Manual 50 4th Edition Updates

1.) Planning and Designing Your Marina

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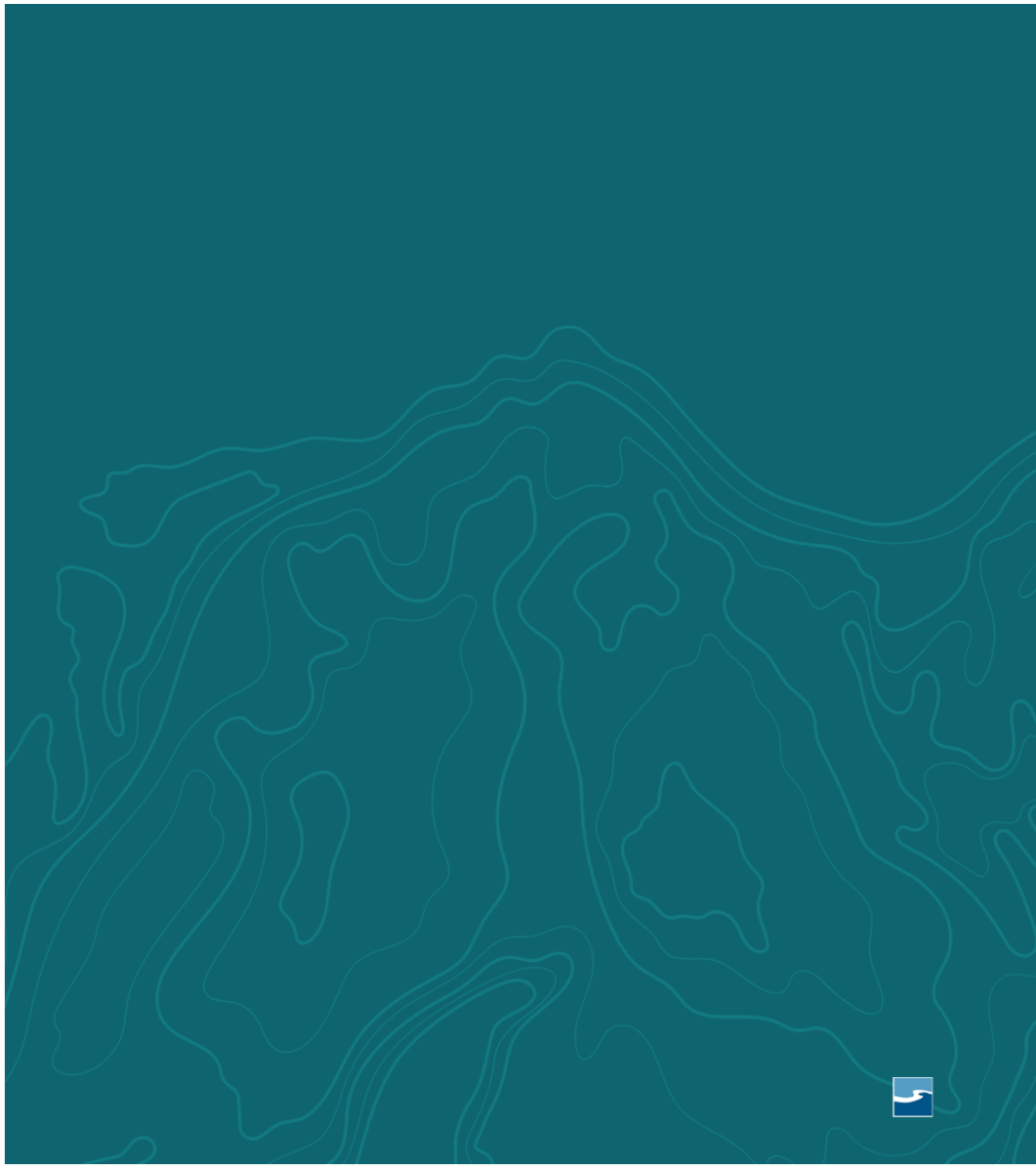
2025

Design Considerations

- Navigational Needs
- Facility Layout
- Harbor Protection
- Protection Devices
- Water Quality



Navigational Considerations

Navigation: Channel Depth

T_1 = Tidal change during ship transit and maneuvering.

