3 Analysis of Characterization of Exposure

In the Navigation Study Fish Ecological Risk Assessment, the ecological stressors take the form of the physical forces produced directly by commercial vessels (i.e., tows) navigating the UMR-IWW System and the indirect effects that result from these forces. The direct physical forces imposed by operating commercial vessels include increases in river current velocity, wake waves, return currents, or drawdown; pressure changes and shear stresses associated with water entrainment through the propeller jet; shear stresses in the vicinity of the moving barge hulls and on the bed sediments beneath the vessel; and bed shear stresses extending to the channel borders and backwaters.

Stressor Characterization

The primary ecological stressor in this assessment of larval fish impacts is the rate of water entrainment $Q_{p,}$ m^3/sec. As commercial vessels push barges through the UMR-IWW System, water pulled through their rotating propellers exerts shear stresses, velocity changes, and pressure changes that could injure or kill early life stages (e.g., eggs, larvae, young of the year), juvenile, and adult fishes that are coincidentally entrained. The potential impact of shear stresses induced by the hulls of the moving barges on fish early life stage mortality was addressed early in the Navigation Study; however, analysis of the likely magnitudes of these forces suggested that impacts would be negligible (Maynord, in preparation). In addition, Keevin, Adams, and Killgore (in preparation) concluded that pressure changes resulting from rapid displacement within the water column will not be a significant source of mortality for early life stages of fish as the result of commercial navigation. The following sections describe the approaches used to quantify the magnitude, extent, and duration of the entrainment rate in relation to baseline and projected traffic intensity.

Frequency of vessel passage

The frequency of vessels passing any arbitrary location per day in a pool is referred to as traffic intensity (i.e., vessels/day). To characterize current commercial traffic intensity, a baseline number of vessels passing through each pool each month was developed using 1992 lockage data. Table 3 lists the average number of vessels per day by month for UMR Pools 4, 8, 13, and 26 and the La Grange Pool in the IWW. In general, the volume of traffic increases from north to south on pools in the UMR, with more southerly pools also showing a longer navigation season.

Table 3
Baseline Traffic Intensity (Mean Vessels/Day) for UMR-IWW System Long-Term Resource Monitoring Pools Based on 1992 Data

Month	UMR 4	UMR 8	UMR 13	UMR 26	IWW La Grange
January	0.0	0.0	0.0	12.9	10.1
February	0.0	0.0	0.0	14.6	11.0
March	1.9	2.2	5.2	21.3	9.4
April	4.8	5.3	8.4	22.8	9.1
May	5.7	6.2	8.9	22.3	8.5
June	5.4	6.1	8.3	21.7	7.8
July	5.9	6.7	9.2	23.3	8.7
August	5.8	6.4	8.3	21.4	8.2
September	4.7	5.2	6.9	20.7	8.6
October	4.7	5.0	7.0	21.7	9.4
November	3.3	3.8	6.0	20.5	9.4
December	0.0	0.0	0.7	17.8	12.3

For the initial risk assessment, four hypothetical future traffic scenarios were constructed assuming 25, 50, 75, and 100 percent increases over the 1992 baseline data. In each analysis, it was assumed that each vessel traversed the entire pool at constant speed and reached the next lock within the day. In the entrainment calculations, it was also assumed that the vessel remained within the navigation channel while underway and that successive vessels were evenly spaced with the distance between them determined by the number of vessels/day and the navigation length of the pool.

Fleet characteristics

Lockage records for 1992 were analyzed to construct a data set assumed to represent the current commercial fleet on the UMR-IWW System. These data describe, by pool and month, the relative distribution of vessels across categories of direction of travel, size, load, speed and whether or not the vessel had a Kort nozzle. Vessels travel either upbound (U) or downbound (D). Vessel sizes (tugboat plus barges) were classified as small (S), medium (M), or big (B). The following specific lengths and widths were assigned to each size category: small vessels, a length of 178.3 m and a width of 10.7 m; medium vessels, a length of 237.7 m and a width of 21.3 m; and big vessels, a length of 297.2 m and width of 32.0 m.

Barge loads were determined as empty (E), mixed (M), or full (F); a corresponding depth of vessel draft was assigned to each category. Empty barges were assigned a draft depth of 0.61 m, mixed loads drafted 2.13 m, and fully loaded barges drafted 2.74 m.

