Maximum Shaft Torque and Turbine Thrust Calculations:

The maximum torque produced by the test turbines as well as the maximum thrust generated was calculated. These values were to be the driving constraint on the Turbine Testing Apparatus Design. The maximum torque determined the shaft diameter on the turbine drive, the selection of sprockets and chain drive, the sizing of the resistance motor, and bearings on both the submerged and motor shafts. The maximum thrust on the turbine was used to calculate thrust bearing size in the drive shaft, the moment on the test apparatus supports, and the approximate motion that will be seen on the dynamometer.

The following assumptions were made about the dynamics of the testing procedure.

$Vw := 3\frac{m}{s}$	Maximum flow velocity
$\rho := 998\frac{kg}{m^3}$	Density of water
$Cp := .45$	Coefficient of performance (max is 0.593 - Betz Limit)
$\lambda r := \frac{1}{3}$	Tip speed ratio (flow velocity:tip velocity) - altered by resistance we apply?
$r1 := 5in$	Rotor radius possibilities r1, and r2

The driving equation of the maximum power produced:

Power Density in Flow:

$P_{fd} := 0.5 \cdot \rho \cdot Vw^3$ $\quad P_{fd} = 1.347 \times 10^4 \frac{W}{m^2}$

Power in Turbine Flow:

$P_f := P_{fd} \cdot Cp \cdot A1$ $\quad \boxed{P_f = 307.209\ W}$

The maximum Power for the above constraints was 307.2 Watts

The equation that yielded the maximum torque:

Rotational Speed:

$$RPM := \frac{Vw}{r1 \cdot \lambda r} \qquad RPM = 676.722\,rpm$$

Torque:

$$Q := \frac{P_f}{RPM} \qquad Q = 4.335\ N \cdot m$$

The maximum Torque for the above constraints was 4.34 Newton Meters

The equation that yielded the maximum frontal thrust:

Frontal Force/Thrust:

$$T := \frac{P_f}{Vw} \qquad T = 102.403\,N$$

The maximum Frontal Thrust for the above constraints was 102.4 Newtons

The equation that yielded the Moment on the Test Apparatus Keel:

$Dw := 19.5in$	Water Center to Water Surface Depth
$Da := 21.5in$	Water Surface to Underside of Carriage
$Ht := 10in$	Tower Height
$Hdyno := 13in$	Dyno Height
$DHn := 11.5in$	Nominal Dyno Plate Height

Length of Keel:

$Lk := Dw + Da - DHn$ $\quad Lk = 29.5\ in$

Moment on Keel:

$Mk := T \cdot Lk$ $\quad \boxed{Mk = 76.731 N \cdot m}$

The maximum Moment on the Keel for the above constraints was 76.731 Newton Meters.

Maximum power, torque, frontal thrust, and moment on the keel will all be used as the driving design criteria for the testing apparatus.