T_2 = Allowance for unfavorable meteorological conditions and lack of precise water-level data

D = Ship static draft

$3Z_1$ = Gross underkeel clearance

Z_1 = Allowance for static draft uncertainties

Z_2 = Change in water density

Z_3 = Squat

Z_4 = Wave response allowance

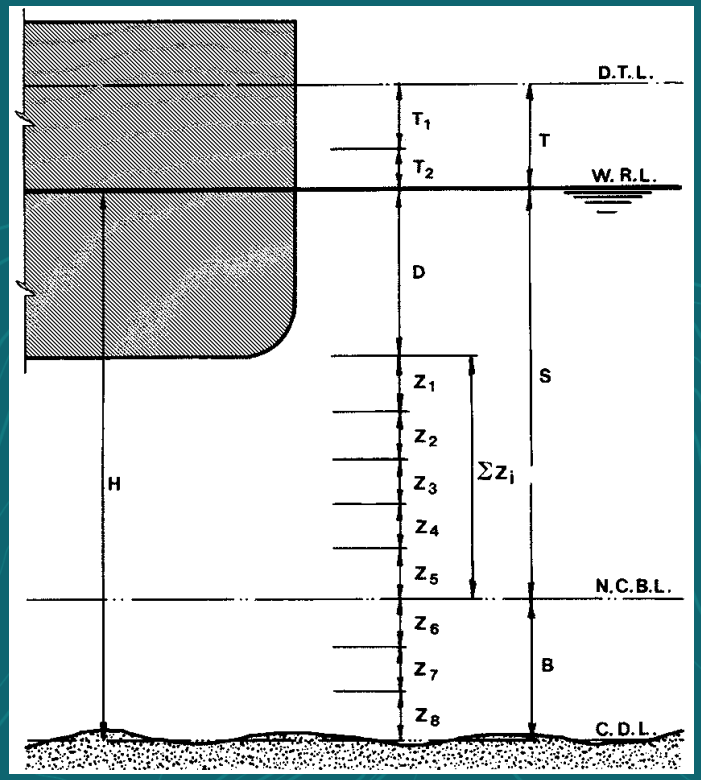
Z_5 = Net underkeel clearance

Z_6 = Allowance for bed-level uncertainties

Z_7 = Allowance for bottom change between regular channel maintenance dredging

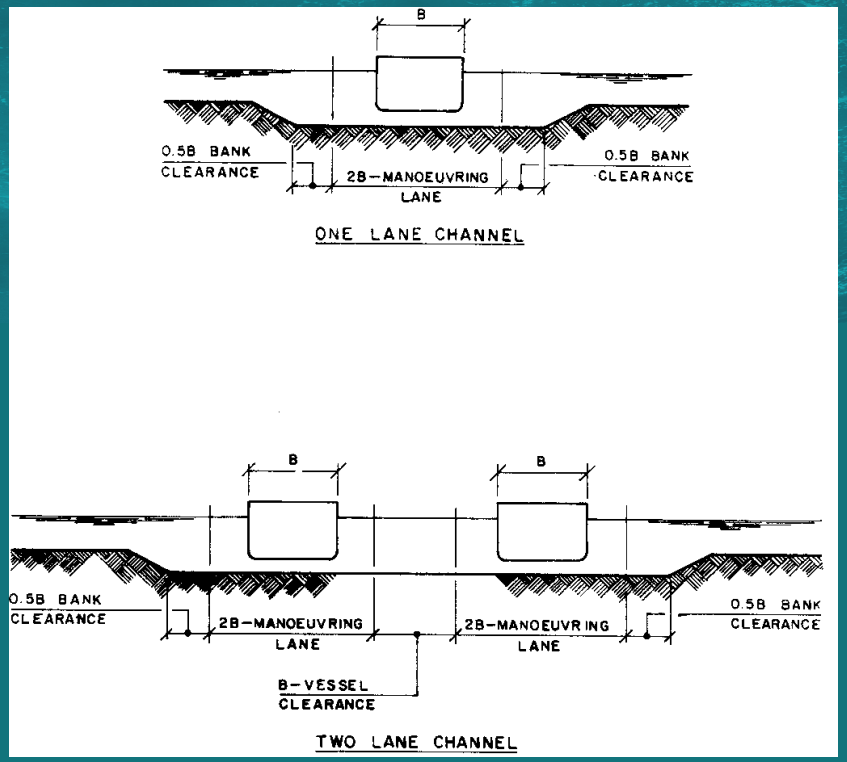
Z_8 = Dredging execution tolerance

D.T.L - design tidal level
W.R.L - water reference level
N.C.B.L. - nominal channel bed level
C.D.L. - channel dredge level



Ref: Trinker "Handbook of Port and Harbor Engineering", 1997

Navigation: Channel Width (Straight Segments)