Vessel speeds were categorized as slow (S), medium (M), or fast (F); however, the actual velocities assigned to these classes differed for the UMR versus the IWW. For vessels navigating the UMR, slow speed was defined as 2.24 m/sec (5 mph), medium speed was 2.91 m/sec (6.5 mph), and fast vessels were assumed to travel at 3.58 m/sec (8 mph). Corresponding vessel speeds assigned to vessels navigating the IWW were 1.34 m/sec (3 mph), 2.24 m/sec (5 mph), and 3.13 m/sec (7 mph).

The preceding classification categories produced 108 possible configurations for commercial vessels operating on the UMR-IWW System. Clearly, not all 108 vessel types occur in each pool each month. Table 4 presents an example of the relative distribution of different vessel types recorded for UMR Pool 8 in August 1992. Separate fleet characteristics files were developed for all pools on the UMR and the IWW. In developing and assessing future traffic scenarios, it was assumed that the current fleet configurations will apply to traffic projections for the remainder of the project period (i.e., the year 2050).

Tow-induced physical forces

The UMR-IWW System Navigation Study has attempted to develop a comprehensive understanding of the physical forces generated by moving commercial vessels in relation to their possible impacts on the early life stages of fish. Separate studies have been performed to characterize the potential magnitude of shear forces in the zone of the rotating propeller, pressure changes associated with rapid water column mixing in the propeller wash, and shear forces induced by the moving hull. In addition, the possible stranding of eggs and larvae as the result of drawdown by passing vessels was studied.

Table 4
Relative Frequency of Different Vessel Types Observed in Pool 8 for the Month of August

Direction	Size	Type	Speed	% Kort	Frequency	Relative Frequency
D	B	E	F	33.33	0.000000	0.00000000
D	B	E	M	33.33	2.647059	0.01557094
D	B	E	S	33.33	0.352886	0.00207612
D	B	L	F	40.00	0.048544	0.00028555
D	B	L	M	40.00	2.087379	0.01227870
D	B	L	S	40.00	2.864078	0.01684752
D	B	M	F	59.09	0.171206	0.00100709
D	B	M	M	59.09	10.957198	0.06445411
D	B	M	S	59.09	10.871595	0.06395056
D	M	E	F	42.86	1.991632	0.01171548
D	M	E	M	42.86	4.158996	0.02446468
D	M	E	S	42.86	0.849372	0.00499631
D	M	L	F	12.50	0.154839	0.00091082
D	M	L	M	12.50	4.438710	0.02611006
D	M	L	S	12.50	3.406452	0.02003795
D	M	M	F	20.00	0.787992	0.00463525
D	M	M	M	20.00	6.510319	0.03829599
D	M	M	S	20.00	2.701689	0.01589229
D	S	E	F	6.25	9.709402	0.05711413
D	S	E	M	6.25	4.923077	0.02895928
D	S	E	S	6.25	1.367521	0.00804424
D	S	L	F	15.38	3.734417	0.02196716
D	S	L	M	15.38	7.433604	0.04372708
D	S	L	S	15.38	1.831978	0.01077634
D	S	M	F	0.00	0.306667	0.00180392
D	S	M	M	0.00	0.493333	0.00290196
D	S	M	S	0.00	0.200000	0.00117647
U	B	E	F	75.00	0.666667	0.00392157
U	B	E	M	75.00	2.666667	0.01568628
U	B	E	S	75.00	0.666667	0.00392157

(Continued)

Table 4 (Concluded)						
Direction	**Size**	**Type**	**Speed**	**% Kort**	**Frequency**	**Relative Frequency**
U	B	L	F	70.59	0.050296	0.00029586
U	B	L	M	70.59	7.594675	0.04467456
U	B	L	S	70.59	9.355030	0.05502959
U	B	M	F	28.57	0.395480	0.00232635
U	B	M	M	28.57	7.514124	0.04420073
U	B	M	S	28.57	6.090395	0.03582585
U	M	E	F	0.00	0.324324	0.00190779
U	M	E	M	0.00	0.459459	0.00270270
U	M	E	S	0.00	0.216216	0.00127186
U	M	L	F	37.50	0.375652	0.00220972
U	M	L	M	37.50	5.259130	0.03093606
U	M	L	S	37.50	2.365217	0.01391304
U	M	M	F	20.00	1.152263	0.00677802
U	M	M	M	20.00	6.460905	0.03800532
U	M	M	S	20.00	2.386831	0.01404018
U	S	E	F	0.00	5.302682	0.03119225
U	S	E	M	0.00	1.839080	0.01081812
U	S	E	S	0.00	0.858238	0.00504846
U	S	L	F	9.09	9.755656	0.05738621
U	S	L	M	9.09	10.253394	0.06031408
U	S	L	S	9.09	1.990950	0.01171147
U	S	M	F	0.00	0.369231	0.00217195
U	S	M	M	0.00	0.553846	0.00325792
U	S	M	S	0.00	0.076923	0.00045249

