturgeon (*Scaphirhynchus albus*) in the Missouri River Below Fort Peck Dam, Montana
(Draft 1/17/03)

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For the U.S. Army Corps of Engineers

Background

Eggs and larvae of numerous fish species in rivers are transported via water currents from upstream spawning areas to downstream habitats where they settle from the current (Mion et al. 1998; Robinson et al. 1998). Despite recognition of this process, there is a substantial information gap in our knowledge of how hydrologic factors (e.g., river currents) and behavior during the early larval stages interact to influence larval drift rate and distance. An understanding of behavior, drift characteristics, and habitat use of larval pallid sturgeon is recognized as a high priority, immediate research need (Montana-Dakota Pallid Sturgeon Work Group 2000) because the information is critical for identifying potential upstream spawning sites, determining the length of river needed by larval pallid sturgeon, predicting potential settling areas for larvae in downstream areas, and predicting the outcome of pallid sturgeon restoration efforts in the Missouri River.

Results from preliminary studies suggest that the behavior and drift characteristics of larval pallid sturgeon are complex. In laboratory studies, Kynard et al. (1998) and Kynard et al. (2002) found larval pallid sturgeon exhibited an 8-13 day period of downstream migration immediately after hatching. Larvae 0-4 days old predominantly drifted, whereas larvae age-5 and older exhibited directed downstream movements indicative of active downstream migration. In addition, the vertical distribution of larval pallid sturgeon in the water column changed with ontogenetic development. Although results from Kynard et al. (1998) and Kynard et al. (2002) provide an initial understanding of behavior and drift characteristics of larval pallid sturgeon, the studies were conducted under a limited suite of laboratory conditions. For example, mean velocity in the laboratory stream was 15 cm/s, and depth was 20-100 cm deep. Hydraulic conditions (e.g., depth and velocity) in the Missouri River generally exceed the laboratory conditions used by Kynard et al. (Galat et al. 2001); therefore, results on the behaviors and drift characteristics from existing laboratory studies may not be directly extrapolated to natural hydraulic conditions. Higher water velocities (e.g., 50 cm/s) may increase the downstream drift rate of 0-4 day old pallid sturgeon larvae and increase the length of river needed by larval sturgeon to complete their ontogenetic development. Incorporating behavioral data from Kynard et al. (1998) with limited hydraulic data from the Yellowstone River, Krentz (2000a) estimated that the minimum drift distance for larval pallid sturgeon was 55-89 km (23-55 miles). Also based on the preliminary research by Kynard et al. (1998), the USFWS (2000) estimated that larval pallid sturgeon may drift in the water column for 64-643 km (40-399 miles).

One of the few remaining concentrations of pallid sturgeon inhabits the lower 113 km (70 miles) of the lower Yellowstone River and 322 km (200 miles) of the Missouri River between Fort Peck Dam, Montana, and the headwaters of Lake Sakakawea, North Dakota (Figure 1). However, long-term viability of this population is in jeopardy. Recruitment has not occurred for several years as evidenced by a population comprised of large (e.g., > 1200 mm, > 8 kg; Liebelt 1996, 1998) and presumably old individuals. The limited availability of spawning habitat and limited availability of riverine habitat for larval pallid sturgeon are primary factors contributing to the lack of recruitment in the Missouri River-Yellowstone River reach (USFWS 2000). However, it is not specifically known what length of free-flowing river is needed by larval pallid sturgeon. Detailed studies of the interactions between river transport processes and larval pallid sturgeon behavior, drift characteristics, and habitat requirements are necessary to gain a better understanding of factors impeding recruitment in the Missouri River-Yellowstone River reach.

The goal of this study is to gain an understanding of the behavior and habitat requirements of larval pallid sturgeon related to the lack of recruitment in the Missouri River-

Yellowstone River reach. The proposed study is comprised of five components: 1) develop river travel time models based on relationships between discharge and velocity for the Missouri River downstream from Fort Peck Dam, 2) quantify behavior and drift characteristics of larval pallid sturgeon in the laboratory through a range of velocities, 3) examine behavior and drift characteristics of larval sturgeon in the field, 4) model transport of larval pallid sturgeon based on results from study components 1, 2, and 3, and 5) evaluate survival of larval pallid sturgeon under environmental conditions similar to those in river-reservoir transition areas such as the headwaters of Lake Sakakawea, North Dakota. Two examples highlight the relevancy of the proposed research to pallid sturgeon restoration and recovery plans.

Example 1 – Yellowstone River

The Yellowstone River is characterized by relatively natural discharge, water temperature, and sediment regimes (White and Bramblett 1993). Pallid sturgeon migrate into the lower Yellowstone River during spring and early summer presumably in response to spawning cues provided by the natural discharge and water temperature regimes (Bramblett and White 2001). There is some indication that spawning may occur in the lower 14 km (9 miles) of the Yellowstone River (Krentz 2000b; USFWS 2000; Bramblett and White 2001). However, lack of naturally reproduced young-of-year and juvenile pallid sturgeon in monitoring surveys (Liebelt 1996, 1998) despite successful spawning suggests a recruitment bottleneck during the early larval life stages of pallid sturgeon. About 64 km (40 miles) to 97 km (60 miles) of free-flowing riverine habitat for larval drift dynamics exists between suspected spawning areas in the lower Yellowstone River and the headwaters of Lake Sakakawea. It has been hypothesized that larval pallid sturgeon cannot survive in silty, depositional habitats such as those found in the river-reservoir transition areas of Lake Sakakawea (Krentz 2000b; USFWS 2000). Therefore, the recruitment bottleneck for pallid sturgeon is likely related to the insufficient length of continuous free-flowing river needed by larvae to complete their ontogenetic development. Results from the proposed study will address this hypothesis.

Example 2 – Missouri River below Fort Peck Dam

As outlined in the Missouri River Biological Opinion (USFWS 2000), operations of Fort Peck Dam will be modified in the future (pending the availability of adequate water levels in Fort Peck Reservoir) to enhance water temperature, increase flows, and provide more suitable spawning conditions for pallid sturgeon in a 322 km (200 mile) reach of the Missouri River downstream from Fort Peck Dam. However, limited information is available to determine how increased channel velocities associated with elevated discharges interact with larval drift behavior to influence larval drift distance. For example, if enhanced discharge and water temperature regimes promote spawning by pallid sturgeon in the Missouri River below Fort Peck Dam, will the length of free-flowing river downstream from the spawning site(s) provide sufficient habitat for ontogenetic development? Detailed knowledge of larval drift behavior and hydraulic forces (e.g., water velocity) that serve as the transport mechanism are needed to thoroughly evaluate this and other related questions.

Scope of Work

Study Component 1 – Development of river travel time models based on relationships between discharge and water velocity (Principal Investigators: Dr. Pat Braaten, U.S. Geological Survey, Biological Resources Division, Fort Peck Project Office, Fort Peck, Montana; John French, U. S. Geological Survey, Water Resources Division, Fort Peck, Montana; Dave Fuller, Montana Department of Fish, Wildlife, and Parks, Fort Peck, Montana; John Remus, U. S. Army Corps of Engineers, Omaha, Nebraska).

River discharge and hydraulic data (depth and velocity) for the Missouri River between Fort Peck Dam and the headwaters of Lake Sakakawea will be compiled from existing sources (e.g., U.S. Geological Survey, U.S. Army Corps of Engineers, Montana Department of Fish, Wildlife, and Parks, North Dakota Game and Fish Department) and from additional data collected as part of the study. Relations between discharge (independent variable) and velocity (dependent variable) will be constructed from existing data to estimate changes in mean velocity as a function of discharge (Figure 2). From this information, it will be possible to estimate travel time (e.g., hours, days) from Fort Peck Dam to selected downstream points in the Missouri River. Based on relations between discharge and velocity, a range of velocities likely encountered by larval pallid sturgeon during drift stages in the Missouri River will serve as treatments for testing larval behavior through a range of velocities (see Component 2 below). Travel time for a range of discharges will also be estimated by measuring the downstream progression of discharge "peaks" or "troughs" between successive USGS gauging stations that correspond to increases or decreases in discharge releases through Fort Peck Dam (Figure 2). Existing gauging stations are located downstream from Fort Peck Dam (06132000), near Wolf Point (06177000), and near Culbertson (06185500).

Existing discharge and velocity data will be augmented by additional data collected during the 2003 field season. Five 16.1 km (10 mile) river reaches will be established at the following locations: 1) downstream from the Milk River (river mile, RM 1751.5 to 1761.5), 2) near Wolf Point (RM 1701-1711), 3) near Poplar (RM 1680-1690), 4) near Culbertson (RM 1620-1630), and 5) near Nohly (RM 1588-1598). Within each reach, one inside-outside bend complex (IOBC; described below) will be randomly selected from all IOBC available in the 16.1 km reach. An IOBC longitudinally progresses from one channel crossover (CHXO; point where the thalweg crosses from one side of the river to the other side of the river) to the next downstream CHXO, and includes the outside bend (OSB) erosional zone and inside bend (ISB) depositional zone (e.g., sand bars, side channels). Four permanent transects will be established within each randomly selected IOBC. The transects will be positioned perpendicular to the flow at the upstream CHXO, between the CHXO and apex of the bend, at the apex of the bend, and between the apex of the bend and the next downstream CHXO. Hydraulic data (cross-sectional area, depth, velocity, discharge) will be measured on each transect using an Acoustic Doppler Current Profiler (ADCP) linked to a differentially corrected GPS unit. Hydraulic measurements will be obtained at a minimum of three discharge levels spanning extremes that occur in 2003.

Study Component 2 – Laboratory quantification of behavior and drift characteristics of larval pallid sturgeon through a range of velocities (Principal Investigator: Dr. Boyd Kynard, Erika Henyey Parker, U.S. Geological Survey, Conte Anadromous Fish Research Center, Turner Falls, Massachusetts).

The drift characteristics and distance drifted of migrant pallid sturgeon ELS (early life stages = free embryo and larvae) depends on the river environment (particularly, water discharge and velocity), and also on behavior of the fish. Recent laboratory studies show that much of migrant ELS behavior in response to physical environmental factors (and habitat) is innate (i.e., illumination intensity, substrate color, and water depth selection; Kynard et al. 2002). Thus, understanding early behavior is critical to predicting and understanding drift characteristics and movement rate of ELS.

The primary objective of the present study is to determine if ELS have a genetic preference to remain in the fastest available velocity. If this is the case, then predicting drift rate of fish in the river will be straightforward. However, if fish prefer to remain in fast flow sometime and in slow flow at other times, predicting their ultimate drift rate from a laboratory study cannot be done because drift rate in the river will vary depending on the actual amount of time fish spend in fast and slow habitat. Thus, drift rate can only be done by in situ monitoring of fish in the river under natural conditions. Objectives of the present study are to 1) determine if migrants drift at the same rate as the fastest water movement in slow, moderate, and fast velocity flows, 2) determine the daily diel drift rate (distance per hour) at the three velocity environments, and 3) determine the diel swimming height above the bottom during day and night.

Drift Rate: The behavior and drift characteristics of ELS during ontogenetic development will be studied through a range of velocities in experimental channels to at least day-14 of the larval interval (cessation of migration). Velocities used in tests will be based on velocity results obtained in Study Component 1 (above). For example, if available mean velocities in the Missouri River downstream from Fort Peck Dam vary from 0.1 m/s to 1.3 m/s through a range of discharges, then ELS behavior and drift characteristics will be examined at a selected subset of velocities within the velocity range. Experience observing ELS indicates that distinguishing the small fish from detritus with video may be impossible at high velocities (e.g., > 0.5 m/s). Given this limitation to experimental tests, we will likely use three velocity environments with maximum velocities of 0.1 m/s, 0.25 m/s, and 0.5 m/s). Obtaining information on drift rate of ELS at higher velocities (e.g., 1.0 m/s) is preferred, but not possible due to limitations observing fish. Using short tests (introducing a fish and following it for a short time) is not an alternative mainly because fish would have to be introduced periodically through the day and night of each day to account for the know difference in diel drift rate during ontogenetic development (Kynard et al. 2002) and fish would have to be kept in separate tanks to test the same fish through time. We do not have the capability to do this. We believe that doubling the drift results of fish at 0.5 m/s to estimate drift at 1.0 m/s would be biologically preferable to extrapolating the results of a series of short drift tests. No information suggests a velocity threshold is needed for migration, instead all evidence indicates ELS have an innate behavior to swim-up above the bottom into the water column regardless of current velocity. The result of this active swimming is that fish move into the current and move downstream in a river. No evidence suggests there is a threshold velocity above which fish cannot resist the current; they do not resist current. However, they may not prefer to use the fastest current during the entire migratory period.

