APPENDIX C
AQUATIC HABITAT EVALUATION

HEP is a method developed by the U.S. Fish and Wildlife Service to facilitate evaluations of aquatic habitat where changes in ecosystem structure are anticipated. HEP can be used to document the quality and quantity of available habitat for selected fish and wildlife species. HEP provides information for two general types of habitat comparisons: 1) the relative value of different areas at the same point in time; and 2) the relative value of the same area at future points in time, facilitating "before" and "after" comparisons.

The HEP is based on the assumption that habitat for selected fish and wildlife species can be described by a Habitat Suitability Index (HSI). This index value, ranging from 0.0 to 1.0, is multiplied by the area of available habitat to obtain Habitat Units that serve as the basis for comparison. The reliability of HEP and the significance of HUs are dependent on the ability to assign a well defined and accurate HSI to the selected evaluation species. The number of HUs is defined as the product of the HSI (quality) and the total area of available habitat (quantity). This appendix summarizes findings and analysis previously reported of HEP surveys conducted in September 2000 and January 2001 at multiple locations along the RGCP (Parsons 2001b). As a comparison, data are presented on September 1999 fish surveys conducted by the USFWS on artificial structures placed at 13 locations in the north reach of the RGCP.

METHODOLOGY

Survey Locations

Ten HEP locations were surveyed along the RGCP, one each in the Seldon Canyon, Upper Mesilla, Las Cruces, and El Paso RMUs and two locations in the remaining RMUs (*i.e.,* Upper Rincon, Lower Rincon, and Lower Mesilla). HEP survey locations (transect series) according to RMU are depicted in Table C-1. Two transects were surveyed at one location with the exception of the Upper Rincon and Lower Mesilla locations where three transects were surveyed.

Transects at each survey location were separated by approximately 100 meters and consisted of up to 20 points depending upon channel width. Depth and current velocity measurements were made at each point, allowing the vertical profile and flow to be determined for each site. In addition, water quality measurements were made, namely temperature, salinity, conductivity, pH, dissolved oxygen, and total dissolved solids. The physical variables measured at each location were used for subsequent HSI calculations.

Delineation of Cover Types

HEP analysis requires the delineation of cover types. Cover types serve to facilitate the selection of evaluation species, the extrapolation of data from sampled areas to non-sampled areas, and the treatment of HEP data. The diversity of cover types in the project area is very limited resulting in the delineation of only one type suitable for the selected evaluation species. The RGCP area's aquatic cover type is characterized as a shallow water stream with little aquatic diversity and productivity.

Table C-1
Transect Location for Aquatic Sampling Sites

Management Unit	Transect Series	Transect Identification	Notes
Upper Rincon	Upper Rincon	UR2, UR3, UR4	At Tipton Arroyo
Upper Rincon	Garfield	G1, G2	Sibley Arroyo
Lower Rincon	Hatch	H1, H2	Downstream of Rincon Siphon
Lower Rincon	Sierra Alta	SA1, SA2	At Rincon Arroyo
Seldon Canyon	Seldon Canyon	SC1, SC2	From Highway 185 at Mile Marker 18
Upper Mesilla	Doña Ana	DA1, DA2	Downstream Shalem Colony Bridge
Las Cruces	Las Cruces	HEP1, HEP2	Downstream of Picacho Bridge
Lower Mesilla	Black Mesa	BM1, BM2	Downstream of Mesilla Bridge
Lower Mesilla	Mesilla Valley	MV, MV2, MV3	Downstream of Mesilla Diversion Dam
El Paso	El Paso	EP1, EP2	At Cottonwood Bosque Area

Aquatic Species Sampling

Electrofishing. Electrofishing was completed using a Smith-Root back-pack (battery) operated unit with direct current. At each sampling location, electrofishing was conducted through representative habitat elements. Shoreline lengths of from 164 to 328 feet (50 to 100 meters) were electrofished, as were any other habitat types at the location such as debris or other materials. Fish captured were identified to species, measured for length, and released.

Seining. Seining, where it was conducted to supplement electrofishing, was completed with a two-person beach seine. The 3-meter wide seine was pulled rapidly through select habitat types or near specific features such as logs or other debris. Fish captured were identified to species, measured for length, and released.

Selection of Evaluation Species

The selection of evaluation species form the basis of the HEP analysis and is used to quantify habitat suitability and determine changes in the number of available HUs. Therefore, the HEP assessment is directly applicable only to the evaluation species selected. This is an important distinction between HEP and the WHAP methodology used for terrestrial surveys. Limited availability of HSI models for the species present in the Project area resulted in selection of two species for HEP analysis, largemouth bass *(Micropterus salmoides)* and flathead catfish *(Pylodictis olivaris)* .