Killgore et al. (in preparation) measured the mortality of larval and juvenile fish entrained through a scale model of a towboat propeller. Instantaneous and delayed mortality was measured for eggs and larvae of shovelnose sturgeon, lake sturgeon, paddlefish, and blue sucker. Mortality was also measured for juvenile common carp. Experiments were performed at four different propeller speeds. Measured mortalities differed among species and life stages; initial mortalities ranged from 9.3 to 55.7 percent across all species, life stages, and propeller speeds; corresponding delayed mortalities ranged from 14.4 to 87.2 percent. Delayed mortality was observed for all species and life stages, except for juvenile common carp. The highest mortality (87.2 percent) was observed for lake sturgeon larvae at the highest propeller speed. The authors concluded that shear stress created by the propeller jet was probably the principal force contributing to mortality for early life stages of fish entrained by passing commercial vessels.

Keevin, Adams, and Killgore (in preparation) used a laboratory pressure chamber to simulate rapid vertical displacement (i.e., pressurization-depressurization) of bigmouth buffalo and blue catfish larvae, juvenile bluegill, and juvenile largemouth bass. The maximum tested pressure change (345 kPa) was equivalent to a 35.2-m displacement within a water column; this distance exceeds depths in the UMR-IWW navigation channel and represents an extreme test for impacts of pressure changes. No significant mortalities among larvae or juvenile fish were observed in these experiments. Keevin, Adams, and Killgore (in preparation) conclude that pressure changes resulting from rapid displacement within the water column will not be a significant source of mortality for early life stages of fish as the result of commercial navigation.

Keevin et al. (in preparation) used a Couette cell to measure the impacts of fluid shear resulting from the passage of a barge hull through the water column. Mortality was measured for three shear levels at three exposure periods for five fish species: larval shovelnose sturgeon, larval bigmouth buffalo, larval blue catfish, juvenile bluegill, and juvenile largemouth bass. When the measured mortality rates were extrapolated to magnitudes of hull shear calculated for barge hulls (Maynord, in preparation), only the shear (250 dynes/cm^2) of a high-speed tow (4.0 m/sec) with a ratio of depth/draft of 1.22 approached values causing measurable mortality in bigmouth buffalo larvae. The remaining species were not significantly ($P<0.05$) impacted by hull shear stress.

Adams et al. (in preparation) measured the propensity for stranding of fish larvae in relation to drawdown (i.e., dewatering) events simulated under laboratory conditions. The study included larval shovelnose sturgeon, larval paddlefish, larval bigmouth buffalo, juvenile blue catfish, juvenile bluegill, and juvenile largemouth bass. Drawdown events were simulated for 1V:5H and 1V:10H slopes in an experimental flume using three drawdown velocities (0.76, 0.46, and 0.21 cm/sec). The results demonstrated that species typically found in the nearshore areas (i.e., littoral zone) were generally less susceptible to stranding; however, species typically inhabiting the main channel (e.g., sturgeon, paddlefish) exhibited a positive rheotaxis and were more likely to become stranded. Thus, the behavioral response of different species to drawdown would likely have to be considered in assessing the larger scale, longer term impacts of commercial traffic on fish larvae. Adams et al. (in preparation) speculated that the relatively low numbers of larvae of main channel species that would occupy the nearshore area would lessen the impacts of drawdown on these species. Additionally, species commonly occurring in this area appear adapted to dewatering events, including vessel-induced drawdown.

As a result of these studies, the risk assessment has focused on the apparent main source of mortality to larval fishes, namely the direct entrainment of individuals through the propeller zone of passing commercial vessels. The impacts of additional forces (e.g., drawdown, hull shear stress) might be assessed in the future, if additional studies or new information provide compelling reasons to do so.

Magnitude of water entrainment rate

The rate of water entrainment Q_p through the propellers of each of the 108 possible vessel types addressed in this assessment was estimated. Estimates of these flow rates derive from the work of Maynord (1999), the DIFFLARV model (Holley, in preparation), and the equations developed by Toutant (1982).

