



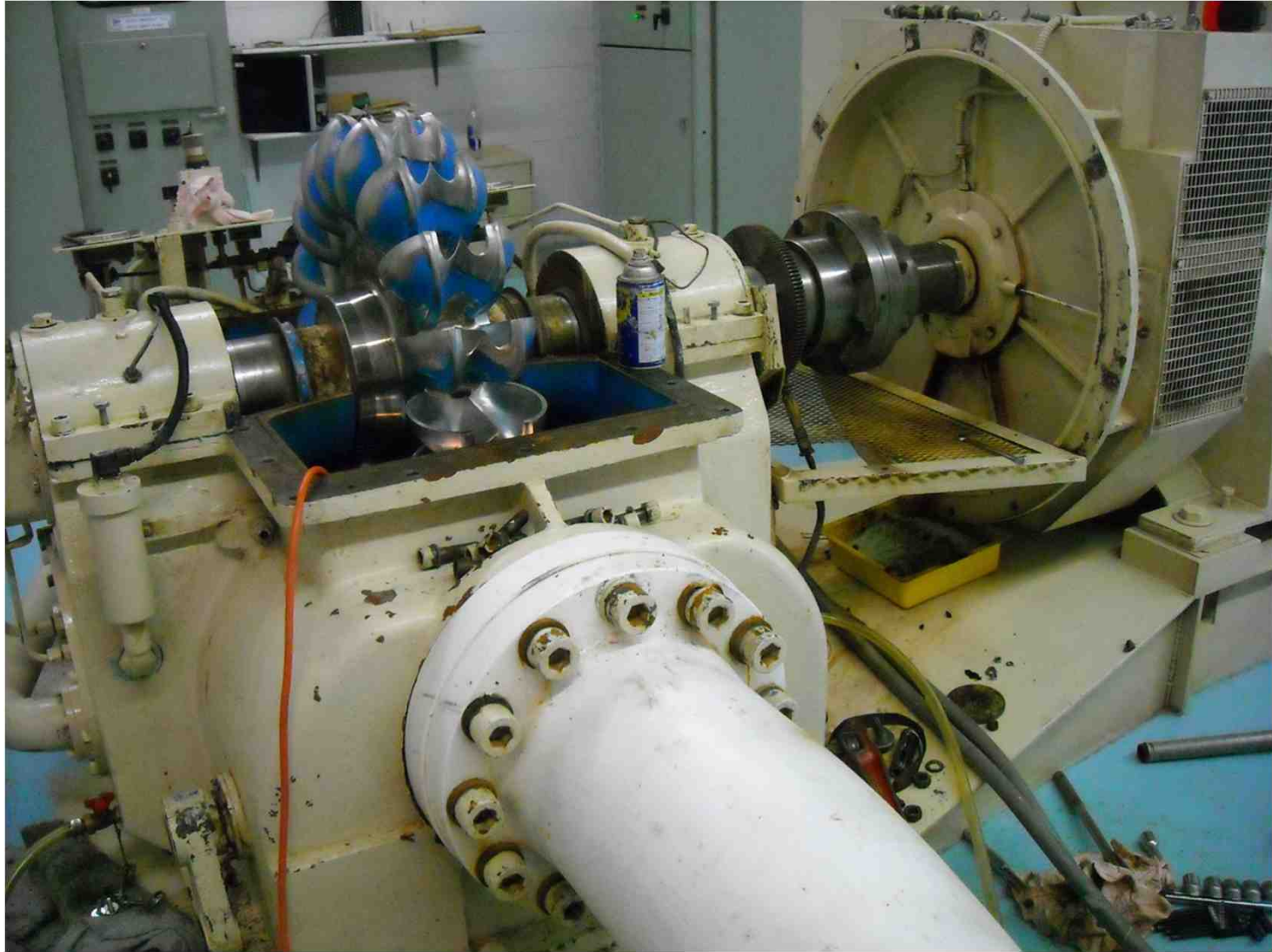
# Building Hydroelectric Generation in Your System

Alden Robinson, P.E.

