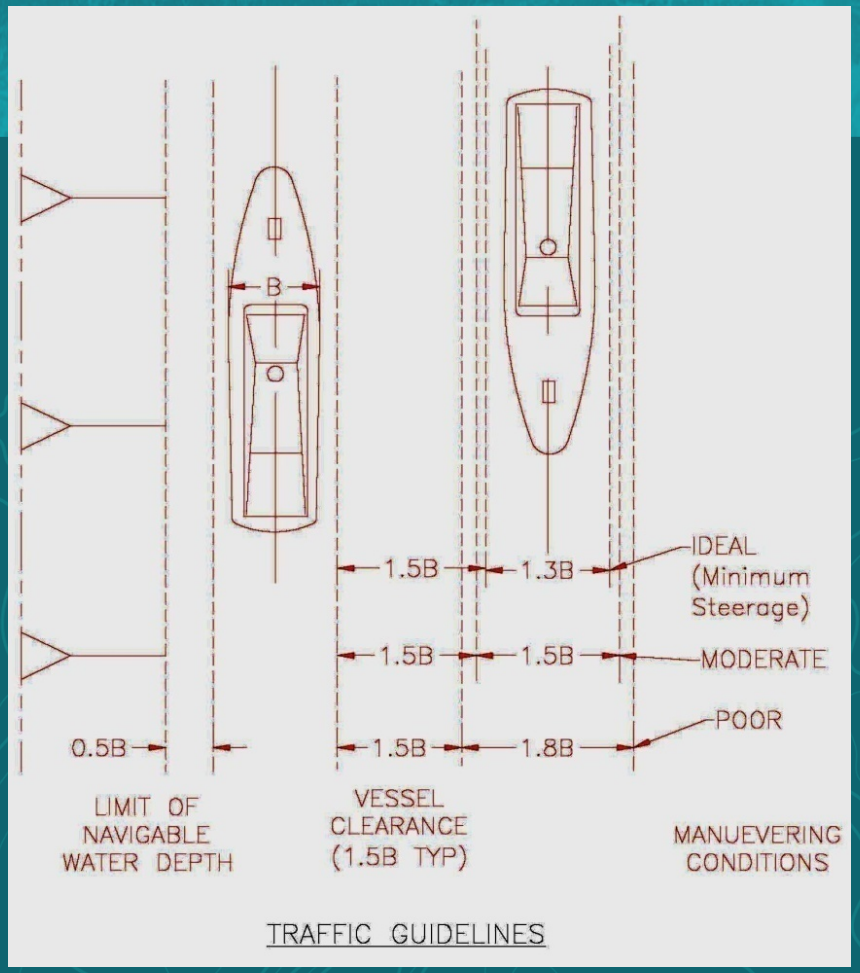
One-Way Ship Traffic Channel Width Design Criteria[1]			
	Maximum Current		
Channel Cross-Section	0.0 to 0.3 m/sec (0.0 to 0.5 knots)	0.3 to 0.8 m/sec (0.5 to 1.5 knots)	0.8 to 1.5 m/sec (1.5 to 3.0 knots)
Constant Cross-Section, Best Aids to Navigation			
Shallow	3.0	4.0	5.0
Canal	2.5	3.0	3.5
Trench	2.75	3.25	4.0
Variable Cross-Section, Average Aids to Navigation			
Shallow	3.5	4.5	5.5
Canal	3.0	3.5	4.0
Trench	3.5	4.0	5.0
Criteria expressed as multipliers of the design ship beam; i.e., W = (factor from table) × B			

Two-Way Ship Traffic Channel Width Design Criteria[1]			
	Maximum Current		
Channel Cross-Section	0.0 to 0.3 m/sec (0.0 to 0.5 knots)	0.3 to 0.8 m/sec (0.5 to 1.5 knots)	0.8 to 1.5 m/sec (1.5 to 3.0 knots)
Constant Cross-Section, Best Aids to Navigation			
Shallow	5.0	6.0	8.0
Canal	4.0	4.5	5.5
Trench	4.5	5.5	6.5
[1] Criteria expressed as multipliers of the design ship beam; i.e., W = (factor from table) × B			

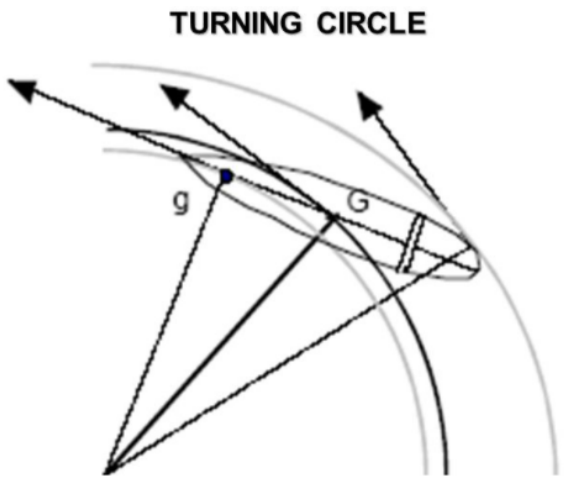
Navigation: Basic Vessel Clearance Needs