Calculating Total Area of Available Habitat

The total area of available habitat for an evaluation species includes all areas that can be expected to provide some support to the evaluation species. Typically, total area of available habitat is calculated by summing the areas of all cover types likely to be used by the evaluation species. Because only one cover type throughout all RMUs was defined, only one value was used to represent total area of available habitat for each RMU. This number was developed by reclassifying digital orthographic imagery using ERDAS Imagine® and using ArcView GIS to calculate total area for open water in the project area.

FLATHEAD CATFISH HABITAT EVALUATION

Specific Habitat Requirements

Flathead catfish habitat requirements vary with age. Young flathead catfish are often found in riffles until they are 5.1 to 10.2 cm (2 to 4.0 inches) in total length. In streams, flatheads from 10.2 to 30.4 cm (4.0 to 12 inches) in total length are generally dispersed, catfish with a total length of 30.4 to 40.6 cm (12 to 16 inches) are typically associated with intermediate depths and cover, and catfish with a total length of over 40.6 cm (16 inches) are solitary and associated with cover in deep pools. Young catfish typically are active only at night.

Flatheads are most common in large, turbid rivers and reservoirs. In large rivers, flathead catfish appear to prefer large, sluggish, deep pools located in low gradient sections. Flathead catfish inhabit a variety of stream types, but tend to avoid streams with high gradients or intermittent flow.

Flathead Catfish Habitat Suitability Model

[From: Lee, L.A., and J.W. Terrell. 1987. Habitat suitability index models: flathead catfish. Fish and Wildlife Service Biological Report 82(10.152).]

Lee and Terrell (1987) developed two habitat models for flathead catfish used to assess different types of habitat impacts (*e.g.*, Riverine Cover model and Macrohabitat model). The Riverine Cover model applies to situations where a diversity of cover types exist. Flathead catfish are often closely associated with cover, both for spawning and other activities, however, because cover requirements for the flathead catfish were not observed in the entire study area the Macrohabitat model was chosen for this species. The Macrohabitat model uses the following variables to assess habitat suitability: V1-stream gradient; V2-turbidity; V3-current velocity; V4-percent riffles; V5-percent runs; and V6-percent pools.

For those variables Lee and Terrell (1987) developed Macrohabitat Suitability Index (SI) graphs used to model individual suitability indices from known values of the habitat variables at a given location. These indices (SIs) represent estimates of the limits to average standing crop imposed by individual habitat variables in an entire water body or sample site large enough to encompass an individual's range throughout an entire life cycle. To derive HSI that is a conservative estimate of standing crop limit imposed by all the model variables, HSI is defined as the lowest SI measured for any variable. "The proper interpretation of the HSI is one of comparison. If two riverine habitats have different HSI's the one with the higher HSI should have the potential to support more flathead catfish than the one with the lower HSI, if no unmeasured habitat variables are more limiting than the model variables."

LARGEMOUTH BASS HABITAT EVALUATION

Specific Habitat Requirements

Optimal riverine habitat for largemouth bass is characterized by large, slow moving rivers or pools of streams with soft bottoms, some aquatic vegetation, and relatively clear water. First and second order streams generally provide poor habitat. A river with a high percent (≥ 60%) of pool and backwater area is optimal. Also, largemouth bass prefer low gradient streams; abundance declines as gradient increases toward headwater areas. Gradients larger than 4 m/km are assumed to be unsuitable.

The species growth is reduced at dissolved oxygen levels less than 8 mg/l, and a substantial reduction occurs below 4 mg/l. Levels below 1.0 mg/l are considered lethal. Largemouth bass are also considered intolerant of suspended solids (turbidity) and sediment. High levels of suspended solids may interfere with reproductive processes and reduce growth. The optimum suspended solid levels are assumed to be 5-25 ppm, and levels below 5 ppm indicate low productivity. Largemouth bass require a pH between 5 and 10 for a successful reproduction. Optimal pH range is 6.5-8.5 although largemouth bass can tolerate short-term exposure to pH levels of 3.9 and 10.5

Adult largemouth bass are most abundant in areas with vegetation and other forms of cover. Optimal cover corresponds to 40-60% of the pool or littoral area; too much cover may reduce prey availability. Optimal current velocities are less than or equal to 6 cm/sec (2.4 inches/sec), and velocities above 20 cm/sec (7.9 inches/sec) are considered unsuitable. Optimal temperatures for growth of adult bass range from 24-30° C (75 to 86 F). Very little growth occurs below 15° C (60 F) or above 36° C (99 F). Salinity levels above 4 ppt cause sharp declines in abundance.