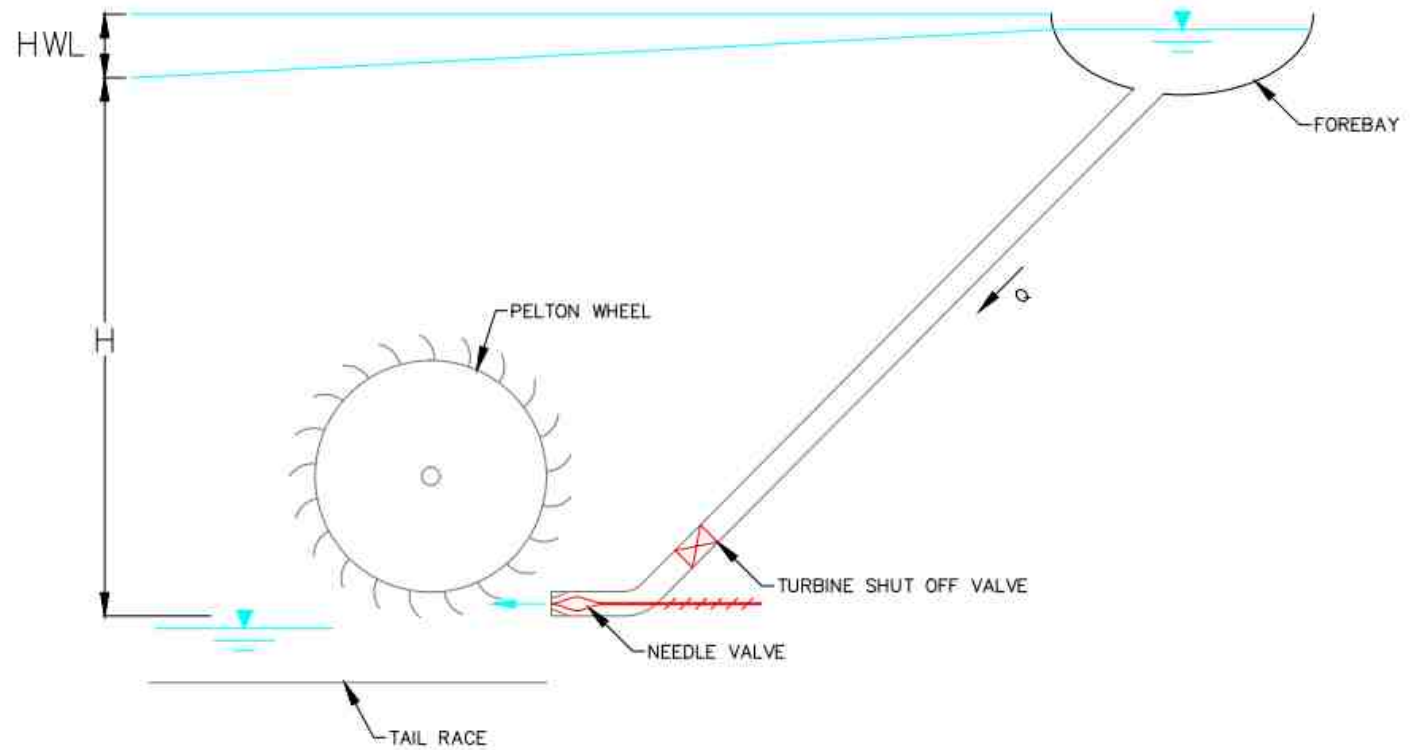




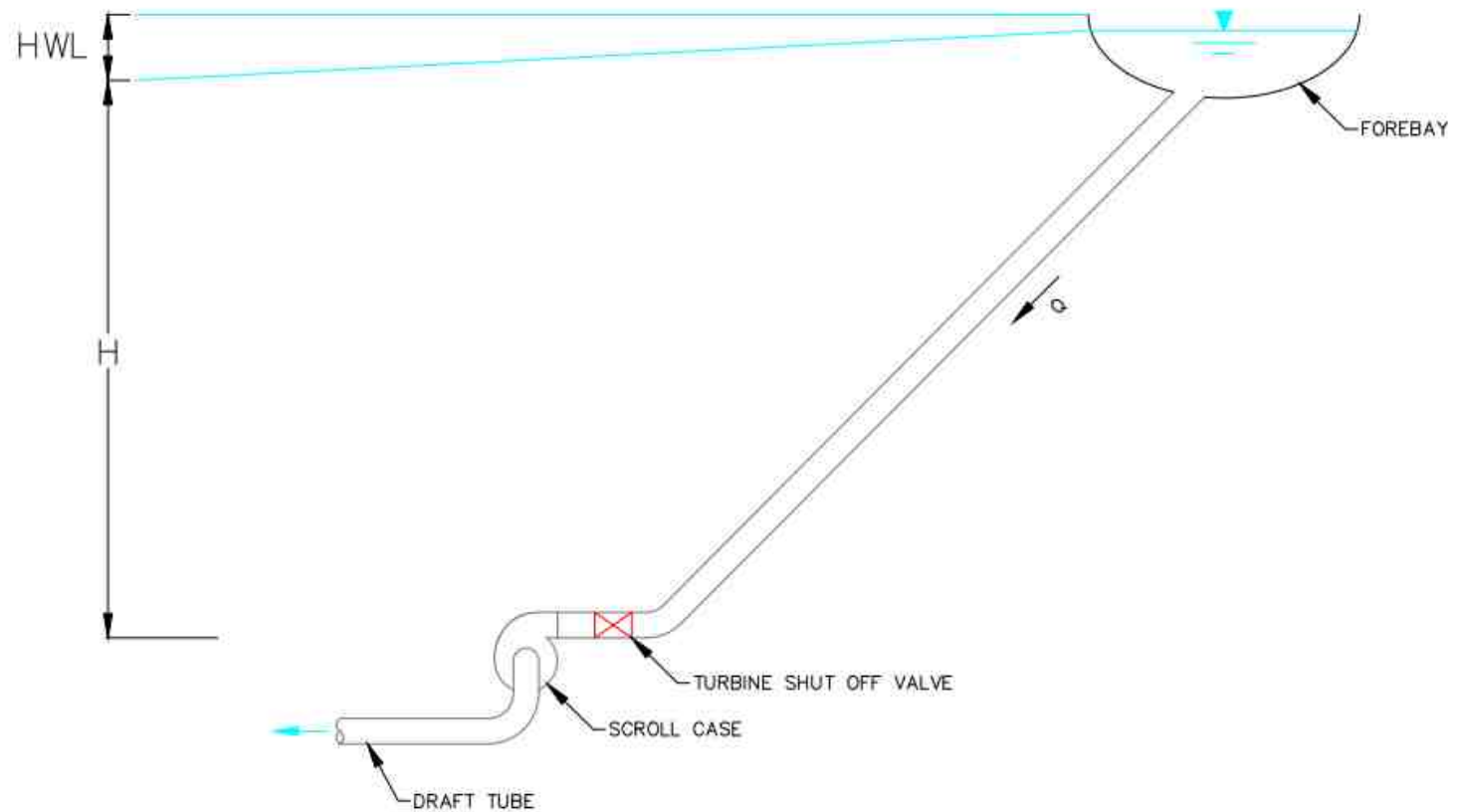




# How it works Pelton Impluse



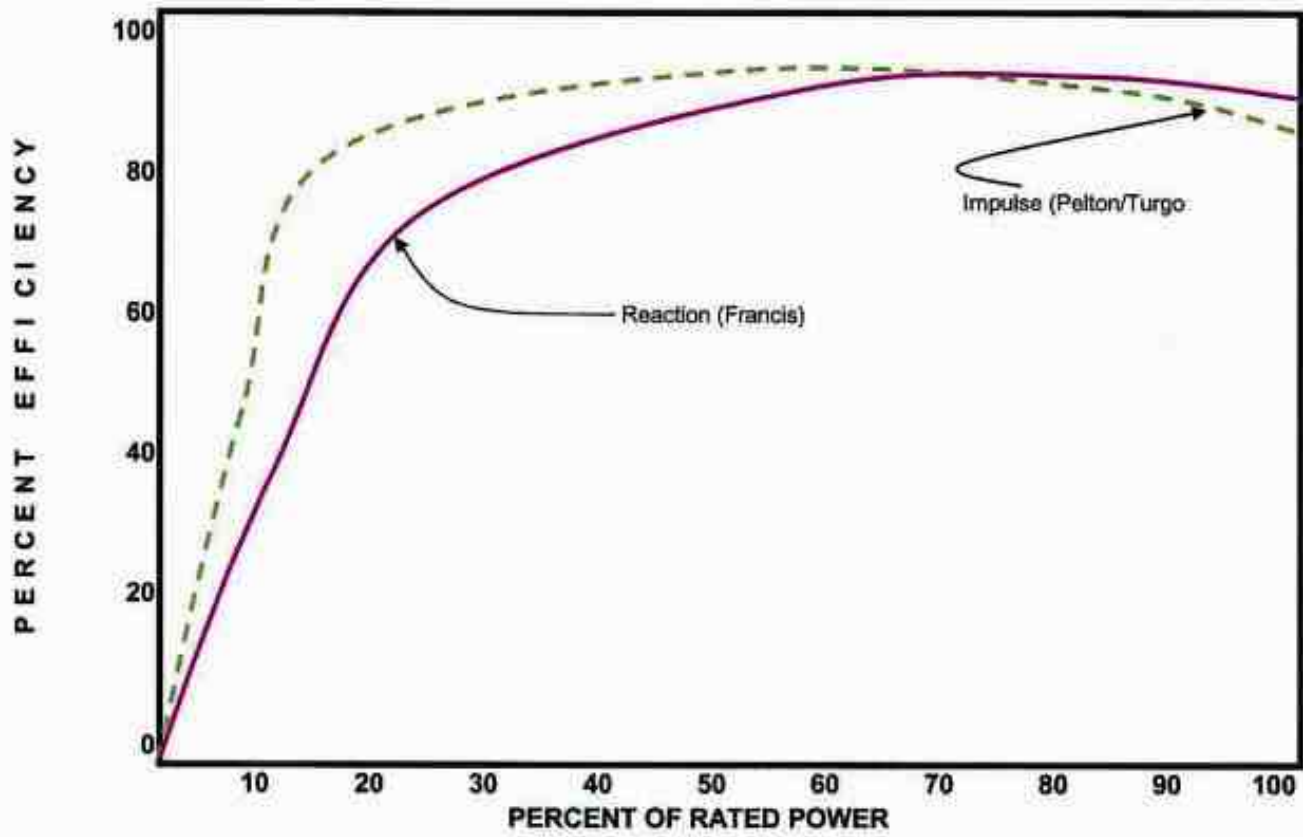
# How it Works-Francis Pressure Drop



# Power Head

- Pressure or Elevation Drop at Machine
- Friction Loss/Pipe Size/Roughness
- Tailwater Level
- Forebay Elevation
- Area/Capacity Curves