The equations developed by Toutant (1982) were used to estimate the effective push *Ep* where

a. For vessels with Kort nozzles:

$$Ep_k = 31.82\, Hp^{\,0.974} - 5.4\,(S^2)\,(Hp)^{0.5} \quad (1)$$

b. For vessels with open wheels:

$$Ep_o = 23.57\, Hp^{\,0.974} - 2.34\,(S^2)\,(Hp)^{0.5} \quad (2)$$

In these equations, *Hp* is the applied horsepower from both propellers, and *S* is the vessel speed relative to the water. If metric units are used, these equations estimate *Ep* in newtons. One-half of the value of *Ep* defines the term, *T*, in the following equation used to calculate Q_p, m^3/sec, for a single propeller (Maynord 1999):

$$Q_p = \frac{V_a p D^2}{8} + \sqrt{\frac{V_a{}^2 p^2 D^4}{64} + \frac{T p D^2}{4 z r}} \quad (3)$$

where

V_a = the advance velocity of the vessel, m/sec
D = propeller diameter, m
T = ½ *Ep* estimated using Equations 1 or 2
z = 1 for Kort nozzles, 2 for open wheels
ρ = density of water (~1 kg/m^3)

Values of propeller diameter were based on a sample of commercial tugboats operating on the Ohio River (Maynord 1999). Small, medium, and big vessels were assigned corresponding propeller diameters of 1.8, 2.7, and 3.1 m. Advance velocities, calculated as the difference between the ambient current velocity and the speed of the vessel relative to the ground, were defined as positive for upbound vessels and negative for downbound vessels.

Based on Equations 1-3 and the characteristics of 108 vessel types, estimates of entrainment rate ranged from 15.4 m^3/sec for a downbound, small, slow vessel with empty barges and a Kort nozzle to 53.7 m^3/sec for an upbound, medium-speed vessel with full barges and a Kort nozzle. The expected value and variance of the entrainment rate for vessels on each pool and for each month were estimated as a function of the numbers of vessels per day distributed among the various classes of size, speed, load, direction, and open wheel/Kort nozzle features of navigating vessels.

The total volume of water entrained per day was calculated as the product of Q_p times the number of seconds required for a vessel to traverse the pool of interest. To characterize the implications of uncertainty on parameters involved in these calculations, the total entrainment volume was calculated using three combinations of estimated entrainment rate and vessel speed (relative to the water):

a. Combination 1: The mean value of Q_p and vessel speed (i.e., the "average" vessel).

b. Combination 2: The mean + 1 standard deviation of Q_p and the mean - 1 standard deviation of vessel speed (e.g., a slow-moving vessel that entrained a large volume).

c. Combination 3: The mean - 1 standard deviation of Q_p combined with the mean + 1 standard deviation of vessel speed (e.g., an efficient vessel moving quickly and entraining comparatively smaller volumes).

Of these possible combinations of estimated Q_p and reported vessel speeds, Combinations 2 and 3 consistently produced the highest and lowest entrainment volumes, respectively. Table 5 lists the mean and standard deviations estimated for the rate of water entrainment Q_p and vessel speed S for UMR Pools 4, 8, 13, 26, and the IWW La Grange Pool.

In addition, the DIFFLARV model (Holley, in preparation) was used to check the assumption independently that the river segment traversed by a commercial vessel is completely mixed before the next vessel passes. This model was developed to estimate what fraction of water entrained by a vessel was previously entrained by the immediately preceding vessel. Caution was taken in developing and applying the larval entrainment model to avoid killing the same individuals more than once. Analysis of DIFFLARV simulations of selected intensive traffic scenarios suggests that entrainment of water by successive vessels passing through a pool is, at most, a few percent given expected traffic densities. As new traffic projections are developed, the DIFFLARV will be used to reevaluate the underlying assumption of complete channel mixing between successive vessel passages.