To determine the average movement rate of fish at each of three velocity environments, we need observations on multiple fish at each velocity condition. However, it is impossible to test fish in a group because each individual is small and cannot be distinguished by video from other individuals each time it makes a loop around the tank. Thus, individual movement rates cannot be determined using video observations of a group. We will determine individual movement rates using two fish of different size in each test tank. We will use three tanks at each velocity environment (total, 9 tanks). We will introduce one hatchling embryo into each tank, and then after 4-5 days (beginning of larval period), introduce a second smaller fish (hatchling embryo from another rearing tank with cooler water that has retarded hatching date). With one large and one small fish in each tank, we can distinguish each individual using video, and thus, determine the movement rate (time to move one loop around the tank) of each fish. Data will be collected on six fish at each velocity level (two fish per tank x 3 tanks at each velocity level) and the mean movement rate of the six fish in each velocity environment will be calculated. If a fish dies, it will be replaced immediately by another fish from the appropriate rearing tank (normal or chilled temperature), so data will not be lost.

Fish movement will be studied using nine circular tanks (5-ft diameter) with a 2.5 ft. diameter circular insert inside the large tank to create a channel. Water depth will be about 16 in; channel color is light blue. The insert will be positioned off-center in the 5 ft. tank to create a 9 in. wide channel at the closest point and a 21 in. wide channel at the opposite end of the channel. This will create a channel with fast velocity along the narrow width and along the entire outside wall, a decreasing velocity in the wide part of the channel away from the outside wall, and a slow-water, eddy along the inside wall of the wide channel. This tank configuration creates the habitat complexity present in a river (but on a smaller scale), and will give fish a choice of velocity habitats.

Our previous research in a similar shallow channel of uniform width and velocity found migrants use the entire water column, bottom to surface, by actively swimming up, stopping swimming and drifting motionless down to or near the bottom, then resuming swim up. Thus, the mean velocity of the fast velocity zone around the channel periphery best reflects the fastest migration route. We will characterize this fast water route in each tank by determining the mean velocity at .2 and .8 depth at 12 equidistant stations around the channel, each station 4.5 in from the outside wall. We will also determine the drift rate of a float (vertical quill float that extends from surface to mid-depth) floated around the tank margin in the fastest water. Mean movement rate of the float will be determined by averaging the results of three float tests in each tank (9 float tests per velocity environment).

The appropriate maximum water velocity environment for the three groups of tanks will be provided by a submersible pump located underneath a bottom plastic ramp (20 in long x 8 in high) placed in the narrow channel. The ramp will create shallow water (8 in deep) and provides the best site to observe passing larvae with video. Past studies indicate day-8 and older larvae will move mostly at night, so we will use IR light to observe migrants at night during the entire study. The bottom and sides of the viewing area will be covered with reflective tape to facilitate seeing fish at night.

Data collected from video observations of migrants will be the number of passes by each fish up- and downstream for 5 min each hour of the 24-h day. The daily downstream movement speed and distance traveled by each migrant in the slow, moderate, and fast velocity test groups will be determined by enumerating the number of passes per 5 min (loops per 5 min). Then, using the distance traveled per loop, we will determine the total distance traveled and movement rate (distance moved/5 min) for each fish. The cumulative distance moved per hour will be determined by extrapolating the movement rate of each fish for each 5 min period to the entire 60 min period. The data from individual fish of each test group will be analyzed to produce a daily mean distance and movement rate with error bars. Day and night variation in distance and movement rate will be examined for significant differences. Mean movement rates of fish (n=6 per velocity group) in each of the three test groups (slow, medium, fast velocity) for each day during day and night will be compared to the mean movement rate of the passive float in the three test groups to determine if fish move at the same rate, faster, or slower than the mean rate of the fastest water flow in the three flow conditions.

Swimming height: Preference of ELS for swimming height above the bottom was investigated in a 150-cm high vertical stream tube which had uniform velocity top to bottom (picture and description in Kynard et al. 2002, the methods of which are provided at the end of this section). During studies in the vertical stream tube, day-7 and older larvae swam to the top of the tube, suggesting they would swim higher, possibly to the water surface, if possible. If larvae swim to the surface and remain there, then any model to predict drift rate should account for the vertical distribution. This knowledge is also useful for directing sampling for ELS in the river.

We will conduct swimming height tests of ELS in a 12-foot high (360 cm) stream tube much like the shorter 150-cm high tube used successfully earlier. This length tube was selected after discussion with Pat Braaten on river depths available to migrating ELS. A small paddlewheel turning at the center of the cylinder creates the same velocity top to bottom of the tube. Fish are introduced to the bottom of the tube via a small introduction tube along the paddlewheel. The paddlewheel will stop 30 cm from the surface and bottom of the tube so as to not interfere with fish preferring to remain at these two areas.

Test procedures follow: each day beginning on day-0 (hatching), 8 fish will be introduced into the stream tube and their swimming distance above the bottom determined for 14-15 min after introduction. Previous results in the 150-cm high tube found observations at 5-6 min were adequate to describe fish behavior. Because the tube in the present study is 2.4 times higher than the original tube, we will observe fish at 14-15 min instead of at 5-6 min. The mean daily swimming height will be calculated from the 8 individual fish and daily means determined for all days. Every other day, tests will also be done at night to determine if fish swimming height is similar day and night.

Methods for holding, rearing, observing migrants, and analysis of data will generally follow those presented in Kynard et al. (2002), which have been used to study the behavior of 13 species of sturgeon. A summary of methods from Kynard et al. (2002) is shown below, although not all of the methods are applicable to the present study. Laboratory studies on pallid sturgeon ELS will be used to generate a water velocity-larval behavior matrix that includes age-related larval drift characteristics (Figure 2).

Methods (from Kynard et al. 2002 for pallid and shovelnose sturgeon)

We conducted tests with 500 Missouri River pallid sturgeon that hatched on 25 June 1997 and 400 day-2 pallid sturgeon received the following year on 16 June 1998. Tests were conducted during 2 years with shovelnose sturgeon of Yellowstone River stock: in 1997, 200 fish that hatched on 18 June and 350 fish that hatched on 20 June; and in 1998, 400 fish that hatched on 24 June. The shovelnose sturgeon tested in 1997 and 1998 were from different parents. Eggs were fertilized at a federal hatchery (see Acknowledgements) then shipped to us.

The number of days after hatching was used to characterize age of fish, not the number of days after fertilization, because early rearing varied unknownly before we received eggs. Fish hatching in the first 24 h were termed day-0 fish, i.e., in 1997 pallid sturgeon were day-0 on 25 June and day-1 on 26 June. We reared fertilized eggs in hatching jars that passed embryos in overflow water into 18 or 30-l circular rearing tanks. Temperature of dechlorinated city water from Montague, MA, was similar in rearing and experimental tanks. Water temperature in the oval migration channel in 1997 was 19.0-21.0°C for pallid sturgeon and 18.0-20.0°C for shovelnose sturgeon; and in 1998, temperature was 16-18°C for pallid sturgeon and 18-18.5°C for shovelnose sturgeon. All test and rearing water temperatures were within the range of temperatures experienced by wild fish (USGS data). The natural photoperiod for the Turners Falls location was maintained at all time. Early larvae were fed 6-8 times daily using a timed feeder and four times daily with live Artemia nauplii. In 1998, larvae were fed a sturgeon starter diet (see Acknowledgements), whereas 1997 larvae were fed commercial BioKyowa.

Illumination, substrate color, height above bottom, and cover.– The year and test (species and test in parentheses) were: 1997 (both species - illumination, substrate color, and use of cover); 1998 (pallid sturgeon - height above bottom; shovelnose sturgeon - illumination, substrate color, height above bottom, and cover).

Aquaria used in illumination and substrate choice were 20-l rectangular glass tanks with black plastic covering the four vertical sides to exclude outside light. Two 0.3 m long, 20 watt fluorescent lights were placed 0.3 m above the test tanks, and with barrier partitions underneath the lights, provided the final light intensity for test aquaria. A black cover over one-half of the illumination aquarium's top divided the tank into almost equal areas of illumination (8.2-5.0 lx), dark (0.7-0 lx), and transition in the center (5.5-2.2 lx). The bottom of the illumination aquarium was clear glass and the aquarium sat on a tan table. The bottom of the substrate color aquarium was also clear, but underneath the bottom, the area was divided equally between black and white by two square pieces of white and black plastic. Illumination intensity above the substrate was: white (4.3-2.6 lx) and black (3.3-3.0 lx). During illumination and substrate tests, aquarium position was reversed after each fish to prevent recording side bias of fish. Water was replaced in aquaria between tests to keep water temperature within 1°C of rearing water.

Five pallid sturgeon and four to ten shovelnose sturgeon were tested daily for preference of illumination intensity and substrate color. Before each test, actively swimming fish were removed from a rearing tank using beaker brailing and placed together in a 1-3 l bucket. During each test, a single fish was removed from the bucket by beaker brailing and placed at the water surface in the center of the aquarium. Without acclimation, fish movement was visually recorded as a continuous time series relative to habitat (illumination test - dark, transition, and illuminated; substrate test - white or black bottom). We used an arcsine-transformation of percent data and the percentage of time sturgeon occurred on white substrate or on the illuminated side in all data analyses and calculated 95% confidence intervals to find differences from 50% (no preference).

In 1998 we daily tested 8 pallid and shovelnose sturgeon for swimming height above the bottom in an artificial stream tube that simulated a vertical section of stream (Figure 1). The stream tube was a clear plexiglass cylinder 153 cm long x 15 cm inside diameter with water 150 cm deep. A clockwise rotating paddlewheel that extended down the center of the tube created a horizontal water flow circling the tube at a velocity of 2 cm s^{-1}. A tan cloth was placed on the opposite side of the stream tube from the viewer to provide a uniform background and contrast to see the small fish. During tests, illumination level measured inside the water-filled tube (top to bottom) was 300-50 lx to 30-5 lx depending on time of day. The tube was drained after each test to remove fish and replace water and maintain water temperature within 1°C of rearing tanks.

Sturgeon for stream tube tests were obtained after mixing rearing tank fish by stirring and using beaker brailing to remove fish. Test fish for each replicate were held in a 2 l bucket, and during tests, a single fish was beaker brailed and poured into the top of the introduction tube, which carried fish to the bottom (Figure 1). Only, upward swimming and cover seeking were noted for the first 60 s (acclimation period). At 1-2 min, 5-6 min, and 9-10 min, we continuously recorded up and down movements and the vertical distance of each move. Height of fish off the bottom was determined visually using a depth scale (5 cm marks with 0 = bottom) inscribed around the outside circumference of the tube. We calculated means of high and low values for each period for each fish and presented the grand means for eight fish as a daily time series.

One-half of the stream tube bottom was covered with two layers of grey rocks (5-cm diameter) to create cover habitat and the other one-half of the bottom was open (without cover). Use of cover was recorded only when fish stopped under or by rocks.

In all substrate, illumination or stream tube tests, fish were randomly selected from hundreds of fish, and after testing, all were returned to rearing tanks. While the probability of selecting any fish a second time increased with the number of days tested, we believe the haphazard selection process should provide a group of fish with a set of random tests.

Migration and diel activity.-Migration was observed in an oval endless channel of green-blue color whose linear margin was divided into 12 sections each 62 cm long (see Figure 1, Kynard & Horgan 2001). A continuous flow-through water system supplied 1 l min $^{-1}$ of city water. The channel was 7.3 m in circumference, 32 cm wide, with water 20 cm deep. In all tests, a small submerged pump created a clockwise flow around the channel. During the brief tests with shovelnose sturgeon in 1997, velocities were fast (mean velocity, range 5-12 cm s $^{-1}$), but for all other tests, velocity was slower with a mean velocity of 5-9 cm s $^{-1}$ in sections 6-7 near the pump and a mean velocity of 4-5 cm s $^{-1}$ in the other sections. The mean velocity for each section was determined by measuring velocity at mid-length of each section on both sides and in the center. We measured velocity 3 cm above the bottom with an electronic meter. Three large rocks (each, 10-15 cm diameter) at the two 180° turns of the tank provided cover and reduced water velocity.

We observed both species in 1997 (10 fish per species) and shovelnose sturgeon was tested again in 1998 (15 fish) because observations in 1997 were terminated after only four days to begin testing pallid sturgeon. If a fish died, it was replaced with another from the rearing tank.