Optimal current velocities for fry are below 4 cm/sec (1.5 inches/sec), and fry cannot tolerate current velocities above 27 cm/sec (11 inches/sec). Cover, in the form of flooded terrestrial vegetation, is an important requirement for fry suitability, because the amount of cover has been positively correlated to number of fry. However, too much cover constitutes poor spawning habitat. Optimal pools or littoral areas are assumed to contain approximately 40-80% cover. Also, stable to increased summer water level is optimal, because it increases cover availability. It is assumed that decreasing water levels would be suboptimal because fry would be more susceptible to predation with the decrease in available cover

Habitat Suitability Model

[Stuber, R.J., G. Gebhart, and O.E. Maughan. 1982. Habitat suitability index models: Largemouth bass. U.S. Department of Interior Fish and Wildlife Service FWS/OBS-82/10.16 .]

Two HSI models exist for the largemouth bass: 1) Riverine HSI Model and 2) Lacustrine HSI Model. The riverine model, applied to the RGCP survey is described below: According to Stuber *et. al.* (1980) the Riverine HSI model has the form:

$$HSI = (C_F \times C_C \times C_{WQ} \times C_R \times C_{OT})^{1/5}$$

Where each of the five components represent food (C_F), cover (C_C), water quality (C_{WQ}), reproduction (C_R), and other (C_{OT}).

Food Component. Percent bottom cover is assumed to be important because bottom cover provides habitat for aquatic insects, crayfish, and forage fish, which are the predominant food items of largemouth bass. Percent pool and backwater area is included to quantify the amount of food habitat.

Cover Component. Percent bottom cover is included because largemouth bass are most abundant in areas with cover. Percent pool and backwater area quantifies the amount of cover habitat. Water level fluctuation is considered to be important because the amount of available cover is dependent on fluctuations.

Water Quality Component. The water quality component is limited to dissolved oxygen, pH range, temperature, turbidity, and salinity measurements. These parameters have been shown to affect growth or survival. Variables related to temperature and oxygen are assumed to be limiting when they reach near lethal levels.

Reproductive Component. Temperature and salinity during spawning and embryonic development describe water quality conditions which affect reproduction. Maximum water level fluctuation is included because optimal development and survival is dependent on stable water levels during spawning. Current velocity is important because embryos require areas of little or no velocity. Percent pool and backwater area quantifies the amount of low velocity spawning areas.

Other Components. The variables which are in the other component are those which also describe habitat suitability for the largemouth bass, yet are not specifically related to the life requisite components already present. Stream gradient is included because largemouth bass prefer slow moving streams.

HABITAT SUITABILITY INDICES

HSI values were calculated for the largemouth bass and flathead catfish by location (Table C-2). Locations were classified according to three prevailing characteristics to compare HSIs among site attributes: main river run, downstream from diversion dams, and downstream from siphons. Documented physical conditions in the Rio Grande appear to be more suitable for the flathead catfish than for the largemouth bass, but HSI values underscore the paucity of aquatic habitat available for both species in the RGCP area.

For largemouth bass, HSI ranged from 0.05 to 0.17, indicating that a large proportion of the surveyed habitat was sub-optimal for the species development. At all but one site the reproductive component of the index was determined to be the limiting factor. Physical conditions contributing to the largemouth bass reproductive success include percentage of total habitat represented by pools and backwaters and a possibly correlated variable, velocity of water in the pools. At most sites percent pool values were less than or equal to 10 percent, significantly limiting the availability of optimal bass habitat. The highest HSI values for largemouth bass were found at three sites located downstream from diversion dams and siphons where pools or slow-moving waters were present. Little suitable habitat was documented at survey locations in the main river run (HSI < 0.1).

Calculated HSI values for the flathead catfish, while higher than those calculated for the largemouth bass, were also indicative of sub-optimal habitat conditions. Index values ranged from 0.10 to 0.55 depending on the location (Table C-2). As with largemouth bass, locations downstream from diversion dams and siphons had the highest HSI values, indicating a positive relationship between the index and percent coverage of pools. For the main river run HSI values for the catfish were generally low, from 0.10 and 0.25. Results of the habitat suitability models suggest that augmenting pool habitat will likely be beneficial for both largemouth bass and flathead catfish.