### Typical Curves Of Turbine Efficiency Variation



# Electric Output

$$KW = \frac{QH}{8.81} e^{(.748)}$$

# Electric Output

$$KW = QH$$









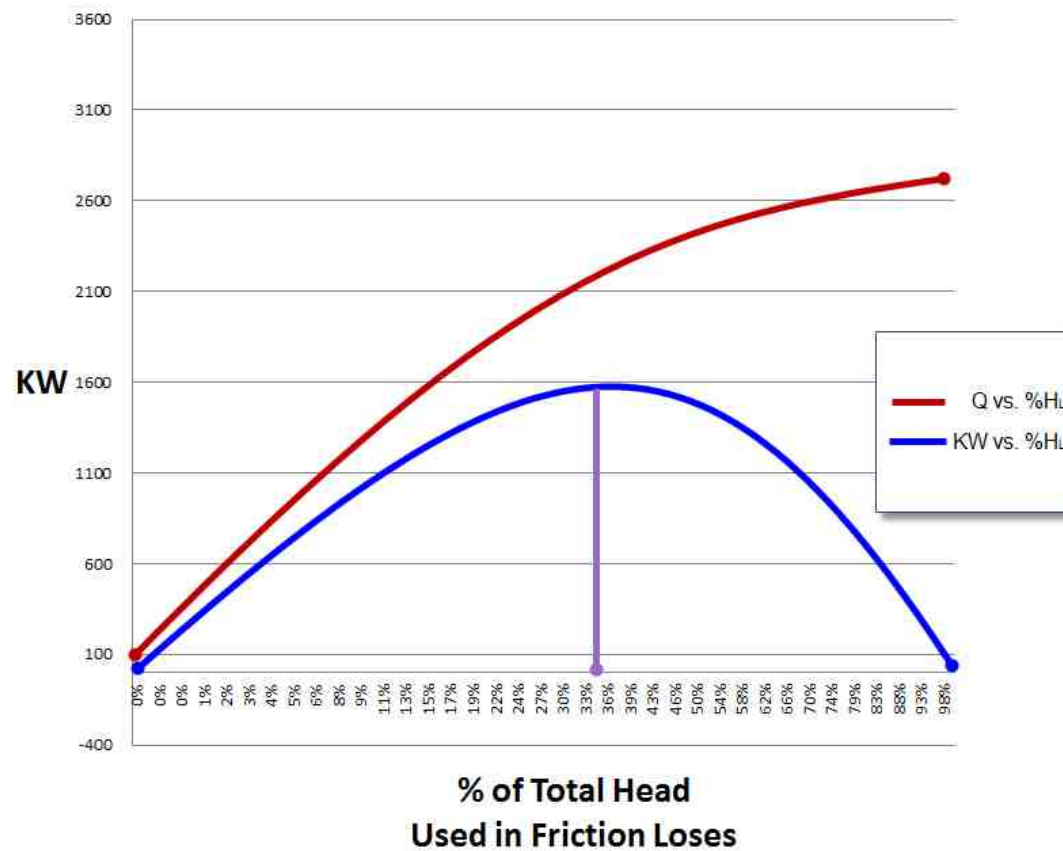








# Penstock- Flow/Penstock Size & Length











# Flow

Accurate Flow Data is Essential

Develop Design Criteria Flows

Run-of-the-River

Irrigation

Storage for Peaking

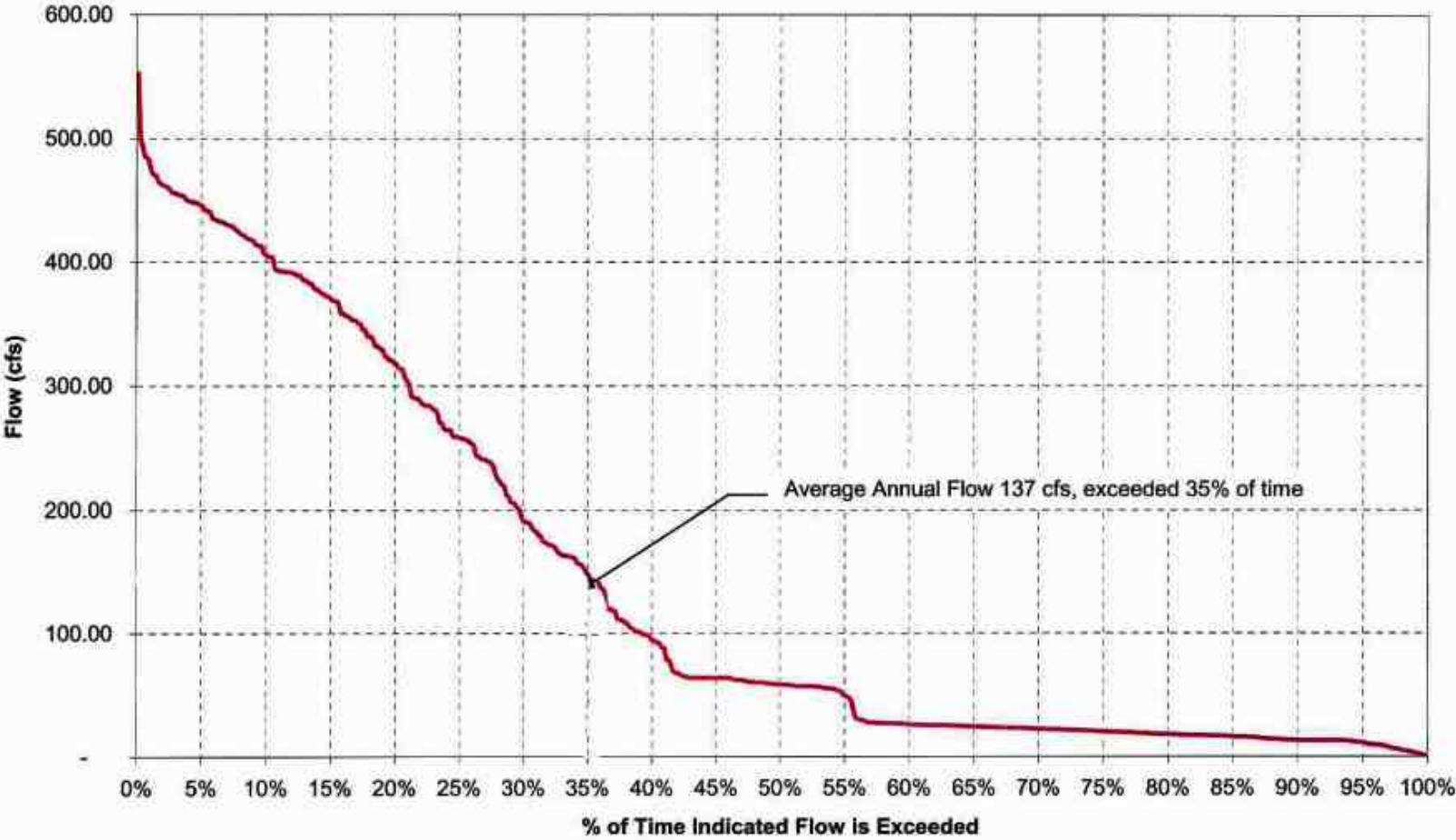
Environmental Releases

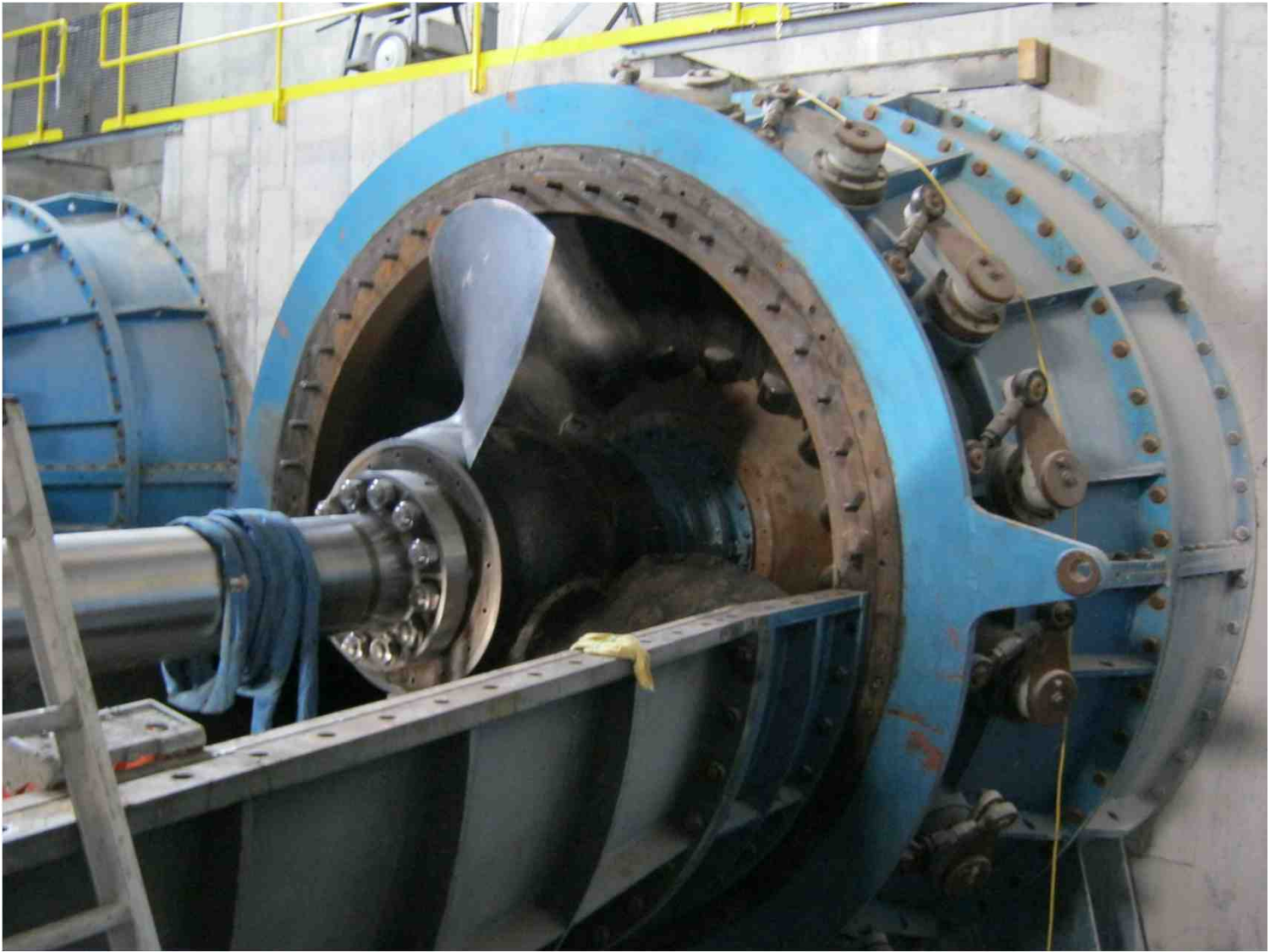
# Raw Data

Date	Ana River Mean Daily Flow	Days	Ana River Mean Daily Flow - Sorted H-L	Days	Increment	Cum. Days	Exceedance	Turbine Flow	Summit Turbine Eff.	Summit Syn. Generator Eff.	Head Loss	Power Head	KW	KW-HRS
	cfs		cfs		%		%	cfs	%	%	ft	ft		
1/1/1952	94.0	1	161.0	1	0.005%	1	0.005%	100.00	89.9%	92.0%	2.5	47.5	332.6	150
1/2/1952	94.0	1	155.0	1	0.005%	2	0.010%	100.00	89.9%	92.0%	2.5	47.5	332.6	150
1/3/1952	94.0	1	150.0	1	0.005%	3	0.015%	100.00	89.9%	92.0%	2.5	47.5	332.6	150
1/4/1952	92.0	1	150.0	1	0.005%	4	0.021%	100.00	89.9%	92.0%	2.5	47.5	332.6	150
1/5/1952	92.0	1	148.0	1	0.005%	5	0.026%	100.00	89.9%	92.0%	2.5	47.5	332.6	150
1/6/1952	92.0	1	144.0	1	0.005%	6	0.031%	100.00	89.9%	92.0%	2.5	47.5	332.6	150
1/7/1952	92.0	1	143.0	1	0.005%	7	0.036%	100.00	89.9%	92.0%	2.5	47.5	332.6	150
1/8/1952	90.0	1	143.0	1	0.005%	8	0.041%	100.00	89.9%	92.0%	2.5	47.5	332.6	150
1/9/1952	89.0	1	143.0	1	0.005%	9	0.046%	100.00	89.9%	92.0%	2.5	47.5	332.6	150
1/10/1952	89.0	1	143.0	1	0.005%	10	0.052%	100.00	89.9%	92.0%	2.5	47.5	332.6	150
1/11/1952	89.0	1	142.0	1	0.005%	11	0.057%	100.00	89.9%	92.0%	2.5	47.5	332.6	150
1/12/1952	89.0	1	141.0	1	0.005%	12	0.062%	100.00	89.9%	92.0%	2.5	47.5	332.6	150
1/13/1952	89.0	1	140.0	1	0.005%	13	0.067%	100.00	89.9%	92.0%	2.5	47.5	332.6	150
12/4/2010	77.0	1	20.0	1	0.005%	19331	99.861%	0.00	65.7%	86.9%	0.0	50.0	0.0	0
12/5/2010	77.0	1	20.0	1	0.005%	19332	99.866%	0.00	65.7%	86.9%	0.0	50.0	0.0	0
12/6/2010	78.0	1	19.0	1	0.005%	19333	99.871%	0.00	65.7%	86.9%	0.0	50.0	0.0	0