We installed a Cohu video camera with infrared light over the oval channel to observe migrants during the day and night in section 1. Silver reflective tape was placed on the channel bottom and sides in the video field of view to enhance seeing the small fish at night. The video system recorded fish for 5 min per hour for 24 h. Because fish could not be marked individually, we recorded the total number of fish moving down- or upstream. These data were used to determine the net number of downstream migrants (number downstream minus number upstream migrants). Mean number of day vs night migrants was compared using t-tests. Also, each day we visually counted the numbers of downstream migrants, upstream migrants, and non-migrants. We evaluated daily downstream movement speed of migrants by determining the time (seconds) for 3-5 fish to move one loop around the channel (1997) or to move 2 m (1998), which we adjusted for total distance (7.3 m) to estimate loop time by age during the day and night. Loop time of only water was measured using a small foam float. Using the hourly video observations of each species, we estimated the average number of downstream loops per fish per day and the cumulative distance moved using the following: (1) number of fish (10 pallid and 10 shovelnose sturgeon in 1997, and 15 shovelnose sturgeon in 1998, (2) net number of downstream migrants (downstream minus upstream number of migrants), (3) twice as many day as night hours for the calendar period, and (4) 7.3 m distance for one loop.

We determined the spatial distribution of fish in the 12 channel sections to determine if fish were randomly distributed. Five times each day, we made an instantaneous count of the number of fish in each section. We analyzed the number of sturgeon in each section for the following periods: pallid sturgeon, late migrants (days 9-12, n = 7 observations) and early residents (days 13-16, n = 14 observations); shovelnose sturgeon, migrants (days 4-8, n = 11 observations), late migrants (days 9-13, n = 32 observations), and residents (days 21-33, n = 28 observations). We used Monte Carlo simulation, n = 10 000, to find the expected distribution of sturgeon numbers in the 12 channel sections if sturgeon selected their location randomly and independently. Simulations were done for 15 fish per channel (shovelnose) and 10 fish per channel (pallid and resident shovelnose). The 10 resident shovelnose were new fish introduced from the rearing tank, not the original fish, which died on day 18. In all observations used in the analysis for pallid migrants, 12 fish were counted even though there were only 10 fish in the tank (i.e. two double counts). Double counting occurs because some fish are moving during observation; we assume that the location of moving fish is random relative to the spatial distribution of stationary fish.

To link behavior to development, we scaled sturgeon development to age and cumulative temperature. Water temperature was recorded daily and these data were used to calculate daily thermal units and cumulative temperature units (CTU) in degree-days after hatching. Cumulative degree-days were calculated to mid-day of each day when behavioral observations were made and reflected temperature during the first 12 h of the current day and the second 12 h of the previous day. For example, day-0 fish accumulated 0 degree days and day-1 fish accumulated 0.5 x temperature °C on day 0 plus 0.5 x temperature °C of day 1.

Study Component 3 – Field examination of behavior and drift characteristics of larval sturgeon (Principal Investigators: Dr. Pat Braaten, Dave Fuller).

This study component will expand on study component 2 (above), but provide a field examination of behavior and drift characteristics of sturgeon in natural habitats of the Missouri River. However, larval shovelnose sturgeon will be used in the field studies because use of larval pallid sturgeon at this time would compromise the existing pallid sturgeon stocking and propagation program in the Missouri River downstream from Fort Peck Dam (Steve Krentz, U. S. Fish and Wildlife Service, personal communication). Although larval shovelnose sturgeon and larval pallid sturgeon exhibit several behavioral similarities (i.e., timing of migration, migration distance, life interval when most distance was moved; Kynard et al. 2002), larval behavior of both species differs with respect to movement characteristics (i.e., peak rate of movement for pallid sturgeon is one-half that of shovelnose sturgeon but pallid sturgeon continue movements twice as long) and diel behavior (i.e., pallid sturgeon are diurnal whereas shovelnose sturgeon are nocturnal). Thus, results of field studies using larval shovelnose sturgeon may not be identical to results that would have been obtained if larval pallid sturgeon had been used. It may be possible in 2004 to repeat Study Component 2 (above) using larval shovelnose sturgeon to more rigorously test for behavioral differences between species.

Field studies will be conducted in side channels and mainstem habitats of the Missouri River. For side channels, five distance markers will be established along the length of a side channel corresponding to point 0 (upstream end of the side channel), point 50 (50 m downstream from the upstream end), point 100 (100 m downstream from the upstream end), point 150 (150 m downstream from the upstream end), and point 200 (200 m downstream from the upstream end). Depth and velocity will be measured at intervals along a transect at each distance marker to obtain an estimate of the average depth and velocity in the side channel. Substrate will be visually assessed as silt, sand, gravel, cobble, and bedrock from grab samples. A larval fish sampling apparatus consisting of two nets (surface net, bottom net; 750 μm mesh) will be positioned mid-channel at the 50 m, 100 m, 150 m, and 200 m distance markers. Five hundred larval shovelnose sturgeon (0 – 4 days old) will be released near the substrate at point 0 in the side channel, and be serially sampled at 20-second intervals at each distance marker following release of larvae. Sampling will occur for 2 minutes beyond the estimated travel time from point 0 to point 200 (based on estimated mean velocity). This study will be conducted in a minimum of three side channels. Bottom profiles of the side channels will be graphed with a chart recorder to identify contours (e.g., dunes) that could influence larval drift and retention. We will explore the possibility of blocking the lower end of the side channels with nets to collect larvae not sampled by the larval sampling devices.

A similar procedure will be used to examine larval drift in the mainstem Missouri River. The study area will extend from the mid-point of one IOBC, through the next CHXO, through the next IOBC, through the next CHXO, and terminate at the mid-point of the next IOBC. Thus, drifting larval sturgeon will be exposed to a variety of natural habitat elements (side channels, sand bars, sand dunes, etc.). Distance markers will be established along the length of the channel corresponding to point 0 (starting point at the IOBC), point 50 (50 m downstream from the start point), point 150 (150 m downstream from the start point), point MID (mid-point of the site; exact distance dependent on total length of the site), and point END (end point; exact distance dependent on total length of the site). Larval drift studies will be conducted at three mainstem sites following the same sampling methodology as in side channels; however, the number of larval sturgeon released at point 0 will be increased to 3,000.

Data generated from field studies of larval drift will be compared to results obtained in the laboratory. For example, the Table 1 below presents hypothetical results from a single side channel that had an average velocity of 0.5 m/s. If larval sturgeon age-0 to age-4 days in natural habitats drift at the rate of average velocity, one would expect centroids of abundance at 100 seconds post-release at the 50-m marker, 200 seconds post-release at the 100–m marker, 300 seconds post-release at the 150-m marker, and 400 seconds post-release at the 200-m marker. Slight differences in timing may occur depending on whether individuals drifted predominantly near the surface or near the bottom (e.g., time to reach a distance marker may increase if individuals drifted along the bottom where velocities are reduced). Summary statistics including mean, minimum and maximum larval drift speed will be determined and compared to laboratory results.

Table 1. Hypothetical results from field studies of larval sturgeon drift characteristics in a single side channel with a mean velocity of 0.5 m/s.

Seconds after release	No. of larvae sampled at 50 m		No. of larvae sampled at 100 m		No. of larvae sampled at 150 m		No. of larvae sampled at 200 m	
	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom
20								
40								
60	1							
80	3							
100	11	6						
120	2	1						
140	1							
160								
180		1	2	1				
200			6	3				
220			1	1				
240			1	1				
260					1			
280								
300					10		2	
320					4	3		
340					2	1		
360						1		
380							1	
400							7	
420							4	2
440								5
460								

Study Component 4 - Model transport of larval pallid sturgeon based on results from Study Components 1, 2, and 3 (Principal Investigators: Dr. Pat Braaten, Dave Fuller, Dr. Boyd Kynard, John Remus).

The information generated from study components 1, 2 and 3 (above) will be used to construct models of downstream transport and drift characteristics of larval pallid sturgeon in the Missouri River downstream from Fort Peck Dam. For initial modeling purposes, seven locations separated by 48.3 km (30 river miles) will be designated as sturgeon spawning areas: 1) immediately downstream from Fort Peck Dam (RM 1770), 2) near Frazer Rapids (RM 1740), 3) near Wolf Point (RM 1710), 4) near Poplar (RM 1680), 5) near Brockton (RM 1650), 6) near Culbertson (RM 1620), and 7) near Nohly (RM 1590). Although sturgeon spawning areas are not known in the Missouri River downstream from Fort Peck Dam, the locations listed above serve as starting points to which additional simulations of larval sturgeon travel time and dispersal rates could be made if accurate spawning locations are identified in future studies. Output from these models will include larval drift duration (hours, days) between river location as a function of discharge, water velocity, drift velocity, and larval behavior, and estimated lengths of river needed by larval pallid sturgeon. Several models will likely be generated (Figure 2). For example, if behavioral studies in the laboratory and field indicate that larval drift rate (m/s) is directly proportional (i.e., 1:1 relationship) to current velocity (m/s), a "Proportional Drift Rate Model" would quantify larval drift travel time between selected points in the river and provide estimates of continuous river length needed by larval pallid sturgeon. Behavioral studies may indicate that the drift rate of larval pallid sturgeon is dependent on current velocity but not directly proportional (e.g., drift rate increases with current velocity, but drift rate is always slower than current velocity). These results would yield a "Modified Proportional Drift Rate Model," whereby travel time between selected points in the river and the length of river needed by larval pallid sturgeon would be based on the drift rate as a function of current velocity. Behavioral studies may indicate that larval drift rate is completely independent of current velocity and that larval pallid sturgeon migrate downstream at a constant rate. Given this scenario, a "Constant Drift Rate Model" could be developed whereby travel time between selected points in the river and length of river needed by pallid sturgeon would be based on the constant rate of larval migration. Additional models that include potential ontogenetic changes in drift rate as a function of current velocity will also be developed pending results from behavioral studies.

Component 5 - Evaluate survival of larval pallid sturgeon in depositional substrates similar to habitat conditions found in the river-reservoir transition area of Lake Sakakawea, North Dakota (Principal Investigator: Dr. Pat Braaten).

It is hypothesized that larval pallid sturgeon cannot survive in silty, depositional habitats such as those found in the river-reservoir transition areas of Lake Sakakawea (Krentz 2000b; USFWS 2000). However, this hypothesis has not been critically evaluated. In this study component, survival of larval pallid sturgeon will be evaluated in the laboratory under different substrate and sediment inflow treatments emulating silt and sand substrate characteristics found in the river-reservoir transition area. Although the spatial and temporal characteristics of substrate in the river-reservoir transition area of Lake Sakakawea are dynamic and dependent on river discharge, river stage and wind (Fred Ryckman, North Dakota Game and Fish Department, personal communication), the laboratory study will isolate substrate type and inflows as causative factors.

In the laboratory, 162 plexiglass tubes (approximate size: 10-liter volume, 15-cm diameter) will be randomly divided into three groups of 54 tubes. Each group of 54 tubes will serve as a turbidity treatment in the experiment (i.e., increasing levels of total dissolved solids; 0 NTU, 75 NTU, 750 NTU). The 54 tubes in each turbidity treatment will be further divided into three groups of 18 tubes with different substrate characteristics (i.e., no substrate, sand, silt; Figure 3). The bottom 10 cm of each vertical tube will be filled with the appropriate substrate as defined by the treatment. Each tube will have a trickle inflow and outflow, but differences in turbidity inflow as described by the treatments. All tubes will be fitted with an air stone and thermometer. Water temperature will be maintained at 22-24°C during the course of the experiment. This temperature range is similar to water temperatures that occur in the Missouri River downstream from the Yellowstone River confluence during late June and July (Braaten and Fuller 2002). Twenty newly hatched (age-0 days old) pallid sturgeon will be added to each tube at the onset of the experiment. Assessments of survival will be initiated on day 1 (first day after larvae are added), and continue on day 3, day 6, day 9, day 12, and day 15. Thus, the survival-assessment period will encompass the complete time period when larval pallid sturgeon are drifting in the water column (e.g., days 0-4) and when larvae have settled to the river bottom (days 5-13).

The following protocol will be used to evaluate survival. On each day, water and sediments will be drained from three randomly selected tubes from each treatment and the number of dead and live larvae will be recorded. Prior to draining tubes, sediments in the bottom of each tube will be measured (mm) to quantify sediment deposition changes throughout the duration of the experiment (mm/hr).

Although included in the current study proposal, this study component will not be conducted under the Scope of Work at this time. Initiation of this study component will be considered for spring and summer 2004.