- General channel widths:
  - $W = 5B_{max}$ (ideal conditions)
  - $W = 9B_{max}$ (poor conditions)

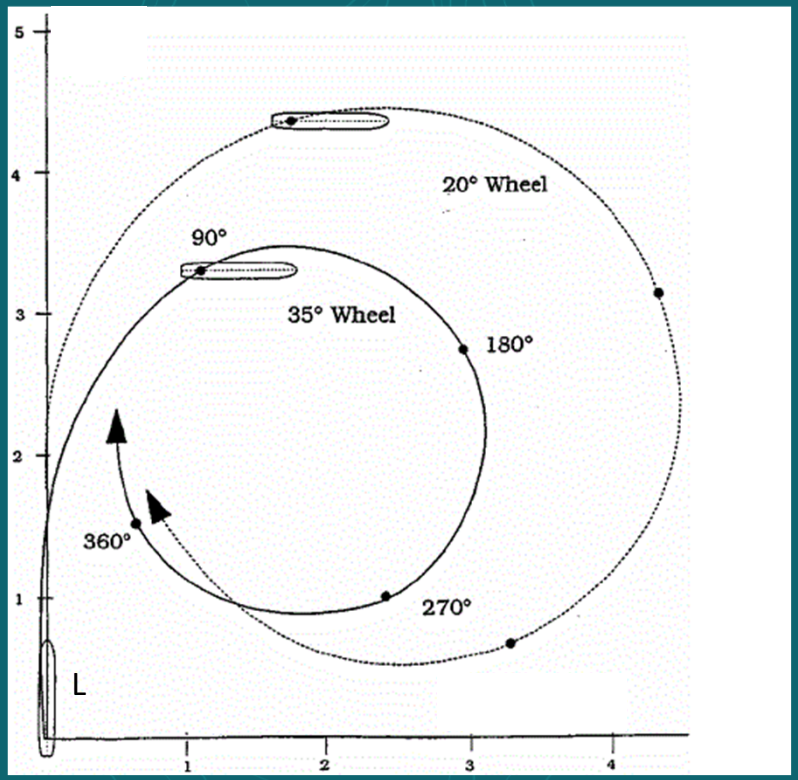
- Boats moored along channel:
  - $W = 6B_{max} + 2B_{moored}$



Navigation: Vessel Turning Capability



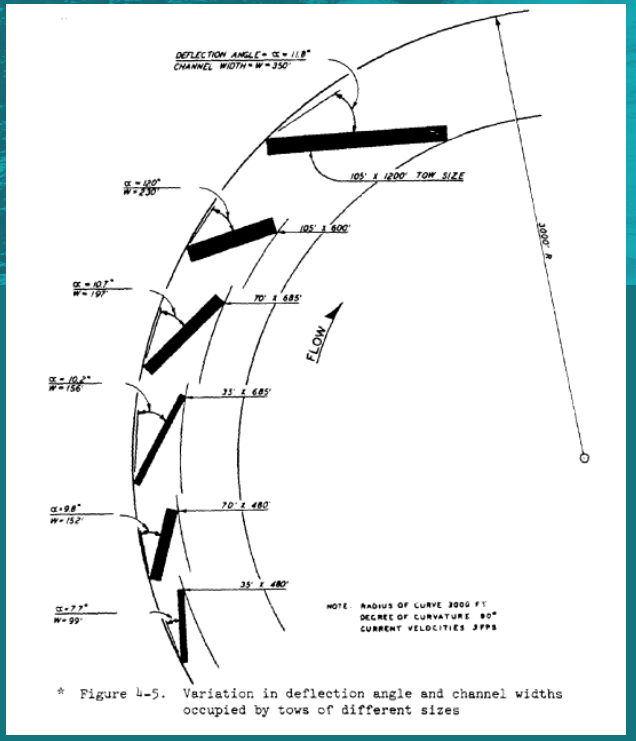
Minimum turning radius for a vessel underway is $1.8 - 2.0L$.



Note: Rudders stall for wheel angles > 40°.