12/7/2010	82.0	1	18.0	1	0.005%	19334	99.876%	0.00	65.7%	86.9%	0.0	50.0	0.0	0
12/8/2010	81.0	1	18.0	1	0.005%	19335	99.881%	0.00	65.7%	86.9%	0.0	50.0	0.0	0
12/9/2010	81.0	1	18.0	1	0.005%	19336	99.886%	0.00	65.7%	86.9%	0.0	50.0	0.0	0
12/10/2010	104.0	1	18.0	1	0.005%	19337	99.892%	0.00	65.7%	86.9%	0.0	50.0	0.0	0
12/11/2010	129.0	1	18.0	1	0.005%	19338	99.897%	0.00	65.7%	86.9%	0.0	50.0	0.0	0
12/12/2010	128.0	1	18.0	1	0.005%	19339	99.902%	0.00	65.7%	86.9%	0.0	50.0	0.0	0
12/13/2010	125.0	1	18.0	1	0.005%	19340	99.907%	0.00	65.7%	86.9%	0.0	50.0	0.0	0
12/14/2010	124.0	1	18.0	1	0.005%	19341	99.912%	0.00	65.7%	86.9%	0.0	50.0	0.0	0
12/15/2010	116.0	1	18.0	1	0.005%	19342	99.917%	0.00	65.7%	86.9%	0.0	50.0	0.0	0
12/16/2010	106.0	1	18.0	1	0.005%	19343	99.923%	0.00	65.7%	86.9%	0.0	50.0	0.0	0
12/17/2010	100.0	1	18.0	1	0.005%	19344	99.928%	0.00	65.7%	86.9%	0.0	50.0	0.0	0
12/18/2010	96.0	1	18.0	1	0.005%	19345	99.933%	0.00	65.7%	86.9%	0.0	50.0	0.0	0
12/19/2010	94.0	1	14.0	1	0.005%	19346	99.938%	0.00	65.7%	86.9%	0.0	50.0	0.0	0
12/20/2010	92.0	1	14.0	1	0.005%	19347	99.943%	0.00	65.7%	86.9%	0.0	50.0	0.0	0
12/21/2010	92.0	1	14.0	1	0.005%	19348	99.948%	0.00	65.7%	86.9%	0.0	50.0	0.0	0
12/22/2010	91.0	1	14.0	1	0.005%	19349	99.954%	0.00	65.7%	86.9%	0.0	50.0	0.0	0
12/23/2010	90.0	1	13.0	1	0.005%	19350	99.959%	0.00	65.7%	86.9%	0.0	50.0	0.0	0
12/24/2010	90.0	1	13.0	1	0.005%	19351	99.964%	0.00	65.7%	86.9%	0.0	50.0	0.0	0
12/25/2010	91.0	1	12.0	1	0.005%	19352	99.969%	0.00	65.7%	86.9%	0.0	50.0	0.0	0
12/26/2010	91.0	1	9.4	1	0.005%	19353	99.974%	0.00	65.7%	86.9%	0.0	50.0	0.0	0
12/27/2010	91.0	1	6.0	1	0.005%	19354	99.979%	0.00	65.7%	86.9%	0.0	50.0	0.0	0
12/28/2010	92.0	1	5.2	1	0.005%	19355	99.985%	0.00	65.7%	86.9%	0.0	50.0	0.0	0
12/29/2010	91.0	1	4.7	1	0.005%	19356	99.990%	0.00	65.7%	86.9%	0.0	50.0	0.0	0
12/30/2010	91.0	1	3.0	1	0.005%	19357	99.995%	0.00	65.7%	86.9%	0.0	50.0	0.0	0
12/31/2010	91.0	1	1.2	1	0.005%	19358	100.000%	0.00	65.7%	86.9%	0.0	50.0	0.0	0