SUPPORT CALCULATIONS

Detailed calculations for HSI data summarized in Table C-2 for flathead catfish and largemouth bass are presented in Tables C-3 and C-4, respectively. Description of model components was previously discussed in the text.

Similarly to the survey data utilized for calculation of habitat suitability indices in seven RMUs along the RGCP, HSI data were calculated for 13 reference locations in the Rincon Valley where artificial habitat structures were placed as mitigation for arroyo dredging as required by the USACE 404 permit. The structures 2 v-notch weirs placed across the RGCP channel, 3 small embayments placed along the river banks, and 7 groins near the mouth of dredge arroyos and two reference arroyos. September 1999 data from an monitoring program conducted by the USFWS for the USIBWC were used in the HSI calculations. These data were selected as potentially representative of more diversified aquatic habitat conditions in the RGCP channel.

Table C-2. Habitat Suitability Indices for Largemouth Bass and Flathead Catfish

Site Attribute	Location (River mi)	Transect Series ID	Largemouth Bass HSI	Flathead Catfish HSI
Downstream from Siphon	82	Hatch	0.17	0.45
Downstream from Diversion Dam	40.2	Mesilla Valley	0.17	0.55
	104.3	Upper Rincon	0.14	0.40
Main River Run	5.0	El Paso	0.05	0.25
	42.5	Black Mesa	0.05	0.25
	45.8	Las Cruces	0.05	0.25
	79	Sierra Alta	0.06	0.25
	100.2	Garfield	0.06	0.10
	51.3	Doña Ana	0.14	0.40
	71.8	Seldon Canyon	0.06	0.25

Table C-3 Calculation of Flathead Catfish Habitat Suitability Indices*
(September 2000 and January 2001 Surveys)

Site	Model Variable	V1	V2	V3	V4	V5	V6	HSI
SC, Seldon Canyon	Input	0.52	140	0.43	10	80	10	0.25
	SI	1	1	0.8	0.7	0.85	0.25	
H, Hatch	Input	1.53	140	0.58	25	45	30	0.45
	SI	1	1	0.45	1	0.95	0.55	
UR, Upper Rincon	Input	0.25	140	0.26	10	70	20	0.4
	SI	1	1	1	0.7	0.875	0.4	
G, Garfield	Input	0.82	140	0.646	25	75	0	0.1
	SI	1	1	0.375	1	0.875	0.1	
LC, Las Cruces	Input	0.625	140	0.48	10	80	10	0.25
	SI	1	1	0.6	0.7	0.85	0.25	
BM, Black Mesa	Input	0.54	140	0.46	10	80	10	0.25
	SI	1	1	0.7	0.7	0.85	0.25	
EP, El Paso	Input	0.54	140	0.38	10	80	10	0.25
	SI	1	1	1	0.7	0.85	0.25	
MDD, Mesilla Diversion Dam	Input	1.86	140	0.273	10	60	30	0.55
	SI	1	1	1	0.7	0.9	0.55	
Doña Ana	Input	0.625	140	0.484	10	70	20	0.4
	SI	1	1	0.6	0.7	0.875	0.4	
SA, Sierra Alta	Input	0.979	140	0.598	25	65	10	0.25
	SI	1	1	0.45	1	0.9	0.25	

* Parsons' 2000 Surveys Along the USIBWC Rio Grande Canalization Project

Variable Descriptions:

V1-Stream Gradient (m/km); V2-Turbidity (JTU); V3-Mean Velocity (m/s); V4-% Riffle; V5-% Run; V6-% Pool.

HSI: value equivalent to lowest SI of the six physical variables.

Input Value Estimation:

V1- Summer stream surface elevation at beginning and ending mile marker used to estimate stream gradient at each site (Alternatives Formulation Report, Appendix C, Parsons ES, Jan 2001).
V2- Intermediate value, 140 JTU, assumed to reflect average turbidity.
V3- used weighted average velocity measured from cross-sectional data collected at each site, Parsons ES, March 2001.
V4:V6- values from field data collected at each site, Parsons, April 2001.