Contractor Responsibilities and Deliverables

Research activities associated with Study Components 1, 2, 3, and 4 (Study Component 5 has been delayed until 2004) will be partitioned to the following agencies as follows. For Study Component 1 (Development of river travel time models based on relationships between discharge and water velocity), compilation of existing hydrologic data for the Missouri River downstream from Fort Peck Dam will be conducted by the MTFWP (Dave Fuller) and the USGS-BRD (Pat Braaten) with assistance from the USACE (John Remus). Study Component 1 also includes field activities for quantifying changes in depth, velocity, and travel time as a function of discharge. These field activities will be jointly conducted by the MTFWP (Dave Fuller), USGS-BRD (Pat Braaten), and USGS-WRD (John French). Results from Study Component 1 will be summarized as an individual report.

Study Component 2 (Laboratory quantification of behavior and drift characteristics of larval pallid sturgeon through a range of velocities) will be conducted exclusively by the USGS-BRD (Boyd Kynard and Erika Henyey-Parker). Results from Study Component 2 will be summarized as an individual report.

Research activities associated with Study Component 3 (Field examination of behavior and drift characteristics of larval sturgeon) will be conducted by the MTFWP (Dave Fuller) and USGS-BRD (Pat Braaten), and results will be summarized as an individual report.

Study Component 4 (Model transport of larval pallid sturgeon based on results from Study Components 1, 2, and 3) will entail a synthesis of all research activities. Thus, all participating agencies (MTFWP, USGS-BRD, USGS-WRD, USACE) will be involved. Study Component 4 will be summarized as an individual final report, and be completed by March 31, 2004 (see Timeline listed below). All reports will be sent to the Omaha District USACE.

Contractors involved in the study will purchase equipment and conduct tasks in accordance with methods specified in the four study components listed above. Quality assurance representatives from the USACE will periodically accompany contractors in laboratory and field activities to perform quality assurance inspections during the course of the study.

Confidentiality: All data collected, analysis of data, etc. performed during the study is the property of the USACE, and is considered provisional until accepted by the Omaha District USACE. Participating agencies will not publish, report, or in any way disseminate information generated from the studies under this agreement without permission from the Omaha District USACE.

Timeline

Activity	Month 2002		Month 2003												Month 2004		
	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Component 1			X	X	X	X											
Component 2								X	X	X							
Component 3							X	X	X	X							
Component 4										X	X	X	X	X			
Component 5	Initiation delayed until spring/summer 2004																
Final Report															X	X	X

Fiscal Year 2003 Budget

Agency	Contact person	Study component participation	Item	Amount
USGS–BRD, Columbia Environmental Research Center	Pat Braaten	1, 3, 4	Technician salary	$21,710
			Equipment	$31,000
			Travel	$8,550
			Subtotal	$61,260
			Overhead (26%)	$15,928
			Total	$77,188
USGS-WRD, Fort Peck	John French	1	Technician salary	$13,061
			Equipment	$10,686
			Travel	$4,400
			Subtotal	$28,147
			Overhead (40%)	$11,259
			Total	$39,406
MT Fish, Wildlife and Parks	Dave Fuller	1, 3, 4	Technician salary	$48,760
			Equipment	$20,500
			Travel	$3,000
			Subtotal	$72,260
			Overhead (19.1%)	$13,802
			Total	$86,062
USGS – BRD Conte Anadromous Fish Research Center	Boyd Kynard	2, 4	Salary	$23,000
			Equipment	$47,600
			Travel	0
			Subtotal	$70,600
			Overhead(28.5%)	$20,100
			Total	$90,700
			Project Total	$293,356

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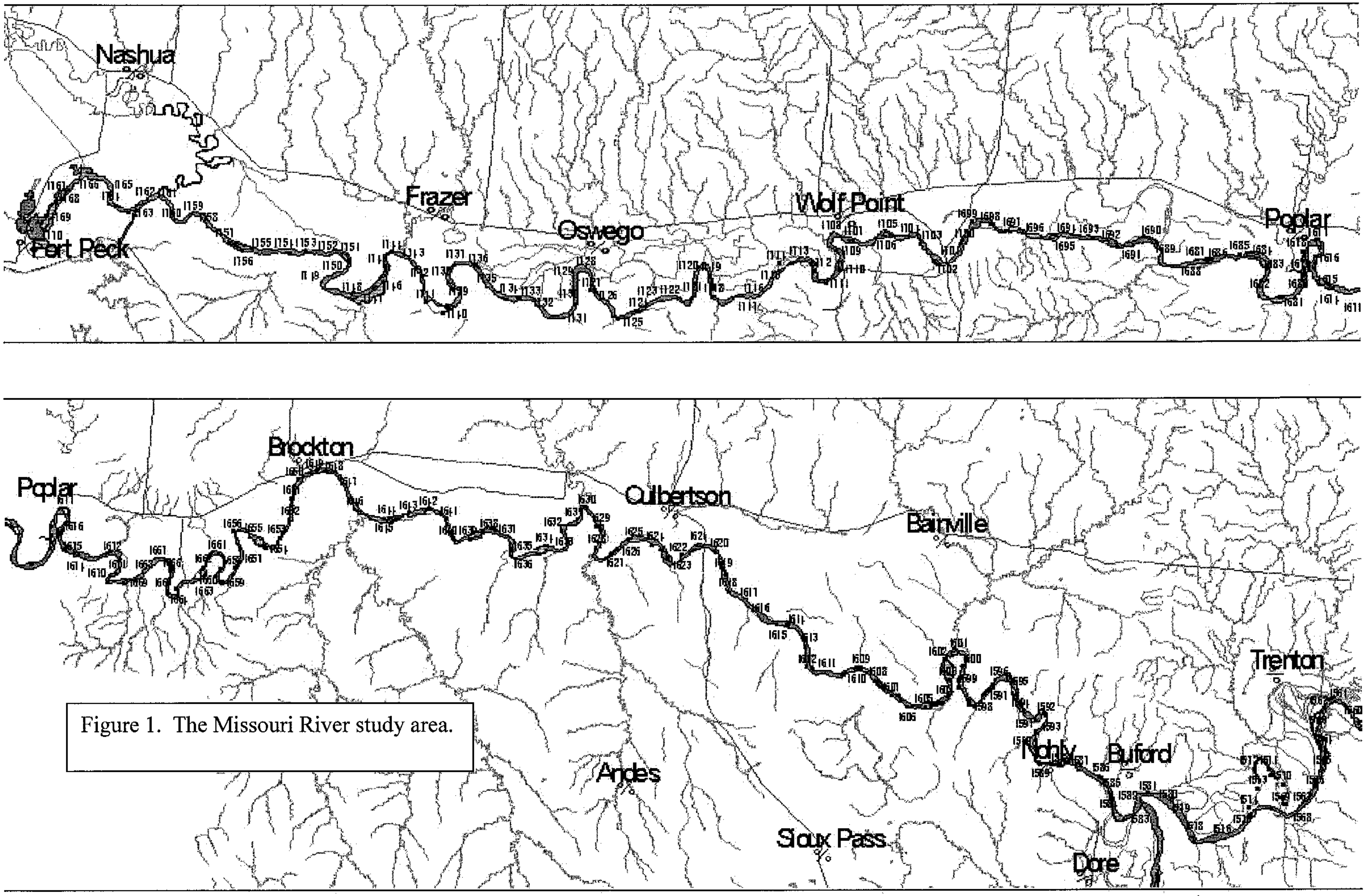
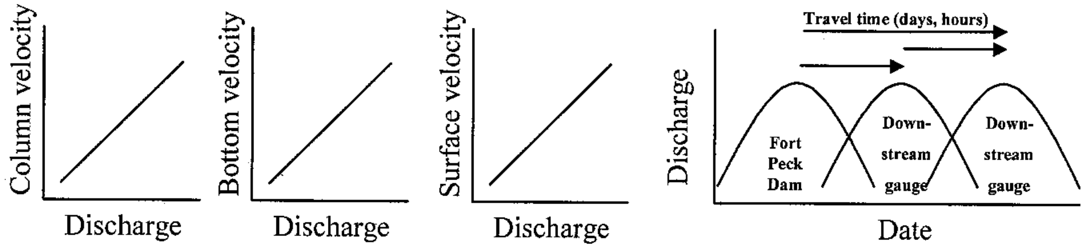


Figure 1. The Missouri River study area.

Conceptual Model Illustrating Research and Modeling Activities and Hypothetical Results for Larval Pallid Sturgeon

Study component 1

Existing hydraulic data



Outputs

a. Range of available velocities

b. Velocity profiles and travel time in the Missouri River

Study component 2

Larval behavior and drift characteristics

Larval age X (days, for ages 0-14)	Treatment velocity (cm/s)	Larval drift velocity (cm/s)	Vertical drift location (cm above bottom)
X	0.1		
	0.4		
	0.7		
	1.0		
	1.3		

Outputs

Study component 4

Model larval transport and length of river needed

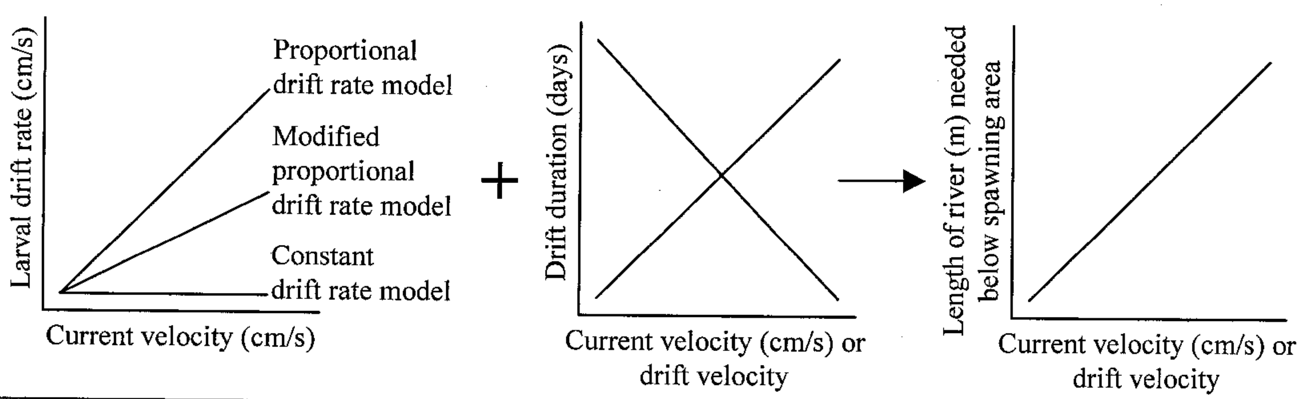


Figure 2. Conceptual model.

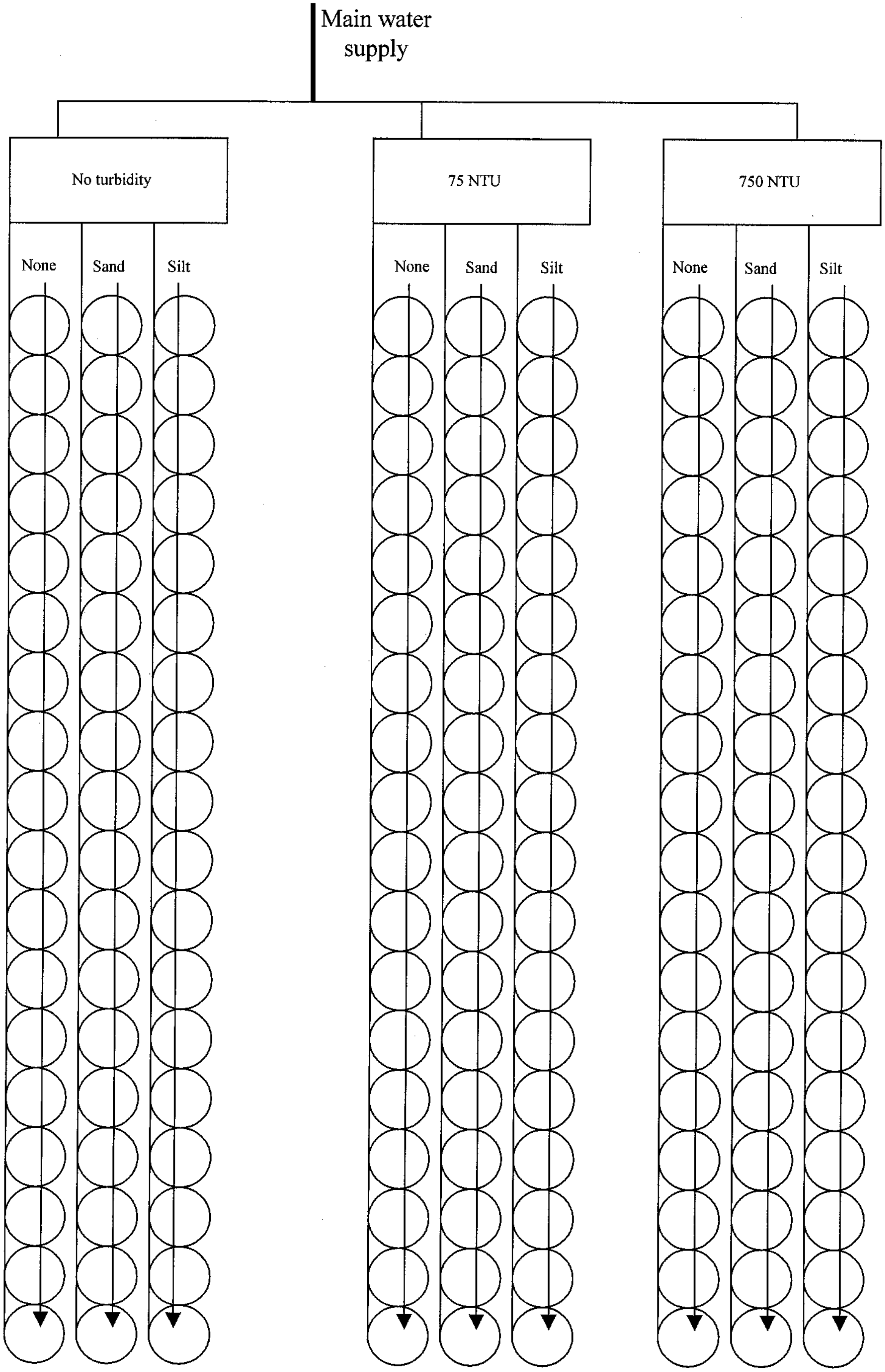


Figure 3. Lab design for survival experiments.