Navigation: Steerage in Turns

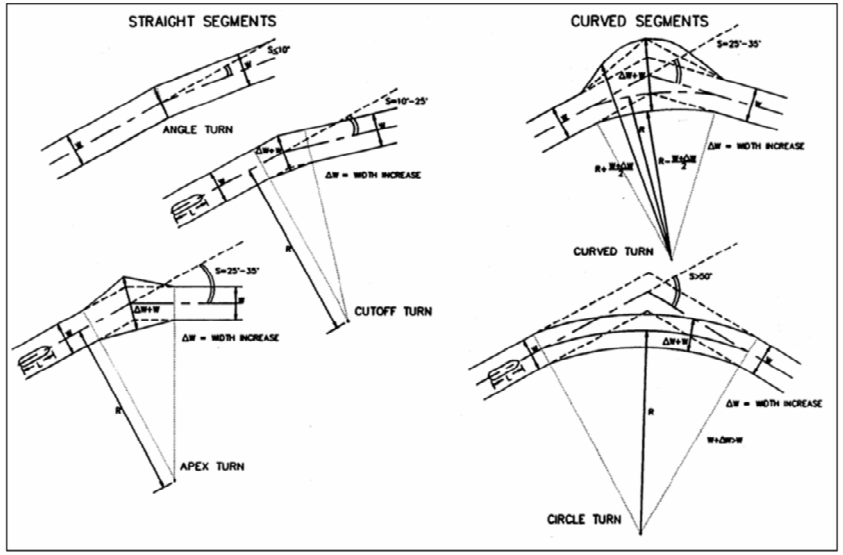
Boats turn similarly to cars steering while backing up.



* Figure 4-5. Variation in deflection angle and channel widths occupied by tows of different sizes

Navigation: Bends Geometry Options

Because vessel turning does not track the theoretical intended curved path of travel, added channel width is necessary in bends.

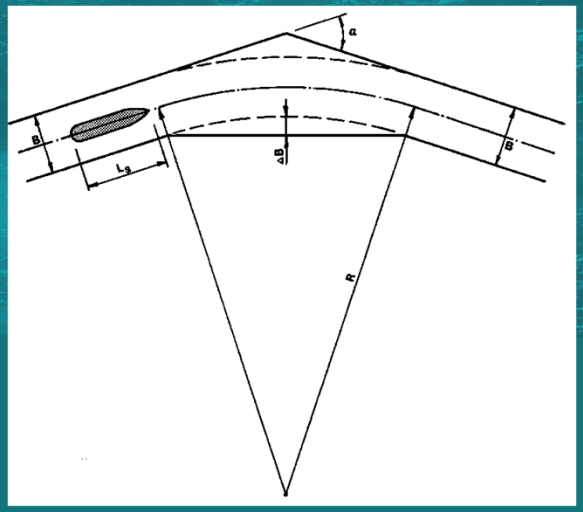


Recommended Deep-Draft Channel Turn Configurations

Turn Angle, deg	R/L	Turn Width Increase Factor[1]	Turn Type
0-10	0	0	Angle
10-25	3-5	2.0-1.0	Cutoff
25-35	5-7	1.0-0.7	Apex
35-50	7-10	0.7-0.5	Curved
>50	>10	0.5	Circle

[1] Expressed as a multiplier of the design ship beam; i.e., ΔW = (factor from table) × B

Navigation: Bend Design Guidelines



Based on ship length (L_s)

$L_s < 150$ m $\quad R_{min} \simeq 1200$ m

$L_s = 150$ m $\quad R_{min} \simeq 2100$ m

150 m $< L_s <$ 210 m

$R_{min} = 1200$–3000 m

On the basis of the ship traveling speed (V_{max})

$V_{max} \leq 5$ m/s $\quad R \geq 4L_s$,

$V_{max} > 5$ m/s $\quad R = 8$–10 times L_s.

Recommended Channel Turn Configurations

Deflection Angle, Deg	Ratio of Turn Radius/ Ship Length	Turn Width Increase Factor (* Ship Beam)	Turn Type
0 - 10	0	0	Angle
10 - 25	3 - 5	2.0 - 1.0	Cutoff
25 - 35	5 - 7	1.0 - 0.7	Apex
35 - 50	7 - 10	0.7 - 0.5	Curved
>50	>10	0.5	Circle