Table C-4 Calculation of Largemouth Bass Habitat Suitability Indices

Parsons Surveys Along the USIBWC Rio Grande Canalization Project (September 2000 and January 2001)

Site	Model Variable	V1	V3	V4	V6	V7	V8	V9	V10	V11	V12	V13	V14	V15	V16	V17	V18	V19	V20	V21	V22	Cf	Cc	Cwq	*Cr*	Cot	***HSI***
SC	Input	10	10	10	7.68	8.06	24.1	21.69	24.1	25-100	0.4	0.4	0.4	Mostly Sand	0	1	0	43	22	43	0.52	0.018	0.068	0.863	*0.055*	1	*0.055*
	SI	0.001	0.375	0.25	0.8	1	1	1	0.8	0.7	1	1	1	0.5	1	0.975	1	0.001	0.001	0.001	1						
H	Input	30	0	0	8.82	8.33	21.14	19.026	21.14	25-100	0.4	0.4	0.4	Mostly Sand	0	1	0	58	29	58	1.5	0.181	0.320	0.806	*0.168*	0.8	*0.168*
	SI	0.325	0.2	0.001	1	1	0.65	0.85	0.65	0.7	1	1	1	0.5	1	0.975	1	0.001	0.001	0.001	0.8						
UR	Input	20	30	30	8.33	8.01	0.65	20.6	0.65	25-100	0.2	0.2	0.2	Mostly Sand	0	1	0	26	13	26	0.25	0.278	0.426	0.886	*0.137*	1	*0.137*
	SI	0.1	0.8	0.75	1	1	0.9	1	0.7	0.7	1	1	1	0.5	1	0.975	1	0.001	0.001	0.001	1						
G	Input	10	10	10	8.36	8.26	23.5	21.2	23.5	25-100	0.3	0.3	0.3	Mostly Sand	0	1	0	65	32	65	0.8	0.018	0.068	0.888	*0.055*	1	*0.055*
	SI	0.001	0.375	0.25	1	1	0.95	1	0.7	0.7	1	1	1	0.5	1	0.975	1	0.001	0.001	0.001	1						
LC	Input	10	10	10	7.67	8.39	21.38	19.42	21.38	25-100	0.4	0.4	0.4	Mostly Sand	0	1	0	48	24	48	0.625	0.018	0.068	0.738	*0.053*	1	*0.053*
	SI	0.001	0.375	0.25	0.8	1	0.65	0.85	0.55	0.7	1	1	1	0.5	1	0.975	1	0.001	0.001	0.001	1						
BM	Input	10	10	10	7.42	8.39	20.9	18.8	20.9	25-100	0.4	0.4	0.4	Mostly Sand	0	1	0	46	23	46	0.54	0.014	0.057	0.688	*0.050*	1	*0.050*
	SI	0.001	0.375	0.001	0.8	1	0.5	0.65	0.45	0.7	1	1	1	0.5	1	0.975	1	0.001	0.001	0.001	1						
EP	Input	10	0	0	8.5	8.53	19.48	17.532	19.48	25-100	0.5	0.5	0.5	Mostly Sand	0	1	0	38	19	38	0.54	0.014	0.057	0.692	*0.049*	1	*0.049*
	SI	0.001	0.375	0.001	1	1	0.45	0.6	0.4	0.7	1	1	1	0.5	1	0.975	1	0.001	0.001	0.001	1						
MDD	Input	30	0	0	7.67	8.34	25	22.5	25	25-100	0.3	0.3	0.3	Mostly Sand	0	1	0	27	14	27	1.86	0.181	0.320	0.894	*0.174*	0.7	*0.174*
	SI	0.325	0.2	0.001	0.8	1	1	1	0.9	0.7	1	1	1	0.5	1	0.975	1	0.001	0.001	0.001	0.7						
DA	Input	20	10	10	7.61	8.34	22.45	20.2	22.45	25-100	0.4	0.4	0.4	Mostly Sand	0	1	0	48	24	48	0.625	0.177	0.315	0.781	*0.137*	1	*0.137*
	SI	0.1	0.375	0.25	0.8	1	0.75	1	0.65	0.7	1	1	1	0.5	1	0.975	1	0.001	0.001	0.001	1						
SA	Input	10	0	0	9.36	8.33	23.62	21.3	23.62	25-100	0.4	0.4	0.4	Mostly Sand	0	1	0	60	30	60	0.98	0.010	0.046	0.900	*0.055*	1	*0.055*
	SI	0.001	0.2	0.001	1	1	0.95	1	0.8	0.7	1	1	1	0.5	1	0.975	1	0.001	0.001	0.001	1						

Notes:

Variable Descriptions:

V1-% pool, backwater coverage; **V3**-% bottom cover (Adult, Juv); **V4**-% bottom cover (Fry); **V6**-Dissolved O2 (mg/L), pools; **V7**-pH, growing season; **V8**-Temp (°C), growing season (Adult, Juv); **V9**-Temp (°C), spawning season (Embryo); **V10**-Temp (°C), growing season (Fry); **V11**-Turbidity (ppm); **V12**-Max salinity (ppt), summer (Adult, Juv); **V13**-Max salinity (ppt), summer (Fry); **V14**-Max salinity (ppt), spawning season (Embryo); **V15**-Substrate composition; **V16**-Avg water fluctuation (m), growing season (Adult, Juv); **V17**-Max water fluctuation (m), spawning season (Embryo); **V18**-Avg water fluctuation (m), growing season, (Fry); **V19**-Avg current vel (cm/sec), summer (Adult, Juv); **V20**-Max current vel (cm/sec), pools, spawning season, (Embryo); **V21**-Avg current vel (cm/sec), summer (Fry); **V22**-Stream gradient (m/km).

Terms used for calculating HSI:

Cf-Food component term; **Cc**-Cover component term; **Cwq**-Water quality component term; **Cr**-Reproductive component term; **Cot**-Other component term.

Calculation of HSI Index:

See formulas presented in Appendix G.
For variables producing a 0 value for the SI, 0.001 was substituted when calculating terms of the HSI.
Since the Cr term was below 0.4 the Cr value was used as HSI for all sites.

Input value estimation:

V6-DO measured in the field assumed to approximate pool DO.
V9-Temp during spawning season assumed to be 90% of temp measured in the field during, (Parsons ES March 2001).
V11-Turbity assumed to be intermediate in value, 25-100 ppm
V14-Spawning season salinity assumed to be approximately salinity measured during summer sampling.
V16, V18-Avg water surface elevation variation assumed negligible due to strict summer agricultural demands.
V17-Max water fluctuation during spawning seasoned assumed to not exceed 1m.
V19, V21-used weighted average velocity measured from cross-sectional data collected at each site, (Parsons ES March 2001).
V20-Max current vel in pools assumed to be half the avg current vel (see V19, V21).
V22-Summer stream surface elevation at beginning and ending mile marker used to estimate stream gradient at each site [Alternatives Formulation Report, Appendix C, (Parsons ES, March 2001)].
All other variable values measured directly in the Sept 2000 field sampling event.

Site Codes:

UR – Upper Rincon; G – Garfield, H – Hatch; SA – Sierra Alta, SC – Seldon Canyon; DA – Shalem Colony; LC – Las Cruces; MDD– Mesilla Dam; BM – Black Mesa; and EP – El Paso.

Table C-5 Calculation of Flathead Catfish Habitat Suitability Indices
Based on Data from Surveys at Artificial Habitat Structures in the RGCP
September 1999 USFWS Sampling Data

Site	Model Variable	V1	V2	V3	V4	V5	V6	HSI
Montoya Weir	Input	<1	140	0	10	40	50	0.7
	SI	1	1	1	0.7	0.95	0.8	
Tierra Blanca Green Weir	Input	<1	140	0	10	40	50	0.7
	SI	1	1	1	0.7	0.95	0.8	
Trujillo Groin	Input	<1	140	0.17	5	70	25	0.4
	SI	1	1	1	0.4	0.9	0.45	
Montoya* Groin	Input	<1	140	0.13	5	70	25	0.4
	SI	1	1	1	0.4	0.9	0.45	
Jaralosa* Groin	Input	<1	140	0	5	70	25	0.4
	SI	1	1	1	0.4	0.9	0.45	
Yeso Groin	Input	<1	140	0.12	5	70	25	0.4
	SI	1	1	1	0.4	0.9	0.45	
Placitas Groin	Input	<1	140	0.09	5	70	25	0.4
	SI	1	1	1	0.4	0.9	0.45	
Garcia Groin	Input	<1	140	0.09	5	70	25	0.4
	SI	1	1	1	0.4	0.9	0.45	
Angostora Groin	Input	<1	140	0.09	5	70	25	0.4
	SI	1	1	1	0.4	0.9	0.45	
Rincon Groin	Input	<1	140	0.06	5	70	25	0.4
	SI	1	1	1	0.4	0.9	0.45	
Trujillo Embayment	Input	<1	140	0.13	0	0	25	0.1
	SI	1	1	1	0.1	1	0.45	
Jaralosa* Embayment	Input	<1	140	0.05	0	0	25	0.1
	SI	1	1	1	0.1	1	0.45	
Rincon Embayment	Input	<1	140	0.33	0	0	25	0.1
	SI	1	1	1	0.1	1	0.45	

Notes:

Variable Descriptions:

V1-Stream Gradient (m/km); V2-Turbidity (JTU); V3-Mean Velocity (m/s); V4-% Riffle; V5-% Run V6-% Pool.