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SCOPE OF SERVICES
FOR
SPILLWAY INVESTIGATION DURING TEST FLOW
AT FT. PECK DAM, MONTANA
30 JULY 2002
REVISION 2 (9 AUGUST 2002)

1. INVESTIGATION AND FLOW TEST GENERAL DESCRIPTION

1.1. Location and General Description.

Fort Peck Dam is located in northeastern Montana on the Missouri River, approximately eight miles upstream from the junction of the Milk and Missouri Rivers. The spillway is located in a pass through the rough, hilly rim of the reservoir basin, about three miles easterly of the main embankment across the Missouri. Montana State Highway No. 24 passes over the spillway and the main embankment of the dam. It joins with U.S. Highway No. 2 at Glasgow, approximately twenty road miles to the northwest of Fort Peck and with State Highway No. 18 to the south.

The spillway is designed to discharge a maximum of 250,000 c.f.s. and consists of an approach channel, a reinforced concrete gate structure, a reinforced concrete discharge channel, and an earth-lined channel to the Missouri River. The approach channel is approximately 2,000 feet long and composed of a lined channel 360 feet long and an unlined channel 1,600 feet long. The reinforced gate control structure is 820 feet long and is set on a curved line. It consists of 17 piers set on a curved line between which are suspended 16 electrically operated vertical-lift steel gates, each 25 feet high and 40 feet long. The piers support the highway bridge, service bridge, walkways, and gate operating platform. The vertical lift gates can be used singly or they can be operated in combinations to achieve the desired flow release. The gate structure also includes 16 stop logs that are each about 43.5 feet long and 3.75 feet high that are used to dewater and allow gate repair. One to seven logs per bay are needed depending upon the reservoir elevation. As many as seven units may be necessary to close one bay at maximum reservoir elevation. The 5,030-foot concrete-lined channel varies in width from 800 to 130 feet and drops 214 feet from the crest of the gate structure to the invert of concrete channel in the cellular cutoff structure. An unlined discharge channel, 2,760 feet long, continuing from the end of the concrete-lined discharge channel, carries spillway flow to the main channel of the Missouri River.

1.2. Study Objectives.

The proposed study objectives are to evaluate the spillway slab stability for a range of flow rates, evaluate scour hole geometry for a range of flow conditions, evaluate the scour hole effect on spillway stability, and perform a preliminary design of spillway rehab alternatives. Described in detail within the following scope, the final report prepared by the A/E shall include conclusions which clearly state:

1. Data collected during the spillway mini-test and full-test flow periods.
2. Determine the spillway slab safety factor for a range of flow rates and identify the flow rate at which slab failure occurs. Impacts of slab doming, drain efficiency, and slab offset shall be clearly stated.
3. Determine the scour hole geometry for a range of flow rates and the spillway flow at which cutoff wall failure occurs. Impacts on the analysis of critical parameters such as tailwater depth, material strength, material weathering and repetitive spillway use, and scour hole geometry shall be clearly stated.
4. A preliminary design of spillway rehab options shall be performed. The reconnaissance level design will evaluate the feasibility of installing a riprap lined plunge pool or spillway flip bucket to provide energy dissipation.
5. Prepare an interim report following the mini-test that describes collected data and performed analysis. Prepare a final report following the full-test that describes collected data and performed analysis for the entire investigation.

1.3. Spillway Function.

The primary function of the Fort Peck spillway is to release surplus water from the reservoir in order to prevent overtopping and possible failure of the dam. The safety of the dam and the downstream developments is dependent upon proper functioning of the spillway under the most adverse conditions.

1.4. General Policy for Operation.

If it becomes necessary to lower the reservoir level by flood control discharge, then it is advisable to let the water run through the spillway gates whenever possible rather than discharge through the flood control tunnels, thereby saving wear and tear on tunnel lining and control shaft gate lip. If the desired discharge is greater than the amount of water discharging through the power units and the reservoir is above elevation 2,225, the excess discharge above that of the power units will be spilled through the spillway gates whenever possible.

1.5. Spillway Scour Hole.

The lined spillway channel terminates at elevation 2011.0 feet m.s.l. with a cutoff wall. At the spillway terminus, a scour hole has formed as a result of spillway operation. The cutoff wall structure is cellular, extends to a depth of 70 feet below the spillway channel invert to elevation 1941.0 feet m.s.l., and also includes wingwalls. A geophysical survey of the scour hole was conducted in May 1996. The survey determined existing scour hole geometry and included a subsurface evaluation of deposited sediments. Significant spillway flows have occurred since the survey date. Measurements are required to define the scour hole geometry. Scour hole measurements are required before the spillway flow tests begin and during the flow test period. A hydraulic analysis was performed to evaluate predicted scour hole geometry for various spillway flows (*Fort Peck Dam Spillway Engineering Reconnaissance Study, August 1997*). The analysis determined estimated scour depth, length, and width for spillway flows as follows:

Discharge (c.f.s.)	Elevation (ft)	Depth (ft)	Length (ft)	Width (ft)
25,000	1981.8	29.2	560	400
125,000	1929.2	81.8	1230	890

1.6. Spillway Exit Channel.

The unlined spillway exit channel continues from the spillway channel chute and cutoff wall for a length of approximately 2700 feet to the Missouri River. Original construction included excavation through the shale bluffs to the Missouri River floodplain. Channel excavation consisted of a bottom width of 130 feet, side slopes of 1V on 2H, and a flat gradient at an elevation of 2010. After exiting the shale bluff, a 12 foot wide pilot channel was excavated through the river floodplain to the Missouri River. Following construction, spillway flows have altered the channel section and grade within the unlined exit channel. Measurements and analysis are required to determine channel degradation during spillway flows and the tailwater rating curve at the spillway exit.

1.7. Slab Drain System.

The drainage system consists of 6- and 8-inch lateral spillway drains which flow into an 18-inch longitudinal collector which extends the full length of the spillway chute slab centerline. All pipes are vitrified clay and are installed beneath the spillway slab. The laterals are present only from the crest structure (approximately station 2+00) down to station 46+00. The 8-inch drains are spaced at 120 foot intervals and are embedded in gravel beneath 5-foot deep concrete collars. The 8-inch lines extend extend from the slab centerline out under the sloping side walls. The 6-inch drains are spaced between the 8-inch pipes at 20 foot centers, and they are embedded in gravel beneath 2-foot-deep concrete collars located at each transverse joint. The 8-inch lines collect seepage water from under the side walls and slab; the 6-inch lines collect seepage water from under the slab and toe of the side walls.

The R.W. Beck study for the Omaha District titled "Ft. Peck Dam Spillway Engineering Reconnaissance Study" concluded "*The slab is not expected to be watertight since aging of the spillway has probably reduced the effectiveness of the water stops. This condition is highly probable* *where a slab displacement of 3/8 inch or greater has occurred. In addition, the spillway flow durations are probably several weeks to months, increasing the chance afor entrance of water and induced uplift. It is assumed induced uplifts will occur and the drains are not effective. Assuming that the induced uplift is 40% of the velocity head, for flows of 25,000 c.f.s. and 125,000 c.f.s., the chute slab safety factor downstream of Station 25+00 is less than 30+00 is less than 1.0. This would result in the slabs lifting off and unraveling, exposing the highly erodible Bearpaw Shale to scour and potential undermining of the upstream slabs and the gated spillway control structure.*

Another way of looking at this condition is to determine what drain efficiency is required to keep the chute slab stable. Drain efficiency is defined as the ratio of the net uplift (after considering the uplift resisting capability of the slab) to the maximum uplift. For a flow of 125,000 c.f.s., the drains will have to be at least 82% efficient, downstream of Station 35+00, if uplift is taken as 100% of velocity head and 55% efficient for an uplift of 40% of the velocity head."

A steel water stop was designed into each joint in an effort to prevent the creation of uplift forces below the slabs due to infiltration of water through the joint. As stated above, due to slab rebound over the years and the observed offsets at some joints, competency of the water stops and the drains are now in question. In an effort to monitor the effectiveness of the drains, vibrating wire pressure transducers were placed in the drain system

Concern has been expressed on the existing condition and water tightness of the slab joints and subdrain pipe because of the rebound movement that the spillway has experienced since construction in the 1930's. Rebound movement of the slabs of up to 3.5 feet has been documented by surveys. A visual inspection in 1995 of the 18" diameter pipe revealed it was partially plugged with soft and loose silt material.

1.8. Spillway Flow Mini-Test.

A spillway flow test is planned to be conducted by the U.S. Army Corps of Engineers, Omaha District, Operations and Engineering Divisions. The test start date is dependent upon Fort Peck pool and downstream channel conditions but is expected to be between 15 May 2003 and 15 June 2003. The specifics are as follows:

Flow Test Scenarios

Duration (days)	Spillway Flow (1000 c.f.s.)	Power Tunnel (1000 c.f.s.)[2]	Combine Flow Total (1000 c.f.s.)[2]
Adjustment: Initial power flow at 8K, reduce to 4K while increasing spillway flow from 0 to 4K.			
4	4	4	8
Adjustment: Increase power flow from 4 to 8K while reducing spillway flow from 4 to 0K.			
1[1]	0[1]	8	8
Adjustment: Increase power flow from 8 to 11K. Reduce power flow from 11 to 7K while increasing spillway flow from 0 to 4K.			
4	4	7	11
Adjustment: Increase power flow from 7 to 14 K while reducing spillway flow from 4 to 0K.			
4	0	14	14
Adjustment: Reduce power flow from 14 to 11K while increasing spillway flow from 0 to 4K.			
4	4	11	15
Adjustment: Reduce power flow from 11 to 7K while increasing spillway flow from 4 to 8K (maintain a maximum total of 15K). Further reduce power flow from 7 to 4K.			
4	8	4	12
Adjustment: Increase power flow from 4 to 7K.			
4	8	7	15
Adjustment: Reduce power flow from 7 to 4K while increasing spillway flow from 8 to 11K (maintain a maximum total of 15K).			
4[3]	11[3]	4[3]	15[3]
1[4]	11 (no fish barrier)[4]	4[4]	15[4]
Adjustment: Day 1- Reduce spillway flow from 11 to 5K while increasing power flow from 4 to 7K. Day 2 - Reduce spillway flow from 5 to 0K while increasing power flow from 7 to 9K. Day 3 - Further reduce power flow from 9K to the desired flow (7 or 8K).			
NA	0[1]	Normal	Normal

1 Monitoring Period. Spillway flow will be stopped during a 4-12 hour period to perform scour hole and exit channel surveys. The monitoring is scheduled to start at approximately 0830 after the listed spillway flows are stopped. After completion of monitoring, the spillway and power flows will be adjusted to the next flow combination.
2 Approximate power flow will vary depending upon pool elevation.
3 Flow combination duration may vary from 4-9 days depending upon monitoring results.
4 Flow combination duration as required may vary to provide data without the fish barrier.