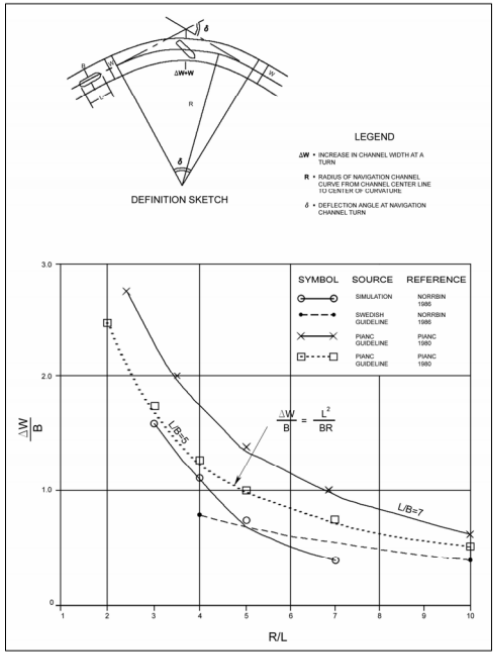
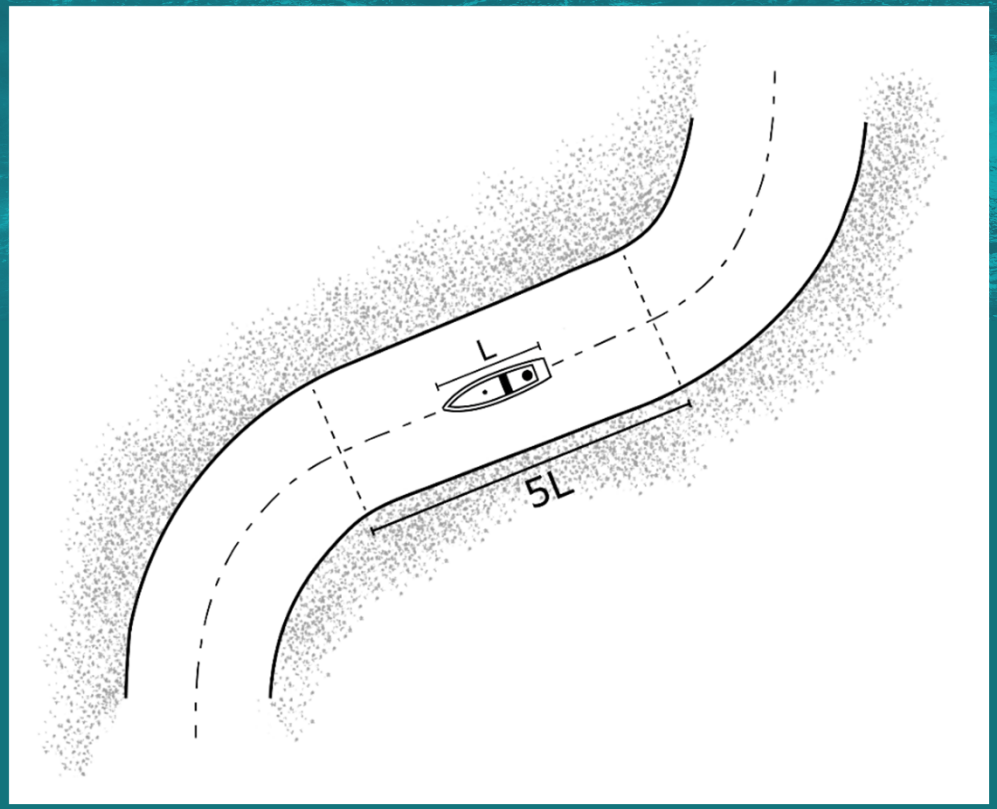
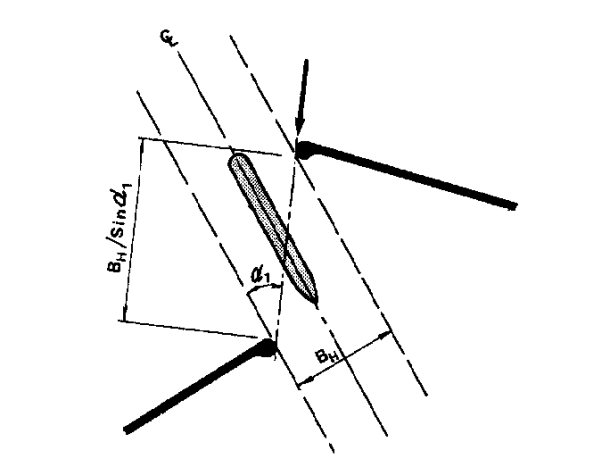