Table 5
Estimated Mean and Standard Deviation (SD) of Entrainment Rate Q_p, m^3/sec, and Vessel Speed *S*, m/sec, for Pools 4, 8, 13, and 26 on the Upper Mississippi River and the La Grange Pool on the Illinois Waterway

		Q_p		*S*	
Pool	**Month**	**Mean**	**SD**	**Mean**	**SD**
4	1	0	0	0	0
4	2	0	0	0	0
4	3	17.84	2.227	3.171	0.4887
4	4	43.61	17.18	2.909	0.4779
4	5	46.88	17.25	2.905	0.4702
4	6	45.93	16.24	2.897	0.4653
4	7	43.26	19.46	2.938	0.4802
4	8	43.44	18.92	2.927	0.4798
4	9	41.84	18.29	2.907	0.4766
4	10	44.03	19.46	2.920	0.4827
4	11	38.95	18.88	2.970	0.4889
4	12	0	0	0	0
8	1	0	0	0	0
8	2	0	0	0	0
8	3	51.08	11.83	2.798	0.4237
8	4	45.96	17.98	2.904	0.4714
8	5	49.25	17.61	2.889	0.4611
8	6	49.35	15.97	2.873	0.4529
8	7	47.63	18.96	2.904	0.4668
8	8	45.92	19.40	2.910	0.4748
8	9	43.11	19.11	2.899	0.4757
8	10	47.74	19.65	2.895	0.4707
8	11	44.46	20.88	2.940	0.4812
8	12	0	0	0	0
13	1	0	0	0	0
13	2	0	0	0	0
13	3	42.98	16.86	2.912	0.4746
13	4	46.98	17.62	2.899	0.4683

(Sheet 1 of 3)

Table 5 (Continued)					
		Q_p		S	
Pool	Month	Mean	SD	Mean	SD
13	5	49.29	17.72	2.895	0.4636
13	6	50.75	16.33	2.872	0.4536
13	7	47.42	18.20	2.897	0.4654
13	8	47.99	18.35	2.881	0.4642
13	9	44.13	18.22	2.897	0.4773
13	10	48.94	18.36	2.875	0.4648
13	11	46.65	20.90	2.927	0.4768
13	12	43.12	20.71	2.953	0.4807
26A	1	26.75	16.07	3.088	0.5015
26A	2	26.11	16.68	3.092	0.5001
26A	3	45.83	18.26	2.905	0.4677
26A	4	50.41	18.07	2.887	0.4575
26A	5	52.74	17.33	2.876	0.4524
26A	6	53.38	18.29	2.877	0.4549
26A	7	51.43	19.13	2.887	0.4609
26A	8	48.73	20.51	2.902	0.4707
26A	9	46.12	20.89	2.919	0.4812
26A	10	49.46	19.02	2.882	0.4629
26A	11	53.71	19.48	2.896	0.4624
26A	12	48.76	22.09	2.944	0.4808
26B	1	39.94	14.36	2.938	0.4803
26B	2	29.60	17.06	3.050	0.4973
26B	3	45.91	18.28	2.904	0.4675
26B	4	50.27	18.32	2.890	0.4588
26B	5	52.78	17.27	2.876	0.4522
26B	6	53.61	18.28	2.877	0.4546
26B	7	51.56	19.27	2.888	0.4611
26B	8	48.14	20.55	2.906	0.4717
26B	9	46.62	20.84	2.917	0.4802
26B	10	50.02	18.88	2.881	0.4617
26B	11	49.79	18.64	2.896	0.4624
					(Sheet 2 of 3)

Table 5 (Concluded)					
		Q_p		*S*	
Pool	Month	Mean	SD	Mean	SD
26B	12	45.17	21.02	2.944	0.4808
LG[1]	1	44.77	17.17	2.737	0.4351
LG	2	39.91	15.10	2.786	0.4409
LG	3	41.02	16.69	2.768	0.4480
LG	4	39.20	16.30	2.776	0.4546
LG	5	37.27	16.73	2.813	0.4616
LG	6	37.16	16.70	2.809	0.4512
LG	7	34.59	17.16	2.852	0.4700
LG	8	34.95	17.82	2.858	0.4697
LG	9	33.79	17.81	2.888	0.4723
LG	10	36.37	16.66	2.830	0.4617
LG	11	40.32	16.16	2.777	0.4445
LG	12	42.70	16.18	2.775	0.4394
					(Sheet 3 of 3)

[1] LG = La Grange

Duration

In the Navigation Study Fish Ecological Risk Assessment, larval fish entrainment mortality is considered each month for an entire year. However, actual larval fish entrainment involves the navigation of commercial vessels during the periods of fish spawning. Spawning seasons vary among fish species on the UMR-IWW System, but all species addressed in this risk assessment spawn some time between April and September.