### Flow Duration Graph

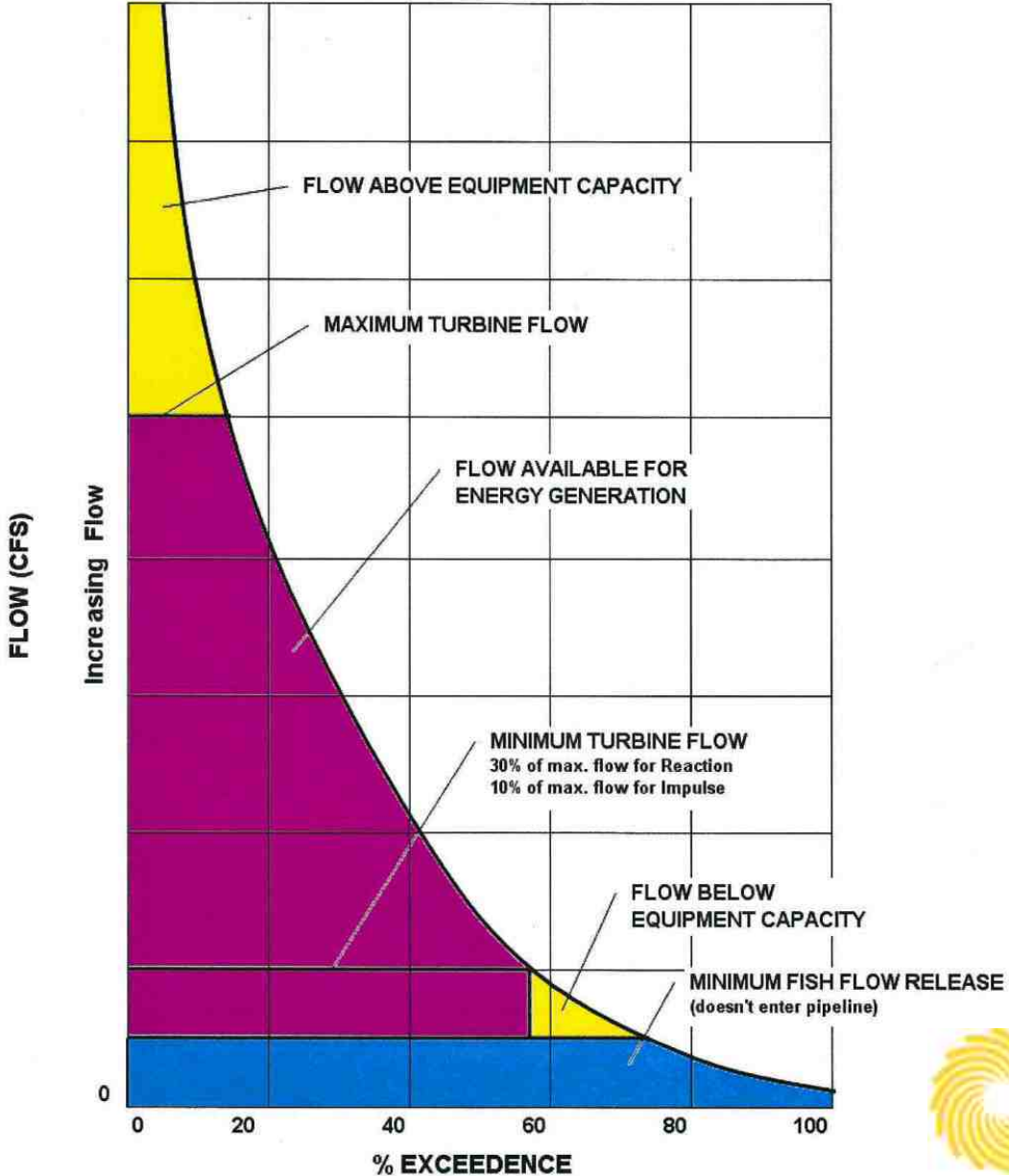




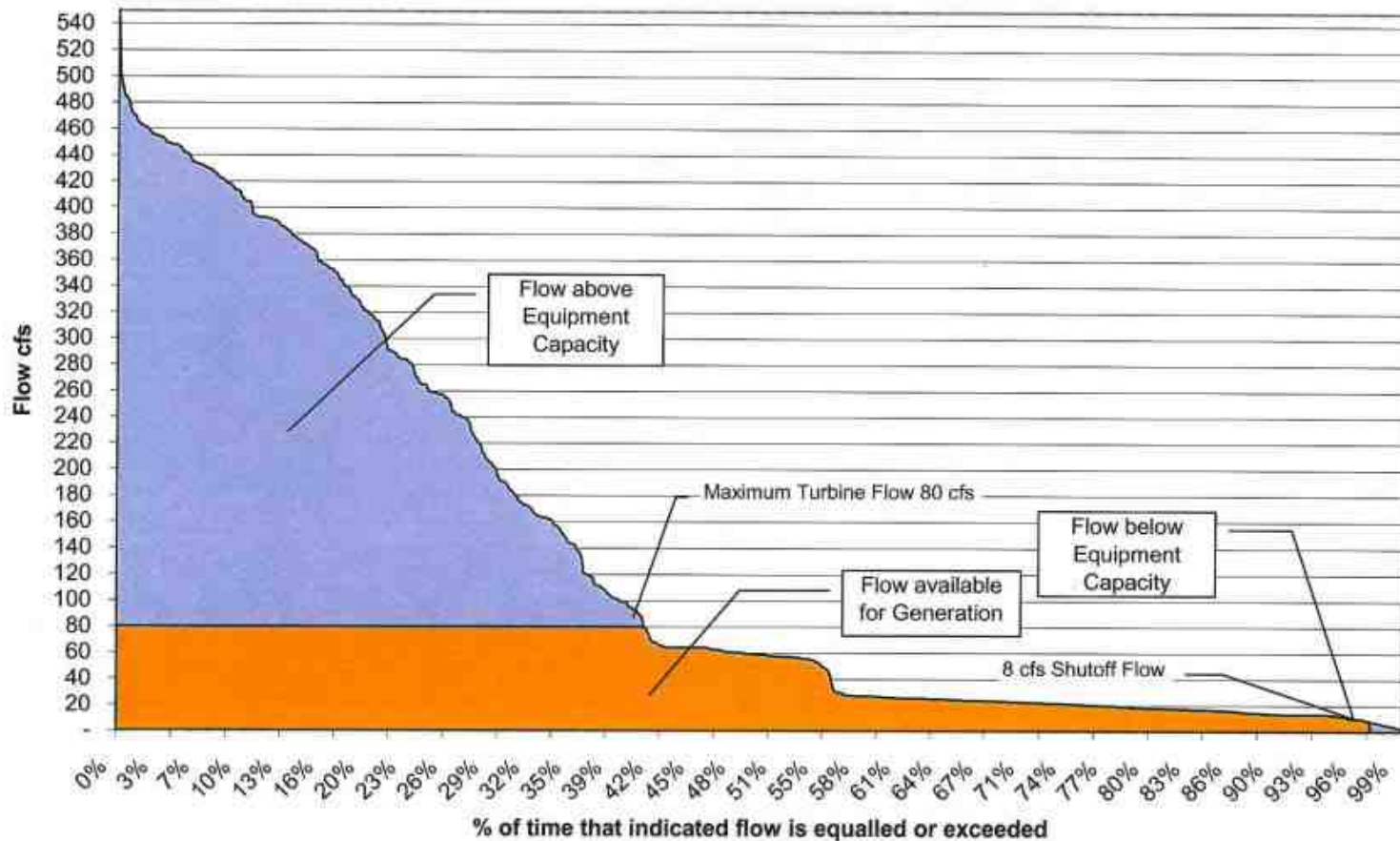




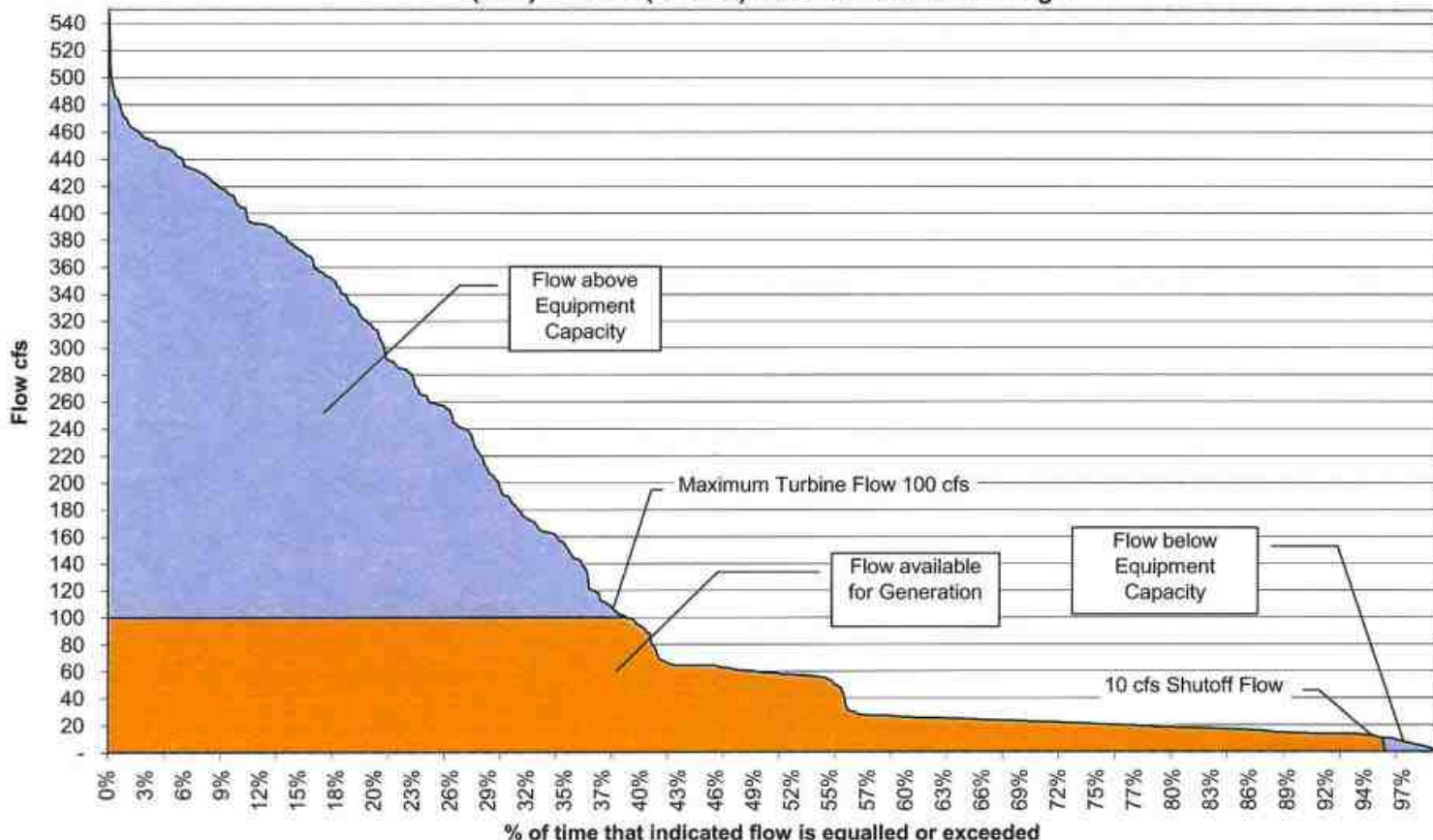
### TYPICAL STREAM FLOW ALLOCATION CURVE



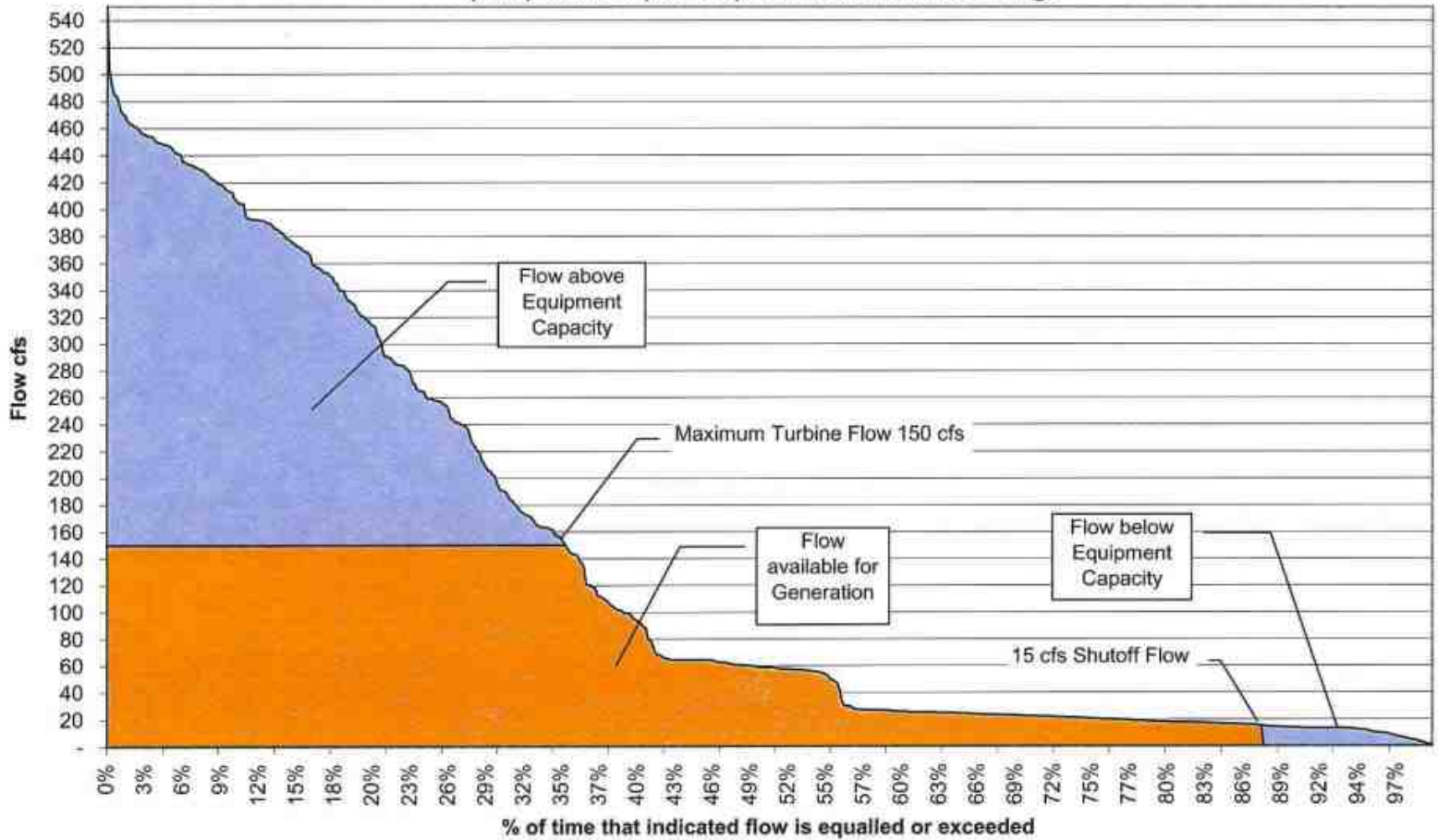
**Alternative No. 1  
Flow Allocation Curve  
(One) 3.0 MW (80 cfs) Turbine/Generator - Turgo**