1.9. Spillway Flow Full-Test.

The Omaha District intends to perform the spillway full-test the calendar year following the mini-test. A full-test protocol will be developed following the mini-test. At this time, the anticipated maximum spillway flow during the full-test is 25,000 c.f.s., (the target flow out of the spillway is 19,000 c.f.s.)

2. WORK TO BE PERFORMED BEFORE MINI-TEST

2.1. Install Fish Barrier. One option the Corps is considering for maintaining fish populations in Fort Peck Reservoir during proposed spillway flow testing is the installation of a temporary fish barrier. The proposed location for this barrier is in the upstream approach channel, with the intent of preventing the movement of fish downstream.

Based on information collected by the Corps, the Corps evaluated various options and determined there are only two viable options for this barrier. The Corps has obtained detailed design and cost information on an electric fish barrier and desires to obtain the same for a net system, which has been identified by fishery agencies, Fort Peck operations personnel, and other Corps personnel as a possible alternative. Debris is not considered to be a significant factor. To that end, the A/E shall develop a design for the Corps-selected netting system, incorporating the following components:

a. Within 8 weeks from award, the contractor shall provide to the Corps for review the installation details of the fish net barrier system.

b. The fish net barrier design will include the anticipated structural support, methods of installation and removal, a method for manual cleaning, and storage requirements for the net. Design calculations and operational considerations will be provided with the design.

c. A budgeting level detailed cost estimate for installation, operation, removal, and storage of the fish net system is required to accompany the design for comparison to the dollar figures generated for the electric fish barrier. The A/E will estimate cost based on A/E contracted personnel performing all required task and the storage facilities being a non-heated government warehouse within 6 miles of the approach channel.

d. It is anticipated that this contract will be modified to install the structure support system for the net during the fall of 2002. The modification is also anticipated to address the purchase and operation of the net system.

2.1.1 Fish Net System. The fish net system is to impair the lake fish greater in length than 4 inches from going over the spillway. As a minimum, the following types of fish are to be impaired from going over the spillway by the net system: Cisco, Walleye, Northern Pike, Buffalo, Small Mouth Bass, Lake trout, Salmon, Catfish, Paddlefish, Shovelnose Sturgeon, Carp, Yellow Perch, Sauger, Burbot (ling), and other related types of fish. Fish Net Design Parameters determined by input from the various stakeholder and regulatory groups are as follows:

a. Use 3/8-inch nylon mesh multi filament net

b. The contractor shall determine the average channel flow velocity for flow rates of 11,000 cfs and 19,000 cfs combined with a range of pool elevations from 2230 to 2245 at 5 foot increments. Average velocities will be determined using an assumed channel bed elevation of 2219 feet (1 foot below the concrete slab in front of the gates at 2220). Channel width shall be determined by scaling from existing plans at the net location. The contractor shall identify flow/depth combinations at which fish impingement occurs. Impingement shall be assumed to occur at an average velocity of 3 ft/sec.

c. The net barrier system design will include the identification of a method for removal and replacement of the net, which allows for removal of a portion of the net (with immediate replacement with another) and manual cleaning. The A/E will consider a system where only half the net system is required to be in use at any one time (allowing for access to the other half for debris removal). The design shall incorporate the requirement to maintain the net barrier within the flow area during the cleaning process.

d. The net barrier system must be functional during the mini tests at pool levels from 2230 to 2245 feet, and may be made up of multiple nets.

e. The contractor shall provide detailed calculations of the loads/force being applied to the net under the flow conditions and the 5 ft depth increments within the pool range given above. A maximum net blockage factor of 30% shall be included in the force computation. The contractor shall identify the factor of safety for both the net and the support system. The contractor shall design the support system to provide a minimum factor of safety of 3.0 at the maximum net loading. The contractor shall design the system such that the net fails prior to failure of the support system. The cost estimates for operating the net system will include the assumption that A/E contracted personnel will check the barrier installation twice daily during the mini-test. The estimate will also include removal and cleaning of the net once every four-days by an A/E contracted cleaning crew with A/E furnished equipment. Impingement will not be concerned as a problem.

f. The net system is to be designed for use a minimum of three times for durations of between 21 and 60 days; the preferred life of the components will be five years. If replacement of any components is anticipated to be required due to degradation of materials during this time frame, these will need to be identified and replacement costs factored into the operational costs.

g. The Corps will be responsible for obtaining any permits required in connection with the fish net system.

h. Backup measures shall consist of a duplicate net. The contractor shall include the cost of the duplicate net in the prepared cost estimate.

2.2. Scour Hole and Exit Channel Survey.
The A/E shall conduct scour hole surveys at the specified times. Scour hole measurements are required before spillway flow tests begin and at specified times during the flow test period. All surveys shall be performed in the same coordinate system that shall be furnished by the government.

2.2.1. Scour Hole Below Water Survey. An accoustical subbottom profiling system or equivalent is required to estimate the thickness of deposited sediments in the scour hole. The profiling equipment shall consist of a sound source, energy source, receiver and recorder. A suitable survey boat is required. A minimum of 5 lines parallel to the spillway and 8 lines perpendicular to the spillway shall be profiled and spaced at 50 feet. Horizontal control of the profiling shall be performed by a laser tracking system. The position of the boat shall be recorded approximately 2 times a second on a navigation computer. The navigation computer shall also be capable of sending a fiducial mark to the subbottom profiler graphic recorder every 10 seconds. Vertical control shall be performed by determining the water surface elevation and using it as a reference. Survey results should clearly identify the extent of deposited material and firm shale within the existing scour hole.

2.2.2. Scour Hole Above Water Survey. In addition to the scour hole below water survey, a land survey is required from the water line to the top of slope. The survey shall be performed in a cross section format. Five perpendicular cross sections shall be used. The approximate location of the cross sections will be furnished on an aerial photograph. The end points of the center cross section shall be marked with a rebar/concrete marker. The government shall furnish a typical section marker detail.

2.2.3. Spillway Exit Channel Survey. Cross section surveys and a centerline profile survey are required of the spillway exit channel. Four perpendicular cross sections are required. The end points of each cross section shall be marked with a rebar/concrete marker. Cross sections shall extend to the top of slope. A centerline profile from the scour hole to the Missouri River is also required. Profile length is approximately 2700 feet. Profile points are required at approximately a 100 foot spacing with additional points as required to identify breakpoints.

2.2.4. Survey Data Format. All surveys shall be performed in a like manner for comparison purposes. All surveys shall utilize the same coordinate system. The horizontal geometry and cross sections shall be plotted in a microstation .dgn file format. Ascii XYZ points and CADD contour mapping shall be provided for each survey.

2.2.5. Additional Surveys. Additional scour hole surveys are required during the spillway flow test period. Survey data collection and analysis shall be performed while considering the requirement to incorporate future survey data for comparison purposes. Surveys shall be performed according to the following schedule:

Approximate Schedule - Spillway Scour Hole and Exit Channel Surveys			
Survey Date	Scour Hole Below Water Subbottom Profile	Scour Hole Above Water	Exit Channel
Just prior to Mini -Test (May 2003)	X	X	X
During Mini-Test 2003	X		
After Mini-Test or Prior to Full-Test [1]	X	X	
During Full-Test 2004[1]	X		
After Full-Test 2004[1]	X	X	X

1 The full-test survey requirements will be further evaluated after the mini-flow test. Survey requirements between the Mini-Test and Full-Test will be dependent upon the time elapsed and the requirement for spillway releases in addition to the proposed test releases.

For scope and estimating purposes, the A/E shall consider the number of surveys in the above table. Additional surveys may be incorporated based on observed response to spillway flows.

2.3. Slope Stability Analyses.

A slope stability analysis shall be performed in the scour hole area for the two scour hole geometries. The wedge method shall be used to analyse the slopes for deep seated failures and infinite slope analyses used to analyze shallow failures. The deep seated failure analysis is necessary for determination of higher spillway flows and anticipated greater erosional extent. The shallow analysis is necessary for determination of sliding of weathered shale at the surface of the slopes at lower spillway flows. The slope stability analysis shall be performed on two cross sections on each side of the spillway centerline and shall be selected by the engineer as judged as potentially the one most unstable. The computer program UTEXAS3 will be used to perform the stabilities. A factor of safety of less than 1.2 will be considered as unstable for the deep seated analysis and 1.0 for the shallow analysis. No subsurface investigations will be performed and all soil strength parameters will be obtained from the report "Fort Peck Lake, Montana, Design Memorandum No. MFP-118, Spillway Slope Excavation, September 1973" and "Design Memorandum No. MFP-109, Spillway Rehabilitation, Revised September 1966". CADD generated drawings for the stability analyses will include drawings showing the four cross sections for each geometry and critical failure surface for each. One of the drawings will be prepared showing a plan view with the section cut locations and the resulting estimated failure outlined.

The results of the stability analyses will be used as a tool for the design of stone or other protection alternative designs in the spillway terminus area for protection of the wingwalls. Refer to section 6 for a discussion of spillway rehab alternative analysis. The stability analysis shall be performed prior to the Mini-Test. At the conclusion of the stability analyses, the A/E shall submit a report including all computations, drawings, and results.

2.4. Develop Mini-Test Spillway Monitoring Plan.

The A/E shall coordinate the Mini-Test data collection and monitoring program with the Omaha District. At a minimum of 25 days prior to the commencement of the Mini-Test, the A/E shall submit a spillway monitoring plan that summarizes data collection in the period before, during, and after the test. The plan shall also detail all personnel that will be involved in the data collection effort and the time(s) that those personnel will be at the Fort Peck project.

3. WORK PERFORMED DURING MINI-TEST

3.1. Spillway Slab Data Collection and Monitoring.

During the mini-flow test period, measured data shall be collected using the previously installed spillway monitoring equipment. Measurement equipment shall be monitored during the test period.

3.2. Spillway Scour Hole Measurements.

Scour hole geometry survey is required prior to the Mini-Test. Following the initial spillway flow period (refer to the spillway mini-test flow schedule, section 1.8), an additional sub-bottom profile measurement is required. All surveys shall be performed as previously described in section *2.2 Scour Hole and Exit Channel Survey*.

4. WORK AFTER MINI-FLOW TEST

Following the Mini-Test, data collection and analysis tasks are required. Analysis performed between the Mini-Test and Full-Test shall be of limited detail. Analysis shall be performed according to the following objectives:

1. Determine the adequacy of collected data and evaluate whether data collection methods require refinement for the Full-Test.
2. Limited detail analysis shall be performed to evaluate spillway slab safety for the proposed Full-Test.
3. Limited detail analysis shall be performed to evaluate potential scour hole erosion during the Full-Test and determine potential project impact.
4. Prepare an interim report to state Full-Test recommendations and allow for government review of methodology and collected data.

4.1. Data Collection and Development.

The A/E shall collect the data obtained during the mini-flow test. Analysis of data shall be performed as required. Collected data shall be provided to the Omaha District as ascii data files on CD-ROM media.

4.2. Scour Hole Survey Data Analysis.

The A/E shall utilize the scour hole survey data collected during the flow test period to present scour hole geometry change. Scour hole geometric change shall be provided for both cross section and plan view in a CADD format.

4.3. Scour Hole Geometry Evaluation.

Computation of scour hole geometry at the spillway shall be performed using the exit flow parameters as determined from evaluation of the concrete lined spillway chute and geologic parameters representative of material within the scour hole area. Scour geometry computation shall incorporate the effects of spillway channel flow distribution and turbulence, flow duration, variable material erosion resistance, flow distribution within the scour hole, downstream tailwater, etc. Determined scour hole geometry shall be calibrated to the extent possible with available prototype measurements. The developed model shall be capable of computing scour geometry for a single flow event or several events in succession. The geometric enlargement of the scour hole after a specified number of flow cycles shall be identified. A flow cycle is defined as a long duration release followed by shale weathering. Scour hole geometry shall be performed in conjunction with identifying potential damage to the spillway cutoff wall, chute, and control structure.

Major tasks consist of the following:

(1) Utilize prototype data to calibrate scour model(s).
(2) Determine peak discharge which causes spillway failure.
(3) Determine spillway scour hole geometry for 4 different conditions.
  A. 10 cycles of 25,000 c.f.s. flow with 30 day minimum flow duration.
  B. 50 cycles of 25,000 c.f.s. flow with 30 day minimum flow duration.
  C. 10 cycles of 40,000 c.f.s. flow with 30 day minimum flow duration.
  D.50 cycles of 40,000 c.f.s. flow with 30 day minimum flow duration.
(4) Interim Report.