HSI:

HSI value equivalent to lowest SI of the six physical variables.

Input Value Estimation:

V1- Since the habitat enhancement structures function to create backwater, stream gradient assumed to be less than 1 m/km at each site area of influence.
V2- Intermediate value, 140 JTU, assumed to reflect average turbidity.
V3- Current velocity measured by NMFO adjacent to structure in Sept 1999 or June 1999.
V4- Value assumed to be 10% for weirs, 5% for groins, and 0% for embayments.
V5- Value assumed to be 40% for weirs, 70% for groins and 0% for embayments.
V6- As with Largemouth Bass HSI calculations value assumed to be 50% for weirs, 25% for groins, and 0% for embayments.

Table C-6 Calculation of Largemouth Bass Habitat Suitability Indices

Based on Data from Surveys at Artificial Habitat Structures in the RGCP (September 1999 USFWS Sampling Data)

Site	Model Variable	V1	V3	V4	V6	V7	V8	V9	V10	V11	V12	V13	V14	V15	V16	V17	V18	V19	V20	V21	Cf	Cc	Cwq	Cr	Cot	HSI
Montoya	Input	50	20	20	6.39	>8	23.4	21.06	23.4	25-100	0.3	0.3	0.3	Mostly Sand	0	1	0	0	0	0	0.64	0.74	0.83	0.82	1	0.80
Weir	SI	0.75	0.6	0.5	0.8	1	0.9	1	0.7	0.7	1	1	1	0.5	1	0.975	1	1	1	1						
Tierra Blanca	Input	50	20	20	5.8	>8	22.4	20.16	22.4	25-100	0.3	0.3	0.3	Mostly Sand	0	1	0	0	0	0	0.64	0.74	0.79	0.82	1	0.79
Green Weir	SI	0.75	0.6	0.5	0.8	1	0.8	1	0.65	0.7	1	1	1	0.5	1	0.975	1	1	1	1						
Trujillo	Input	25	10	10	7.1	>8	21.2	19.08	21.2	25-100	0.3	0.3	0.3	Mostly Sand	0	1	0	17	17	17	0.24	0.39	0.73	0.15	0.10	0.15
Groin	SI	0.2	0.375	0.225	0.8	1	0.65	0.85	0.5	0.7	1	1	1	0.5	1	0.975	1	0.2	0.001	0.001						
Montoya*	Input	25	10	10	6.86	>8	22.3	20.07	22.3	25-100	0.3	0.3	0.3	Mostly Sand	0	1	0	13	13	13	0.24	0.39	0.78	0.16	0.25	0.16
Groin	SI	0.2	0.375	0.225	0.8	1	0.775	1	0.6	0.7	1	1	1	0.5	1	0.975	1	0.5	0.001	0.001						
Jaralosa*	Input	25	10	10	7.58	>8	24.7	22.23	24.7	25-100	0.3	0.3	0.3	Mostly Sand	0	1	0	0	0	0	0.24	0.39	0.89	0.62	1	0.56
Groin	SI	0.2	0.375	0.225	0.8	1	1	0.95	0.9	0.7	1	1	1	0.5	1	0.975	1	1	1	1						
Yeso	Input	25	10	10	6.29	>8	25	22.5	25	25-100	0.3	0.3	0.3	Mostly Sand	0	1	0	12	12	12	0.24	0.39	0.89	0.16	0.28	0.16
Groin	SI	0.2	0.375	0.225	0.8	1	1	0.95	0.9	0.7	1	1	1	0.5	1	0.975	1	0.55	0.001	0.001						
Placitas	Input	25	10	10	6.74	>8	25.7	23.13	25.7	25-100	0.4	0.4	0.4	Mostly Sand	0	1	0	9	9	9	0.24	0.39	0.89	0.37	0.38	0.37
Groin	SI	0.2	0.375	0.225	0.8	1	1	0.7	0.95	0.7	1	1	1	0.5	1	0.975	1	0.75	0.1	0.001						
Garcia	Input	25	10	10	6.21	>8	25.4	22.86	25.4	25-100	0.4	0.4	0.4	Mostly Sand	0	1	0	9	9	9	0.24	0.39	0.89	0.38	0.38	0.38
Groin	SI	0.2	0.375	0.225	0.8	1	1	0.8	0.95	0.7	1	1	1	0.5	1	0.975	1	0.75	0.1	0.001						
Angostora	Input	25	10	10	6.9	>8	24.7	22.23	24.7	25-100	0.4	0.4	0.4	Mostly Sand	0	1	0	9	9	9	0.24	0.39	0.89	0.39	0.38	0.39
Groin	SI	0.2	0.375	0.225	0.8	1	1	0.95	0.9	0.7	1	1	1	0.5	1	0.975	1	0.75	0.1	0.001						
Rincon	Input	25	10	10	3.71	>8	24	21.6	24	25-100	0.4	0.4	0.4	Mostly Sand	0	1	0	6	6	6	0.24	0.39	0.76	0.48	0.50	0.44
Groin	SI	0.2	0.375	0.225	0.4	1	1	1	0.8	0.7	1	1	1	0.5	1	0.975	1	1	0.25	0.001						
Trujillo	Input	100	0	0	6.9	>8	23.9	21.51	23.9	25-100	0.2	0.2	0.2	Mostly Sand	0	1	0	13	13	13	0.32	0.46	0.86	0.22	0.25	0.22
Embayment	SI	1	0.2	0.001	0.8	1	0.95	1	0.8	0.7	1	1	1	0.5	1	0.975	1	0.5	0.001	0.001						
Jaralosa*	Input	100	0	0	6.95	>8	22.3	20.07	22.3	25-100	0.1	0.1	0.1	Mostly Sand	0	1	0	5	5	5	0.32	0.46	0.79	0.68	0.50	0.52
Embayment	SI	1	0.2	0.001	0.8	1	0.775	1	0.65	0.7	1	1	1	0.5	1	0.975	1	1	0.3	0.001						
Rincon	Input	100	0	0	2.56	>8	23.9	21.51	23.9	25-100	0.4	0.4	0.4	Mostly Sand	0	1	0	33	33	33	0.32	0.46	0.76	0.22	0.001	0.22
Embayment	SI	1	0.2	0.001	0.4	1	0.95	1	0.9	0.7	1	1	1	0.5	1	0.975	1	0.001	0.001	0.001						