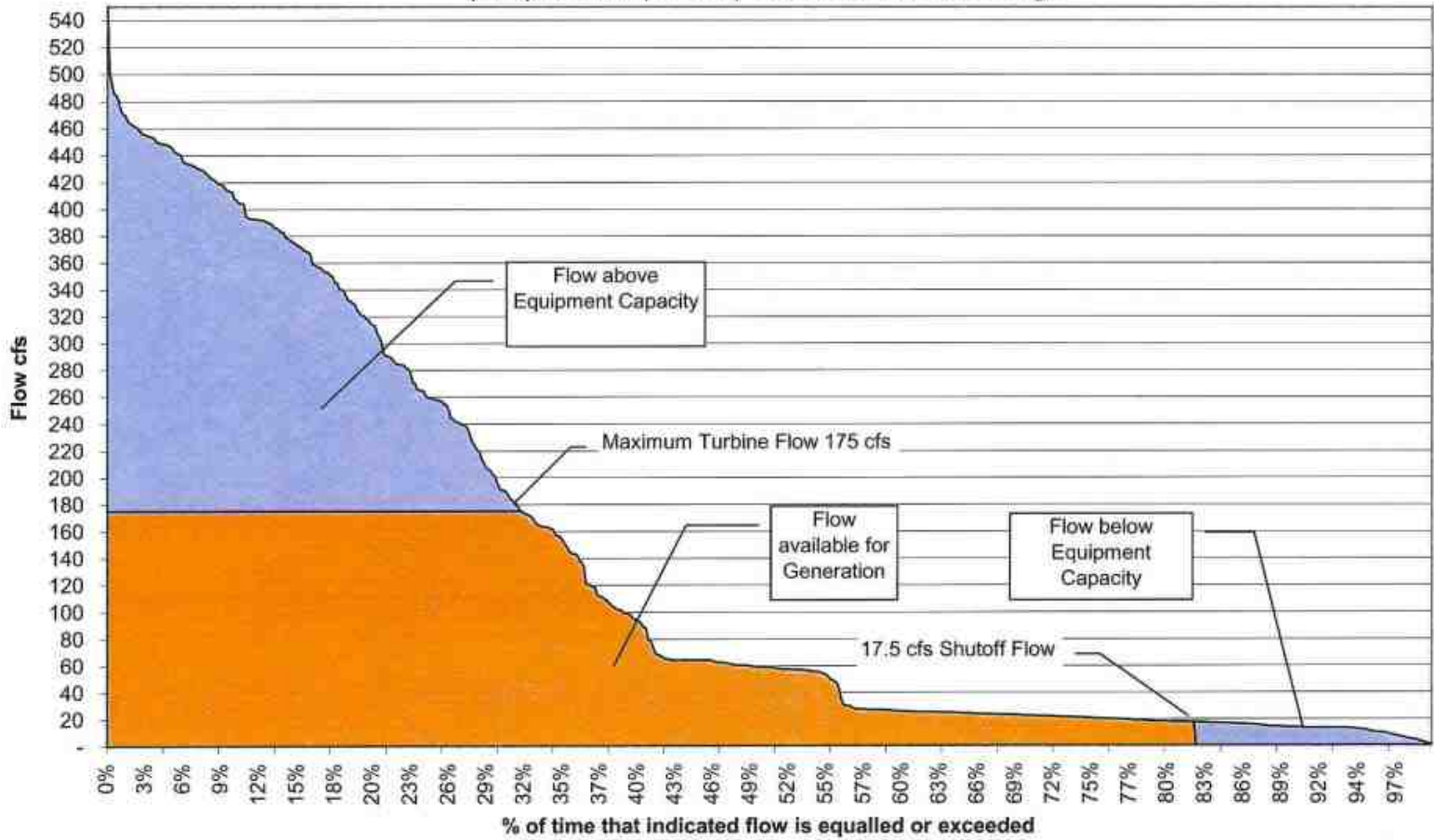
**Alternative No. 2  
Flow Allocation Curve  
(One) 3.7 MW (100 cfs) Turbine/Generator - Turgo**



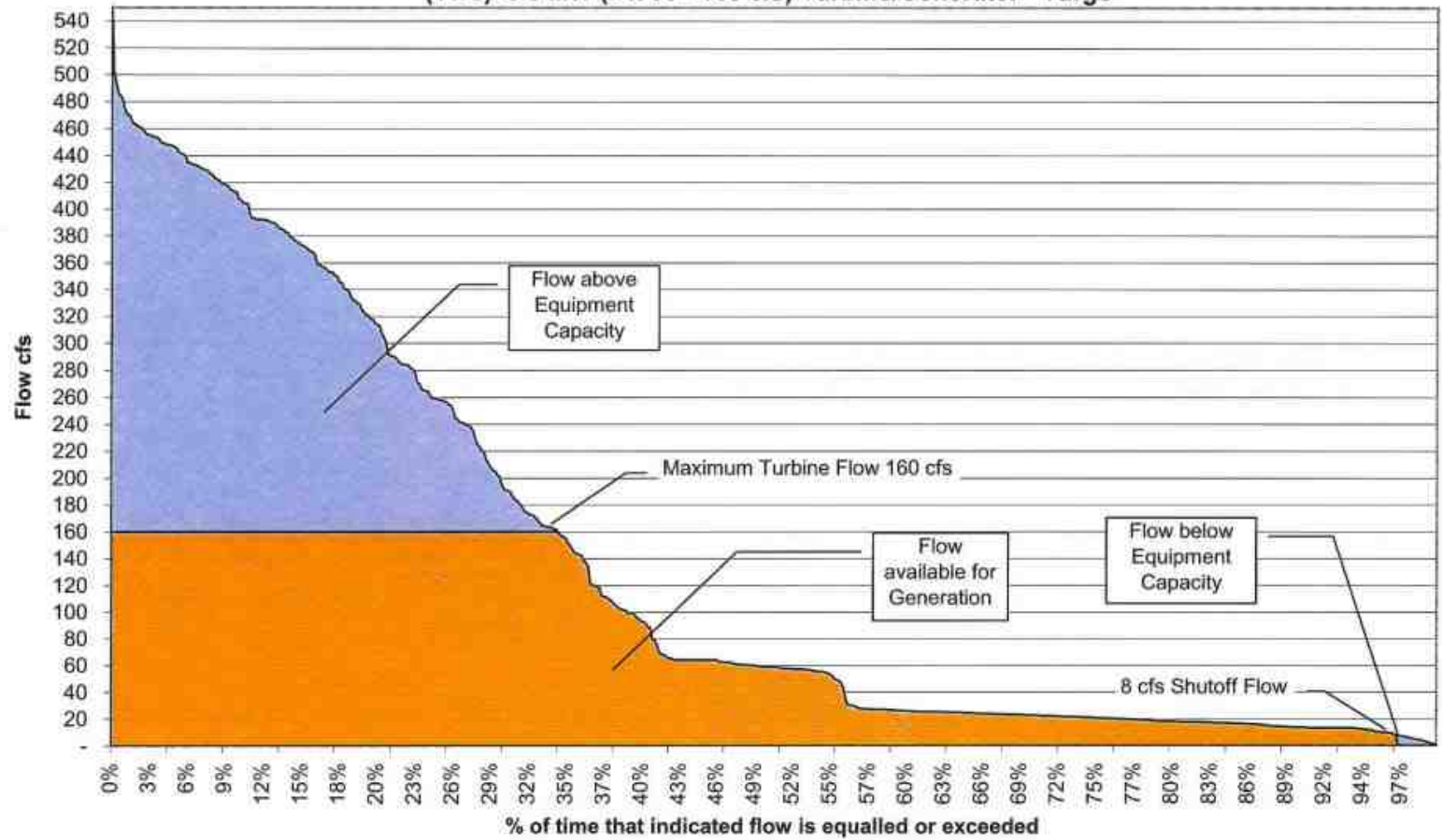
**Alternative No. 3  
Flow Allocation Curve  
(One) 5.8 MW (150 cfs) Turbine/Generator - Turgo**