Spatial-Temporal Scale

The spatial scale of the assessment of larval fish entrainment includes the volume of each pool between the main channel borders defined by the UMR-IWW System Aquatic Habitat Classification System (Wilcox 1993). Within the main channel borders, which are defined as the areas between the navigation channel and the riverbank (Wilcox 1993), the analysis focuses on the navigation channel. The navigation channel is the designated navigation channel marked by channel buoys; the navigation channel on most of the UMR-IWW System is 91.4 m (300 ft) wide in straight reaches and 152.4 m (500 ft) wide in bends (Wilcox 1993). Each pool is assumed to be completely mixed with the relative concentration of larvae of different fish species determined by its pool *i* and month *j* specific w_i value.

The larval fish entrainment rates are estimated for each month using an input of average vessels per day corresponding to the month and the pool. The temporal scales of the assessment are determined by pool-specific differences in the number of months in the navigation season and their overlap with the spawning months of the selected 30 fish species in the UMR-IWW System.

Seasonal Pool Volumes

The estimates of larval fish entrainment are influenced by pool volume, which varies seasonally in relation to discharge and operation of dams. In this assessment, pool volumes were estimated using changes in bathymetry associated with seasonal differences in discharge and corresponding stage height. Analyses of existing data were used to estimate the 5^{th}, 50^{th}, and 90^{th} percentiles of discharge for pools on the UMR-IWW System, and these percentiles defined "low," "medium," and "high" stage heights and corresponding pool volumes (Table 6). The seasonally-dependent probability of these stage heights was estimated for each pool.[1] Expected values of pool volume were calculated monthly for each pool as the average of the low, medium, and high pool volumes weighted by their probabilities of occurrence. These volumes were used in estimating *R*, the ratio of entrained volume to total pool volume, in the CEM model.

Exposure Profile for Larval Entrainment by Commercial Navigation

The primary product of the exposure analysis is an "exposure profile" that describes the nature of the stressor and quantifies its frequency, magnitude, extent, and duration in a manner relevant to the ecological effects of concern and the methods selected, as part of the problem formulation process, to characterize ecological impacts and estimate risks (USEPA 1998). For the assessment of larval fish entrainment, the stressor is the amount of water (mean, standard deviation) that passes through the propellers of the commercial vessels that traverse each pool each month. Entrainment volumes were calculated for a reference traffic intensity (i.e., the 1992 baseline) and percentage increases (25, 50, 75, and 100 percent) in the average number of vessels per day over this reference. For the reference traffic and each percentage increase scenario, these entrainment volumes are used to estimate the total number of fish larvae entrained in each pool during each month. The entrainment volume, normalized to the weighted average monthly pool volume, is used to estimate larval entrainment for each pool and month. The number of killed fish larvae are used to estimate losses in future adult fish, future recruitment, and biomass production.

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[1] Kevin Landwehr, personal communication, U.S. Army Engineer District, Rock Island

Table 6
Pool Lengths and Volumes Corresponding to Low, Medium, and High Stage Heights for the UMR-IWW System

Pool	Length, km	Stage Height, 10^6 m^3		
		High	Medium	Low
4	71.0	827.4	633.4	586.1
5	23.7	46.3	39.4	23.7
5A	15.5	23.7	18.5	18.1
6	23.3	35.5	27.4	27.8
7	19.3	40.1	34.4	33.2
8	37.0	52.9	52.5	46.0
9	51.5	93.4	68.7	66.9
10	51.5	122.5	86.2	77.5
11	51.5	124.7	102.3	92.3
12	43.5	137.2	108.3	100.8
13	54.7	151.2	121.6	109.9
14	46.7	143.0	117.2	105.7
15	16.3	53.1	45.1	42.3
16	41.4	122.0	89.5	77.5
17	32.4	93.0	63.2	57.2
18	42.8	154.7	119.5	105.5
19	74.5	420.6	350.2	326.1
20	33.8	153.4	104.1	90.2
21	29.5	109.9	74.2	66.3
22	38.1	167.5	113.2	100.5
24	44.7	193.5	148.2	134.0
25	51.5	191.1	138.0	117.2
26A	39.2	111.6	81.9	74.7
26B	26.1	226.7	166.3	151.6
27	24.6	423.1	256.6	159.1
LG[1]	124.7	158.3	91.3	71.6
PE[2]	118.0	196.0	89.2	76.0
SR[3]	21.9	13.9	12.3	11.5
MA[4]	43.3	33.5	24.7	22.8
DI[5]	23.3	17.2	16.0	15.4

[1] LG = La Grange, [2] PE = Peoria, [3] SR = Starved Rock, [4] MA = Marseilles, [5] DI = Dresden Island