4.3.1. Scour Hole Geometry Computation. Computation is required as follows:

General. Computation of scour hole geometries shall be performed by the A/E within the general framework of the following guidelines. The A/E shall review existing reports, the original model study data and reports, measured and computed flow parameters and air entrainment, previous scour hole survey data, and new survey data to aid in the calculation of scour hole geometry progression. The data shall be incorporated into predictive models that calculate the scour hole geometry at various flows. The predictive models shall be capable of determining scour hole geometry (width, depth, and extent) from the input data consisting of flow and geotechnical parameters. During the scour hole geometry computation procedure, coordination is required between hydraulic, geotechnical, and structural disciplines to interpret, evaluate, and direct further computations.

Scour Depth. Two predictive models to determine scour depth shall be utilized. One model shall use the spreadsheet developed during the *Fort Peck Dam Spillway Engineering Reconnaissance Study (R.W. Beck, 1997)*. The model shall be revised as necessary to incorporate measured data from the mini and full test flows. A second model shall be based upon available plunge pool scour guidance using the erodibility index approach as described within the final draft chapter for the second edition of the American Society of Civil Engineers= Sedimentation Engineering Manual #54. The erodibility index method is also available within an existing computer model.

Scour Geometry. Scour hole geometry shall be computed assuming average geologic parameters for the scoured material supplemented with measured data. Spillway channel exit flow parameters shall be determined from the computed model data as described in the Evaluate Spillway Chute section. Geometric shape of the scour hole shall be determined including the length, width, and depth for each peak discharge. The scour hole geometry (depth, width, and length) shall be related to the peak spillway discharge which causes failure of the spillway terminus structure (either the cutoff wall or the wing walls).

Scour hole geometry shall be illustrated for 4 different scenarios. The 4 scenarios consist of a 30 day peak flow rate of 25,000 and 40,000 c.f.s. combined with a repetition of 10 or 50 cycles. In between each flow cycle, the A/E shall assume that the shale is weathered to the maximum deterioration possible. Illustration of scour hole geometry shall require establishing 5 foot contours within the scoured area for a given flow event. A CADD drawing file (Intergraph dgn file format) of the scour hole geometry shall be created in a state plane coordinate system to allow overlaying of the scour hole with existing topography. Although not necessarily a part of the computer model, the A/E shall provide documentation explaining the specified durations.

The A/E shall select the computational method to evaluate scour hole geometry. The elliptical shape method employed in the *Fort Peck Dam Spillway Engineering Reconnaissance Study (R.W. Beck, 1997)* shall be evaluated as well as other suitable methods. The scour hole geometry computational method shall be validated with prototype data. Scour hole geometry is of critical importance since the identified failure mode for the cutoff wall and wingwalls is due to lateral scour.

4.3.2. Tailwater Depth Computation. The government shall furnish the A/E three tailwater rating curves for use with determining scour hole formation. Rating curves shall consist of a normal, maximum, and minimum tailwater elevation. The normal tailwater curve shall be used in conjunction with determining scour hole geometry for the interim report. The maximum and minimum tailwater curves shall be used during the sensitivity analysis performed for the final report. Tailwater rating curves will be revised following the mini-test and full-test based on measured data.

4.3.3. Air Entrainment.
Computations shall be performed to determine spillway flow air entrainment for use with the scour predictive model. Computational analysis shall use the measured spillway flow data to provide flow parameters for use with available literature that provides methods of estimating air entrainment. Computational analysis may be of limited detail and utilize the available procedures and charts such as those described within *EM 1110-2-1603 Hydraulic Design of Spillways* or similar.

4.3.4. Sensitivity Analysis.
For parameters which cannot be identified with a high degree of accuracy or which dramatically affect results, a sensitivity analysis shall be performed. Between geotechnical and hydraulic parameters such as tailwater depth and rock erosion resistance, the A/E shall compute scour hole geometry while adjusting various parameters. Sensitivity analysis shall be performed for the 25,000 and 40,000 c.f.s. flow rates while varying a maximum of 4 parameters. The bulk of the sensitivity analysis shall be performed following the full-test.

4.3.5. Interim Report Requirements.
A report section shall be prepared which describes the basis for the scour hole geometry models and all associated tasks. The report shall briefly describe the computational methods and preliminary results, and survey data collected during the mini-test. Limited detail and calibration is required for the interim report. The report shall be of draft quality. Comments provided by Omaha District shall be used to evaluate full-test data collection protocol and incorporated in the final report. The interim report shall be prepared according to the structure described in the report format section.

<u>A-E Interim Report Products</u>

- Preliminary scour hole maximum depth (2 computation methods)
- Preliminary scour hole geometry computer model which relates scour to hydraulic and geotechnical parameters
- Preliminary scour hole estimate for the full-test flow period
- Interim Report documentation

4.4. Evaluate Spillway Chute
Following construction of the spillway channel, significant upheaval has occurred which has produced discontinuities in the spillway channel and walls. Flow within the spillway channel is extremely high velocity and generally varies from 40-70 ft/sec. An evaluation of the potential for spillway damage to occur during or following various flow conditions was conducted in the *Fort Peck Dam Spillway Engineering Reconnaissance Study (R.W. Beck, 1997).*

4.4.1. Flow Parameter Computation

The A/E shall use the spillway flow model developed in the previous study to compute spillway flow parameters (R.W. Beck, 1997). The A/E shall determine spillway flow velocity, depth, and distribution for a range of flow rates. The A/E shall calibrate the flow model using measured data. Computations shall be performed for a range of spillway flows with a maximum of 5 flow rates shall be evaluated. Flow bulking due to air entrainment shall be included in the evaluation using measured data and available published data. The computational model shall begin downstream of the gates and piers based upon flow depths determined in the physical model and prototype testing.

NOTE: Work performed for the interim report shall consist of calibrating the model to the mini-test data and using the model to predict full-test flow parameters.

4.4.2. Sensitivity Analysis

Spillway flow parameters shall be determined for calibrated values. Based on the range of measured data, minimum and maximum loss conditions shall be determined. Sensitivity analysis shall be restricted to two discharge rates selected by the A/E which correspond to critical minimum and maximum flow rates with respect to spillway damage. The A/E shall identify the sensitivity parameters for the interim report. The bulk of the sensitivity analysis shall be performed following the full-test.

4.4.3. Chute Damage Evaluation

The A/E shall use measured data to evaluate pressure fluctuations and/or uplift pressures on the spillway chute slabs to identify slab stability. The A/E shall determine the minimum pressure fluctuation which will cause chute uplift and/or major slab damage. Using the measured and computed data, the A/E shall correlate the minimum allowable pressure fluctuation to a maximum allowable flow rate. The A/E shall address uncertainties in the analysis and employ an appropriate safety factor. The effect on flow parameters caused by spillway channel irregularities shall be fully investigated. Flow acceleration and concentration due to slab uplift areas shall be included in the analysis.

In addition to the failure analysis, the A/E shall determine the safety factor for a range of flow rates. A maximum of 5 five flow rates will be considered. Flow rates shall be determined in coordination with Omaha District and will vary from 10,000 c.f.s. to 75,000 c.f.s..

NOTE: Work performed for the interim report shall consist of calibrating the model to the mini-test data and using the model to evaluate potential damage for the full-test flow period. The A/E shall develop stop-test criteria based on the spillway instrumentation to prevent any potential damage during the full-test.

4.4.4. Interim Report

A report section shall be prepared which describes the chute evaluation model and all associated tasks. The interim report shall include all measured data and the results of any preliminary computations. The report shall be prepared according to the structure described in the report format section. CADD drawings illustrating existing spillway details are not required for this item.

<u>A-E Interim Report Products</u>

- Presentation of Measured Data
- Preliminary Model Calibration
- Full-test stop criteria
- Interim Report documentation

4.5. Develop Full-Test Spillway Monitoring Plan.

The A/E shall coordinate the Full-Test data collection and monitoring program with the Omaha District. At a minimum of 25 days prior to the commencement of the Full-Test, the A/E shall submit a spillway monitoring plan that summarizes data collection in the period before, during, and after the test. The plan shall also detail all personnel that will be involved in the data collection effort and the time(s) that those personnel will be at the Fort Peck project.

4.6. Data Collection Evaluation

The A/E will determine the adequacy of collected data and evaluate wheteher data collection methods require refinement. The A/E shall include a summary of data collection efforts, evaluation of data collection methods, and an a summary of recommendations for the Full-Test within the interim report.

4.7. Interim Report Submittal and Review

An interim report shall be submitted to the government following the Mini-Test data collection and data evaluation with the products previously stated. Following interim report submittal, a review will be conducted by the Omaha District. Written comments will be furnished to the A/E within 30 calendar days of receiving the interim report. Incorporation of review comments will be performed during preparation of the final report.

5. WORK DURING SPILLWAY FULL-FLOW TEST

NOTE: SECTION 5 ITEMS FOR WORK DURING THE FULL-FLOW TEST ARE INCLUDED FOR INFORMATIONAL PURPOSES PERTAINING TO A FUTURE WORK EFFORT. THESE ITEMS SHOULD NOT BE INCLUDED IN THE CURRENT COST ESTIMATE.

5.1. Spillway Slab Data Collection and Monitoring.

During the full-flow test period, measured data shall be collected using the previously installed spillway monitoring equipment. Measurement equipment shall be monitored during the test period.

5.2. Spillway Scour Hole Measurements.

During the spillway flow period, a sub-bottom profile measurement is required. At the conclusion of the spillway test period, scour hole geometry above water, exit channel surveys, and a sub-bottom profile survey is required. All surveys shall be performed as previously described in section *2.2 Scour Hole and Exit Channel Survey.*

6. WORK AFTER SPILLWAY FULL-FLOW TEST

NOTE: SECTION 6 ITEMS FOR WORK AFTER THE FULL-FLOW TEST ARE INCLUDED FOR INFORMATIONAL PURPOSES PERTAINING TO A FUTURE WORK EFFORT. THESE ITEMS SHOULD NOT BE INCLUDED IN THE CURRENT COST ESTIMATE.

The A/E shall use all data collected during the full-flow test to update all computational models prepared following the mini-flow test. Work after the full-test shall complete all tasks previously described in *Section 4 Work After Mini-Test.*

6.1. Data Collection and Development.

The A/E shall collect the spillway instrumentation data and scour hole survey data obtained before, during, and following the full-flow test. Analysis of data shall be performed as required. Collected data shall be provided to the Omaha District as ascii data files on CD-ROM media. In addition, the collected data shall be presented within an appendix of the final report. Data presentation shall include a listing of data collection times, data collection locations, and relevant spillway flow data. Data analysis shall be presented in the chute evaluation section. Data collection format shall be summarized.

<u>Collected Data Final Report</u>

Present spillway collection data including location, data collection times, and spillway flow history. Collected data may be presented within an appendice of the final report.

6.2. Scour Hole Survey Data Analysis.

The A/E shall utilize the scour hole survey data collected during the flow test period to present scour hole geometry change. Scour hole geometric change shall be provided for both cross section and plan view in a CADD format. Data presentation shall include a listing of data collection times, locations, and spillway flow history. Data analysis shall be presented in the scour hole geometry section. The actual data may be presented in CD format and included within the report.

Survey Data Final Report

Collected scour hole and exit channel survey data shall be presented in plan view, cross section, and tabulated format within an appendice of the final report.

6.3. Scour Hole Geometry.

Computation of scour hole geometry at the spillway shall be performed to complete all tasks previously described in section 4.3. Analysis shall be updated to revise scour hole depth and geometry for the full-test measured data. Revised tailwater depth, air entrainment, and a sensitivity analysis shall be performed.

Scour Hole Analysis Final Report Requirements.

A report section shall be prepared which describes the basis for the scour hole geometry model and all associated tasks. The report shall describe the computational methods, modifications performed to calibrate to measured data, model accuracy, and conclusions. The report conclusions shall clearly state:

(1) The spillway flow at which cutoff wall failure occurs and the failure mode.
(2) The scour hole maximum length, depth, and width for the 25,000 and 40,000 c.f.s. flow rates.
(3) Impact of flow cycles on scour hole geometry.

The final report shall be prepared according to the structure described in the report format section. CADD drawings consisting of scour hole geometries for the 25,000 and 40,000 c.f.s. flow rates shall be prepared.

A-E Work Products

- Scour hole maximum depth models (2 computation methods)
- Scour hole geometry computer model which relates scour to hydraulic and geotechnical parameters
- CADD dgn file(s) of scour hole contours
- Final Report documentation

6.4. Evaluate Spillway Chute

Computation of scour hole geometry and spillway chute stability at the spillway shall be performed to complete all tasks previously described in section 4.3. Analysis shall be updated to revise the spillway flow model calibration, the chute damage analysis, the sensitivity analysis, and etc.