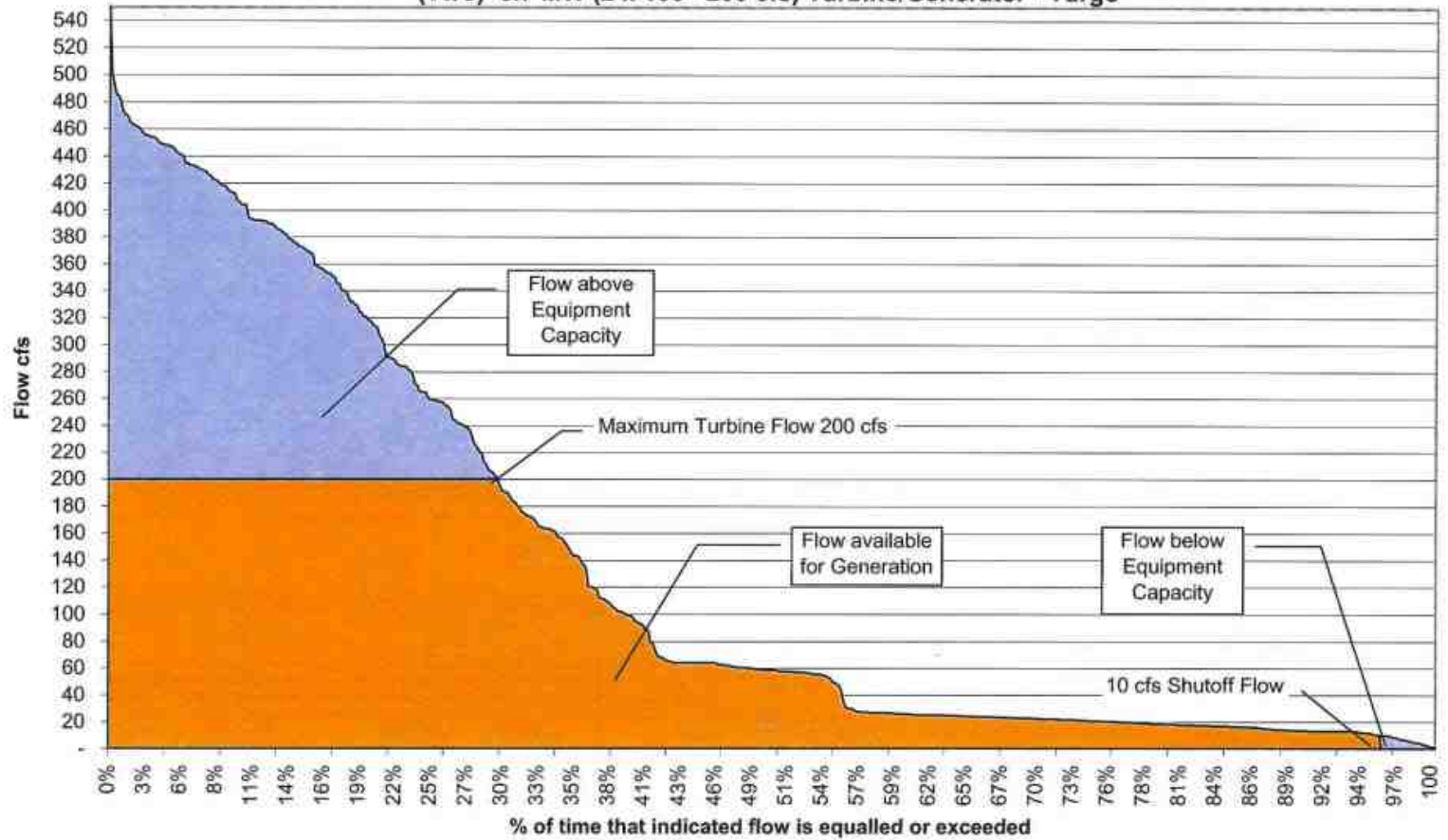
**Alternative No. 4  
Flow Allocation Curve  
(One) 6.5 MW (175 cfs) Turbine/Generator - Turgo**



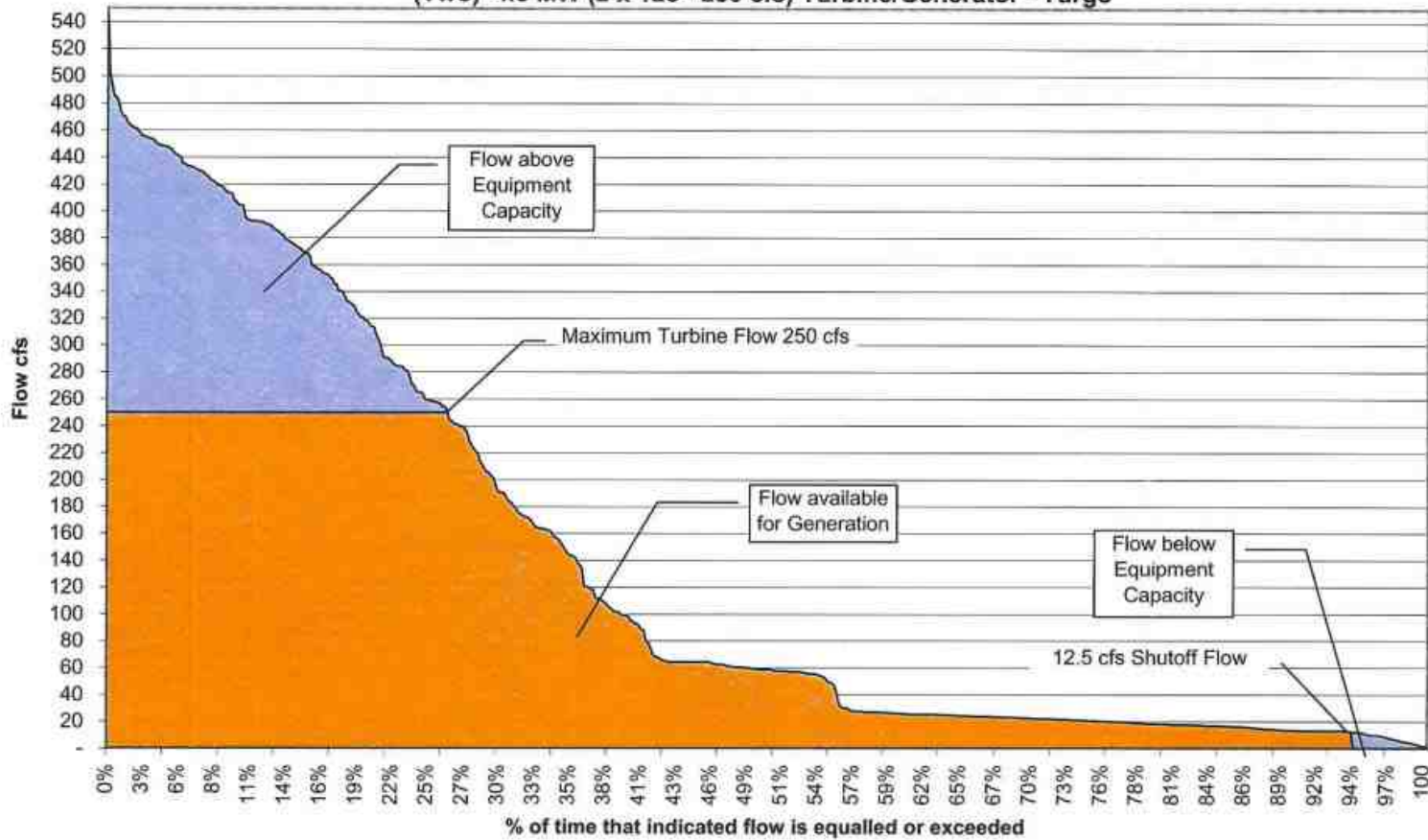
**Alternative No. 5  
Flow Allocation Curve  
(Two) 3.0 MW (2 x 80= 160 cfs) Turbine/Generator - Turgo**



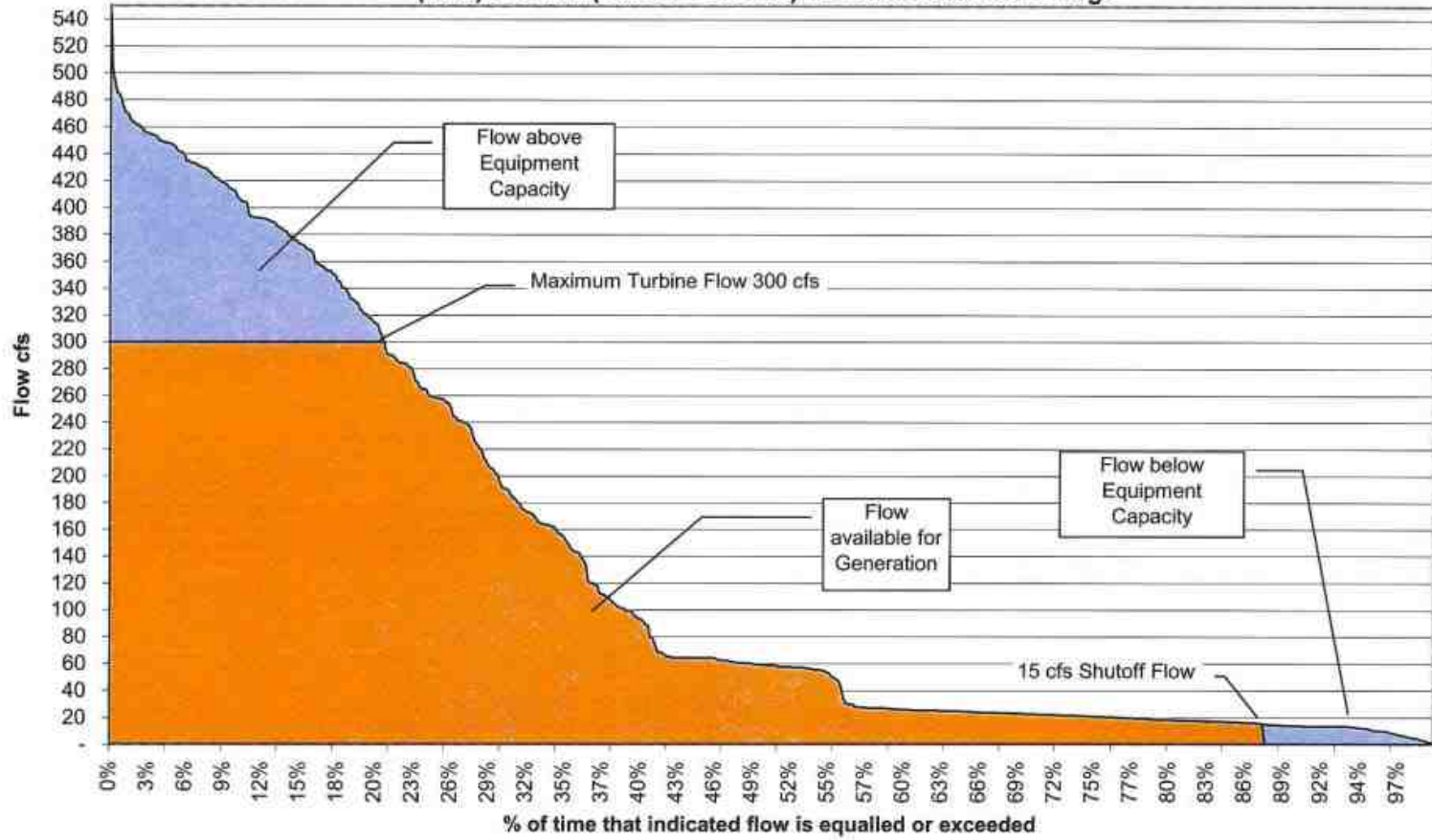
**Alternative No. 6  
Flow Allocation Curve  
(Two) 3.7 MW (2 x 100= 200 cfs) Turbine/Generator - Turgo**