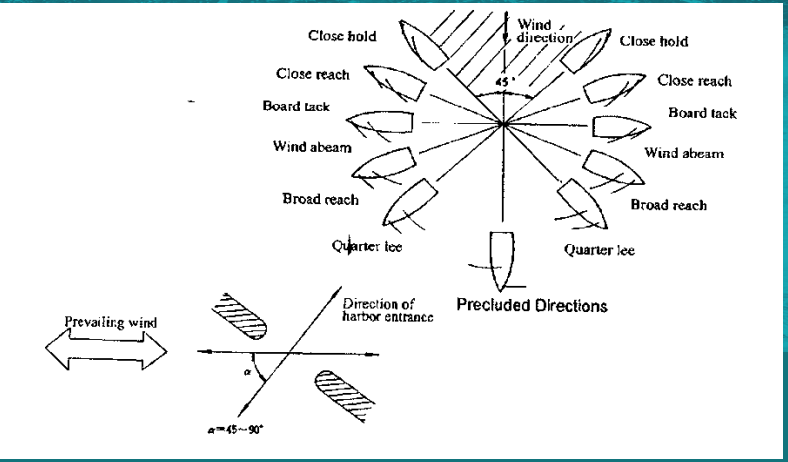
Figure 8-3. Channel width increase in turns

Navigation: Reversing Bend Design Guidelines



Navigation: Harbor Egress

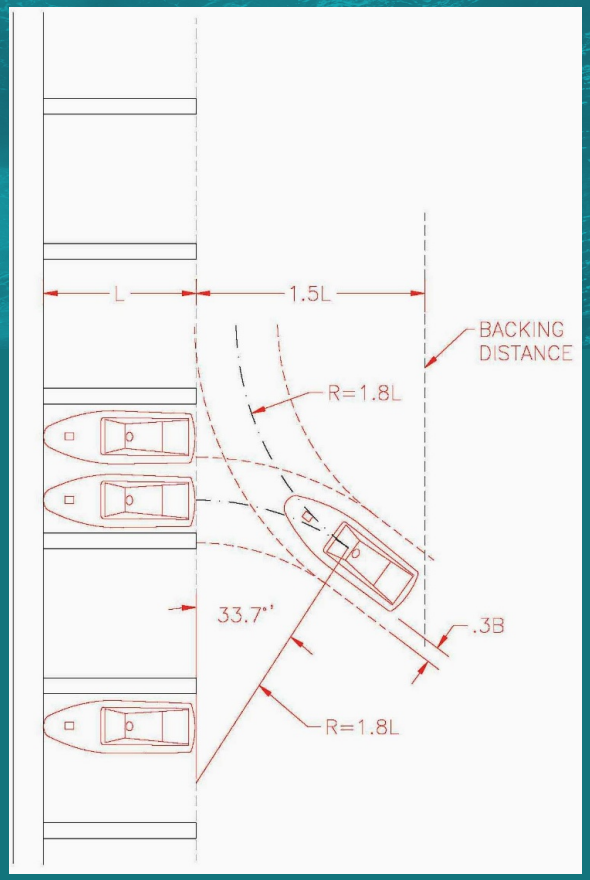




- Power Boats (ingress)
  - Poor steerage in following seas
  - Align approach 25° – 35 ° off wave angle
- Sail Boats (egress)
  - Poor motive in head winds
  - $\alpha > 45°$
- Design marina approach using quartering seas
- Maximize tip shadow, but avoid shore parallel approach