Spillway Chute Final Report Requirements.

A report section shall be prepared which describes the chute evaluation model and all associated tasks. The final report shall describe the computational methods, modifications performed to calibrate to measured data, model accuracy, and conclusions. The report conclusions shall clearly state:

(1) The spillway flow at which initial chute damage occurs.
(2) The factor of safety for 5 separate flow rates.
(3) Impact of flow cycles on chute slab stability

The final report shall be prepared according to the structure described in the report format section.

A-E Work Products

- Presentation of Measured Data
- Calibrated Spillway Flow Model and Calibration Results
- Identification of Minimum Flow for Chute Damage
- Safety Factors for Various Flows
- Final Report documentation

6.5. Preliminary Design of Spillway Rehab Alternatives.
The A-E shall develop preliminary design data and a cost estimate for energy dissipation devices applicable to the Fort Peck spillway. Energy dissipation devices shall be designed which reduce the scour at the existing cutoff wall to an acceptable level by altering flow parameters or moving the location of the scour hole. The preliminary design analysis shall be of sufficient detail to allow screening of alternatives.

Energy dissipation structures including a flip bucket modification to the spillway chute and a lined plunge pool are standard options that shall be evaluated. The feasibility for other options for dissipating energy such as a conventional stilling basin, installing roughness elements on the spillway chute, inducing a hydraulic jump, and etc. shall be briefly discussed. Within the preliminary analysis, the A/E shall discuss the advantages and disadvantages the identified energy dissipation alternatives. Analysis shall compare the energy dissipation capability for each type of device. This level of analysis shall provide an initial assessment of various types of energy dissipation structures. Potential impacts of the energy dissipation device during flows that exceed design capacity shall also be discussed. The preliminary design and analysis shall include the results of the previous slope stability analysis. The A/E shall anticipate evaluating a minimum of 5 separate alternatives. The level of detail for each alternative may vary. Some alternatives may be eliminated from further consideration as the design progresses.

Energy Dissipator design shall be performed in accordance with criteria presented within EM 1110-2-1603, Hydraulic Design of Spillways, Engineering Monograph No. 25, Hydraulic Design of Stilling Basins and Energy Dissipators, and other applicable design criteria. Design of the energy dissipator shall be evaluated for 2 flow rates as furnished by Omaha District. The design tailwater elevation shall also be furnished by Omaha District. A limited detail (non-MCASES) cost estimate shall be performed for a single energy dissipation structure.

Preliminary design of the energy dissipation structure shall include a brief assessment of structural compatibility with the existing spillway structure. Modifications to the existing structure shall be roughly identified. A maximum of 3 separate CADD drawings to illustrate the design of the energy dissipation structure shall be prepared.

Spillway Rehab Alternatives Final Report Requirements.
A report section shall be prepared which describes the analysis and all associated tasks. The report shall describe the computational methods, limitations, impacts to the existing structure, cost estimate, and recommendations for a selected alternative for detailed design. The report conclusions shall clearly state:

(1) The spillway rehab alternatives considered and design data for each alternative.
(2) The cost estimate for each alternative.
(3) Impact of flow cycles on scour hole geometry.

The final report shall be prepared according to the structure described in the report format section. CADD drawings consisting of scour hole geometries for the 25,000 and 40,000 c.f.s. flow rates shall be prepared.

A-E Work Products

- Initial assessment of various energy dissipation structures

- Reconnaissance level evaluation of constructing a flip bucket and riprap lined plunge pool
- Developed computational models, spreadsheets, and hand calculations
- Cost estimate for a single energy dissipation structure
- Preliminary design CADD drawings

6.6. Draft Report Submittal and Review. The A-E shall submit a draft final report for review. The A-E shall be approximately 95 percent complete at this time. The draft report shall include all major items as discussed within all sections of this scope. The Omaha District shall review the draft report and provide comments for inclusion within the final report. Written comments will be provided to the A-E within 30 calendar days from the time that the draft report is received.

6.7. Final Report Submittal.
Following draft report submittal and receipt of Omaha District review comments, the A-E will have 30 calendar days to resolve all comments and submit the final report.

7. QUALITY CONTROL PLAN.

Quality control review shall be conducted by the Contractor for the entire work effort. The contractor (referred to as Architect-Engineer or Architect-Engineering Firm in this paragraph) shall submit, for evaluation and concurrence, a Quality Control Plan to be used for projects in private industry. The Architect-Engineer is totally responsible for the product being developed, and any review performed by the Corps of Engineers, Omaha District does not relieve the A-E from their professional design liability. Therefore, the A-E will have a Quality Control Plan in place before work begins. The Omaha District is responsible for evaluating the A-E's Quality Control Plan, evaluating the acceptability of the products delivered, and facilitationg the resolution of policy, regulation, and design related issues. The A-E will be informed of problems with the products, the Quality Control Plan or the processes being used for product development.

7.1. Acceptability Criteria. This should include a listing of design, regulatory, and customer critieria for the project and products being delivered.

7.2. Quality Control Procedures. The A-E will outline the procedures to be used for interfacing with any of their subcontractors. This plan should note when key reviews will occur during design development, how lessons learned are incorporated, and how deficiencies are tracked and handled.

7.3. Quality Control Organization. The plan shall describe a quality control organization with names of individuals, responsibilities, and chains of authority. It shall describe who is responsible for internal quality control reporting, and the quality control reporting to the Government.

7.4. Quality Control Documentation. The A-E firm shall provide written documentation signed and dated by the primary A-E firm and their consultants that states "The products included with this deliverable were completed and reviewed in accordance with our Company's Quality Control Plan that is on file with the Omaha District's Project Manager. All applicable design checks, interdisciplinary checks and quality control reviews have been completed by the designated designers and reviewers as stated in the Quality Control Plan. "Our company believes this product is in compliance with all applicable criterai and the stated scope of work. Incomplete work will be added to this product at no additional cost to the government." The A-E firm shall provide a separate Design Quality Review Document which shall be devoted to the findings of all Design Quality Control Reviews and shall be submitted with each design submittal. This document, which should include Quality Control Review comments, summaries fo reviewer's evaluation of the design, signatures of reviewers, etc., provides an indication that the Quality Control Plan was implemented and the results thereof. The completed Quality Control Report shall be included as an appendix within the final report. While quality control procedures will be implemented throughout the project, a completed Quality Control Report is not required as part of the interim report submittal.

8. GOVERNMENT FURNISHED MATERIALS.

Reference materials listed in the Slope Statility Analysis section will be provided by the Government. No additional materials will be provided in support of this effort. The access to the scour hole pool is limited and any special effort such as a crane to place a boat in the scour hole pool are the contractor's responsibility.

9. COORDINATION AND MEETINGS.

Coordination and meetings with the Government are required during this effort. Appropriate coordination will occur during the contract to assure clear communication between both parties.

9.1. The contractor will partake in a minimum of the following formal coordination meetings:

a. One 4-hour start-up meeting conference call with all contractor team members available for their portion of the meeting.

b. One all day site-visit and coordination meeting at Fort Peck Dam, Montana to continue start-up discussion, to verify field conditions and measurements by the contractor, and to discuss initial design conceptions for the fish net design. This meeting will take place within the first two weeks after award of the contract. A minimum of two contractor personnel will attend this meeting.

c. One two-hour conference call after the Corps review of the contractor's fish net design.

d. One two-hour conference call after the contractor submits his plans of action for the final contractor of the fish net system. (This meeting and the following meetings are dependent on the Corps ability to add the fish net system to this contract by modification).

e. One all day site visit in March or April just prior to the mini-test. Meeting at Fort Peck Dam, with a minimum of two contractor personnel attending.

f. Two two-hour conference calls after Corps review of the contractor's interim report following the mini-test.

g. One all day site visit in March or April just prior to the full-test. Meeting at Fort Peck Dam with a minimum of two contractor personnel attending. **(FUTURE EFFORT)**

h. Two two-hour conference calls after the completion of the full-test.**(FUTURE EFFORT)**

i. One all day meeting at Omaha, Nebraska after Corps review of the final report documents.**(FUTURE EFFORT)**

9.2. The above meetings are in addition to normal coordination and informal conference calls which will occur during the course of the contract. If the contractor proposes additional personnel at the site visits, they should be included in the proposal.

9.3. Additional meetings may be necessary; the Corps will visit the contractor's office for those meetings.

9.4 Monthly status reports of approximately one page in length will be provided to the Corps. During periods of non-activity between spillway tests, a report stating such is sufficient.

10. WATER AVAILABILITY.

The Mini-Test and Full-Test will only occur if there is sufficient water available to fully complete the test. Water depth above the spillway crest sufficient to provide the test releases is necessary. There is a possibility that water will not be available in year 2003. Delays due to non-availability of water will be addressed by contract modification. The Government shall inform the A/E regarding water availability and a decision regarding test status in the spring of each year by a date not later than 30 calendar days prior to starting the test (approximately 15 April).

11. FY02 WORK ITEMS.

T he scope requires completion of identified work items during FY 2002 (fiscal year ending 30 Sep 2002). The contractor shall complete all the following work items prior to the end of FY 2002.

11.1. Complete initial portion of the design and budget estimate for fish net system..

12. OMAHA TECHNICAL POINT OF CONTACT.

The Omaha District has designated a technical point of contact (POC). The contractor shall designate a person to function as project engineer (PE) on the study and will be responsible for all coordination with the Omaha District POC. The POC and PE will serve as the liaison for the transfer of all data files and shall coordinate communication between the Corps and the contractor.

CORPS TECHNICAL POC:
Terry Matuska, (402) 221-4485
terry.j.matuska@usace.army.mil

Alternate:
Daniel Pridal, (402) 221-4419

U.S. Army Engineer District, Omaha
CENWO-ED-HD
106 South 15th Street
Omaha, NE 68102

13. SCHEDULE.

Due to the limitations imposed by water availability, schedule adjustments may be necessary. Assuming water is available, the following project schedule for the major project milestones applies:

PROJECT COMPLETION SCHEDULE	
Task	Completion Date
Contractor Submits Initial Proposal, by noon CDT	15 August 2002
Negotiations Complete	20 August 2002
Notice of Award	22 August 2002
Submit Fish Net System Design	17 Oct 2002
Work Prior to Mini-Test	15 May 2003
Mini-Test Data Collection	15 May – 15 June 2003
Work After Mini-Test, Interim Report	30 Sep 2003
Full-Flow Test Data Collection	15 May – 15 June 2004
Work After Full-Flow Test, Draft Final Report	30 January 2004
Final Report Submittal	15 April 2005

14. CONFIDENTIALITY.

All data collected, analysis preformed and any other information generated as part of this delivery order is the property of the Corps of Engineers. The contractor shall not publish, distribute or in anyway disseminate any data, reports or other information generated by the delivery order, or as a direct result of this delivery order, without written permission from the Omaha District.

15. REPORT SUBMITTAL AND FORMAT.

Report submittals shall include the products described above and adhere to the following requirements:

a. All reports as described above and any supporting technical appendices in both hard copy (10 bound and 1 unbound) and in Microsoft Word format.

b. A completed Quality Control Plan.

c. Computer files of all models used during the analysis along with any documentation needed to run the models. This includes input and output files.

d. Microsoft Excel format (or similar) and ASCII data files used to produce all graphs, charts etc.

e. All charts graphs, calculation sheets, references, etc., utilized during the project.

f. All government furnished items.

g. A complete photocopy of the project file. This file shall be well organized and annotated where necessary to avoid confusion. This file shall include meaningful telephone conversation logs, a copy of each cited article or book (excluding government furnished items), calculations, listing of computer files, etc.

h. All computer files shall be submitted electronically. Computer files submitted for the final report shall also be submitted on a recordable compact disc (CD).

i. The report shall be presented in a "reader friendly" style and include the components as follows:

Report Appendices
The report appendices shall be separated by sheets with identifying tabs, and each appendix shall have its own table of contents.

Report Consistency
The main text of the report and the report appendices shall have the same type of print, and the report appendices shall have organizational formats consistent with each other.

Drawings, Sketches, Graphs, and Photographs
All parts of the report, both the main text and the appendices, shall have an abundance of drawings, sketches, graphs, and photographs close to the text which they explicate. They shall be of high quality (photographs in color), easily understood, and be tailored to match the message being conveyed by the text.

Report Components
The A/E shall organize the report to present the performed data collection and analysis in an orderly format. The report requirements for each analysis item are discussed in the individual item scope. Report components shall include, as a minimum, the following items:

Executive Summary
Index
Project Data, Location, History, and Description
Design and Analysis
Appendices (computations, drawings, photos, correspondence, collected data, personnel, quality control report, etc.)

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