Notes:

Variable Descriptions:

V1-% pool, backwater coverage; **V3**-% bottom cover (Adult, Juv); **V4**-% bottom cover (Fry); **V6**-Dissolved O2 (mg/L), pools; **V7**-pH, growing season; **V8**-Temp (°C), growing season (Adult, Juv); **V9**-Temp (°C), spawning season (Embryo); **V10**-Temp (°C), growing season; V11-Turbidity (ppm); V12-Max salinity (ppt), summer (Adult, Juv); V13-Max salinity (ppt), summer (Fry); V14-Max salinity (ppt), spawning season (Embryo); V15-Substrate composition; **V16**-Avg water fluctuation (m), growing season (Adult, Juv); **V17**-Max water spawning season (Embryo); V18-Avg water fluctuation (m), growing season, (Fry); V19-Avg current vel (cm/sec), summer (Adult, Juv); **V20**-Max current vel (cm/sec), pools, spawning season, (Embryo); **V21**-Avg current vel (cm/sec), summer (Fry); **V22**-Stream gradi

Terms used for calculating HSI:

Cf-Food component term; **Cc**-Cover component term; **Cwq**-Water quality component term; **Cr**-Reproductive component term; **Cot**-Other component term.

Calculation of HSI Index:

See formulas presented in Appendix G.
For variables producing a 0 value for the SI, 0.001 was substituted when calculating terms of the HSI.
Since the Cr term was below 0.4 the Cr value was used as HSI for all sites.

Input value estimation:

V1-Embayments may provide 100% backwater, weirs 50%, and groins 25%.
V3&V4-Embayments provide 0% bottom cover, weirs 20%, and groins 10%.
V6-DO measured in the field assumed to approximate pool DO.
V7-pH assumed to be greater than 8 as it was at all transect series during Parsons ES, Sept 2000 sampling
V9-Temp during spawning season assumed to be 90% of temp measured in the field during, Parsons ES, Sept 2000.
V11-Turbity assumed to be intermediate in value, 25-100 ppm.
V14-Spawning season salinity assumed to be approximately salinity measured during summer sampling.
V15-Substrate composition assumed to be mostly sand.
V16, V18-Avg water surface elevation variation assumed negligible due to strict summer agricultural demands.
V17-Max water fluctuation during spawning seasoned assumed to not exceed 1m.
V19, V21-Velocity measurements from NMFRO Annual Report and represents June 1999 sampling event.
V20-Max current vel in pools assumed to be half current vel (see V19, V21).
All other variable values measured directly in the June1999 field sampling event.