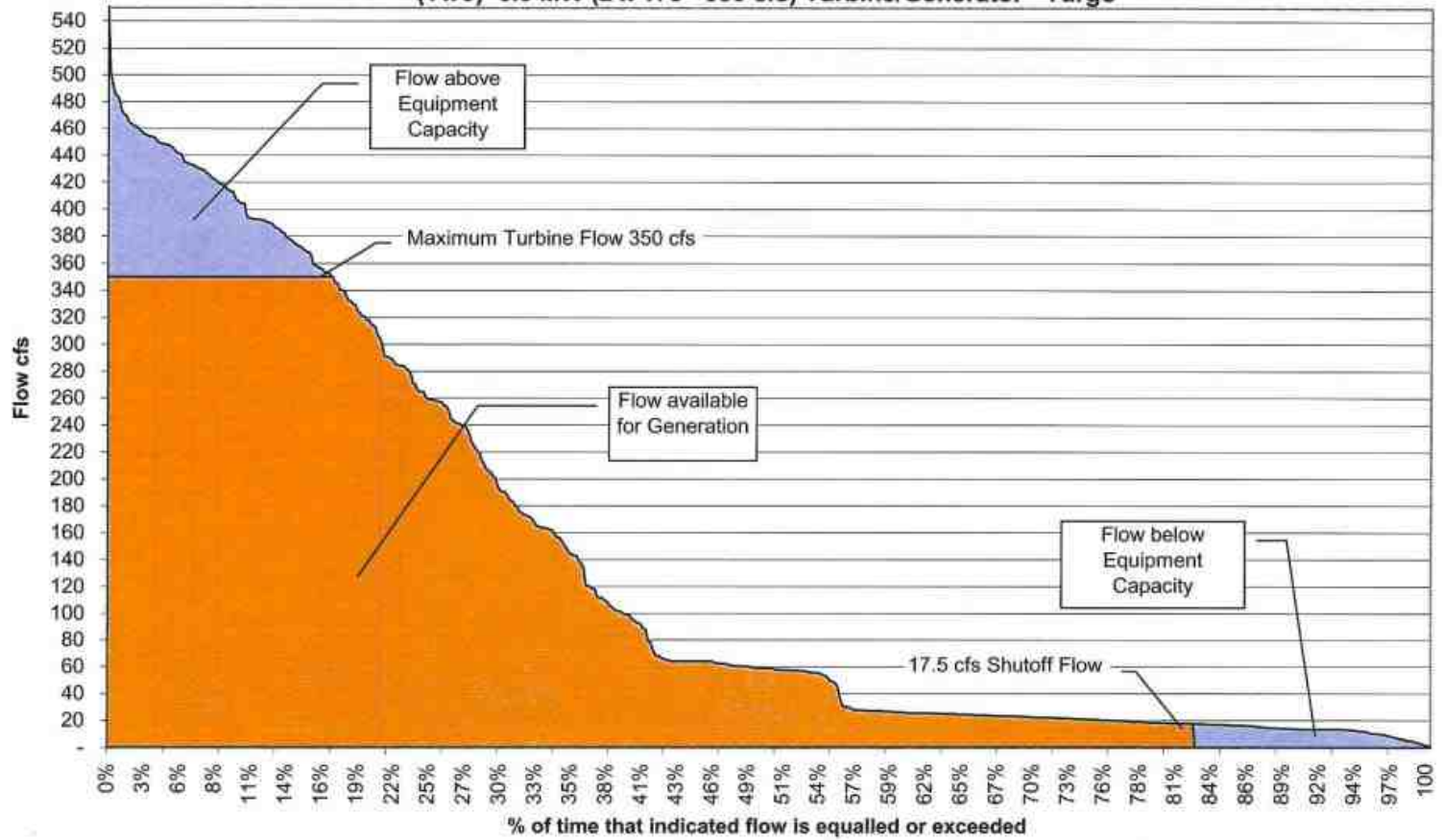
**Alternative No. 7  
Flow Allocation Curve  
(Two) 4.5 MW (2 x 125= 250 cfs) Turbine/Generator - Turgo**



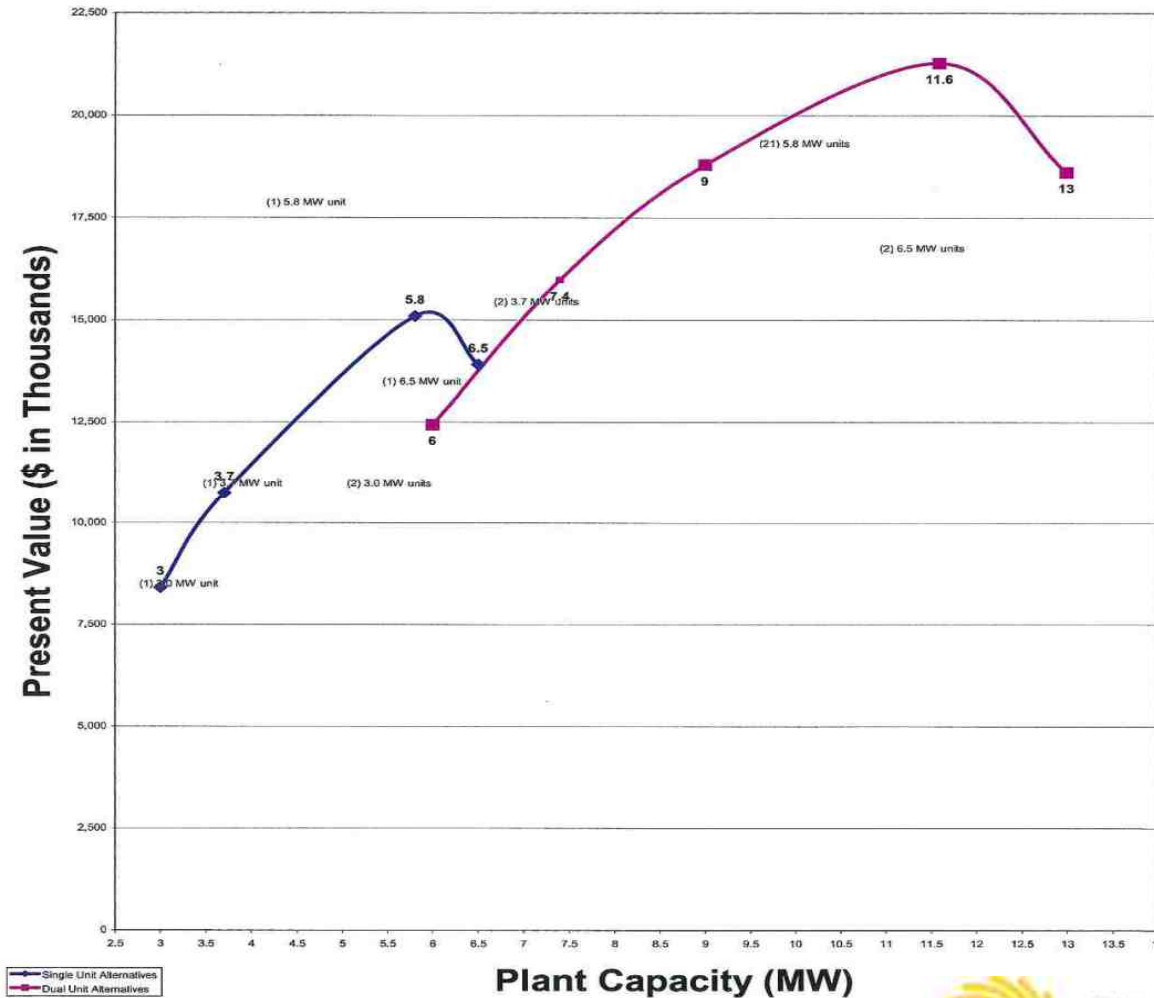
**Alternative No. 8  
Flow Allocation Curve  
(Two) 5.8 MW (2 x 150= 300 cfs) Turbine/Generator - Turgo**



**Alternative No. 9  
Flow Allocation Curve  
(Two) 6.5 MW (2 x 175= 350 cfs) Turbine/Generator - Turgo**



# Present Value vs. Plant Capacity



# Other Critical Issues

- Funding
- Water Rights
- FERC License or Exemption
- Concept Design
- Cost Estimate
- Power Purchase Agreement
- Interconnect /Wheeling
- Cash Flow Analysis

## 4 Fatal Flaws

- Water Amount
- Diversion-Fish, Trash, & Screens
- Control Strategy
- Do It Yourself Method
  - “Expertise costs, lack of expertise costs more”