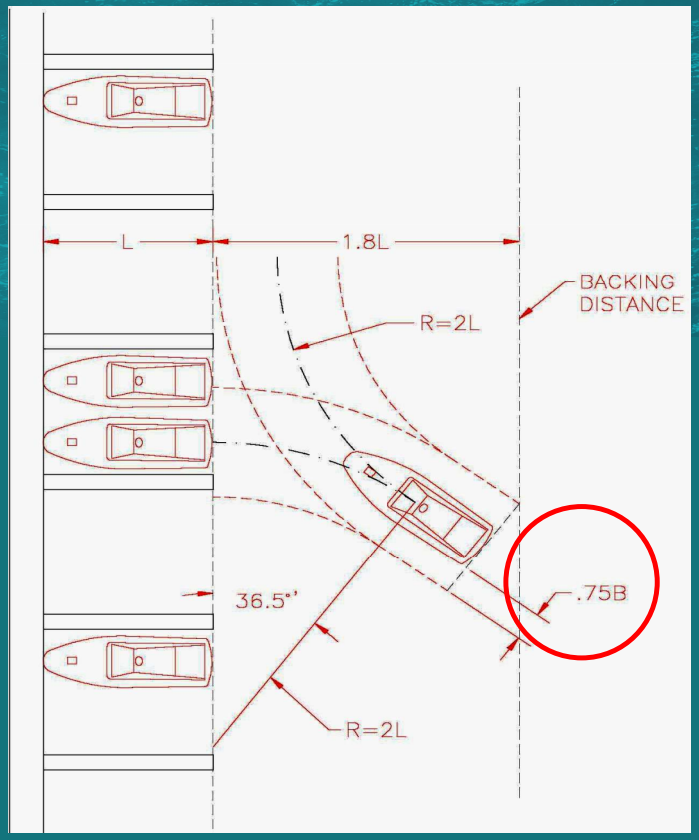
New Basin Layout Guidelines

Navigation: Typical Interior Fairway



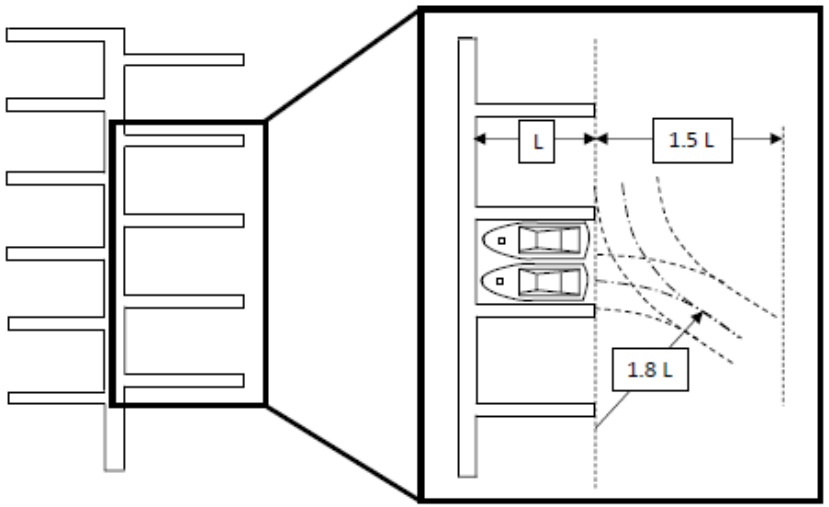
Unaided turn requires fairway = $1.5L$

Navigation: Rough Water Fairways



Rough water turn requires fairway = $1.8L$

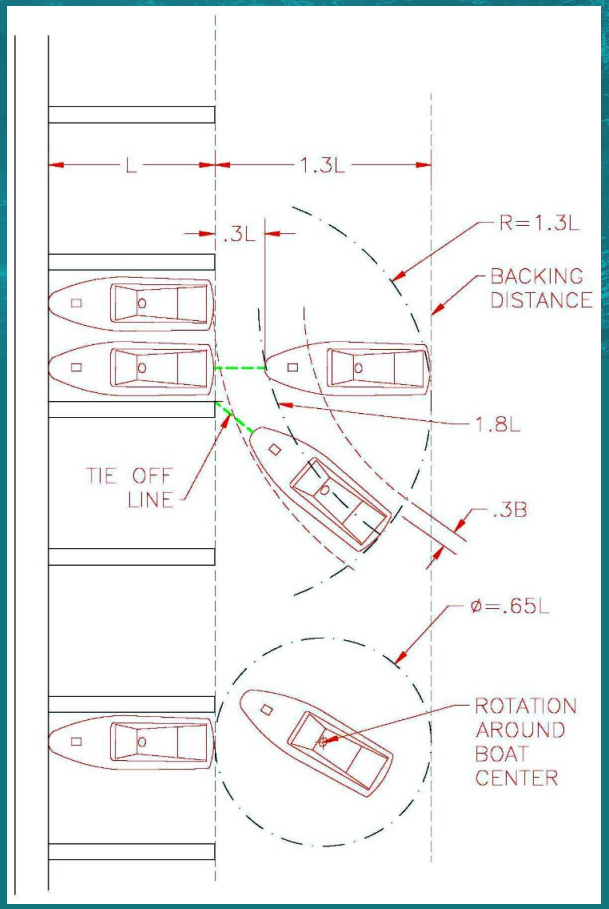
Navigation: Typical Fairway

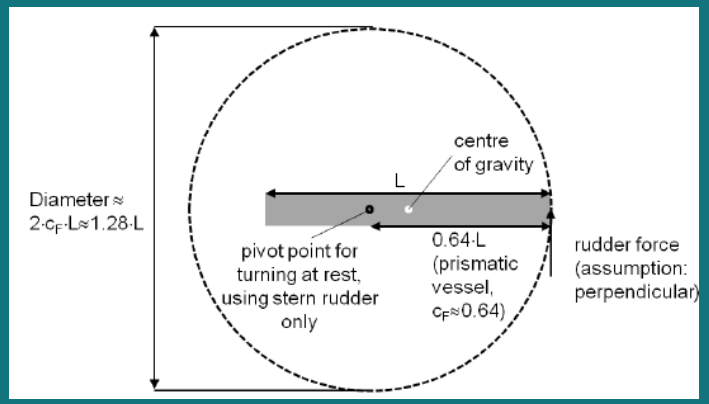


Unaided turn requires fairway = $1.5L$

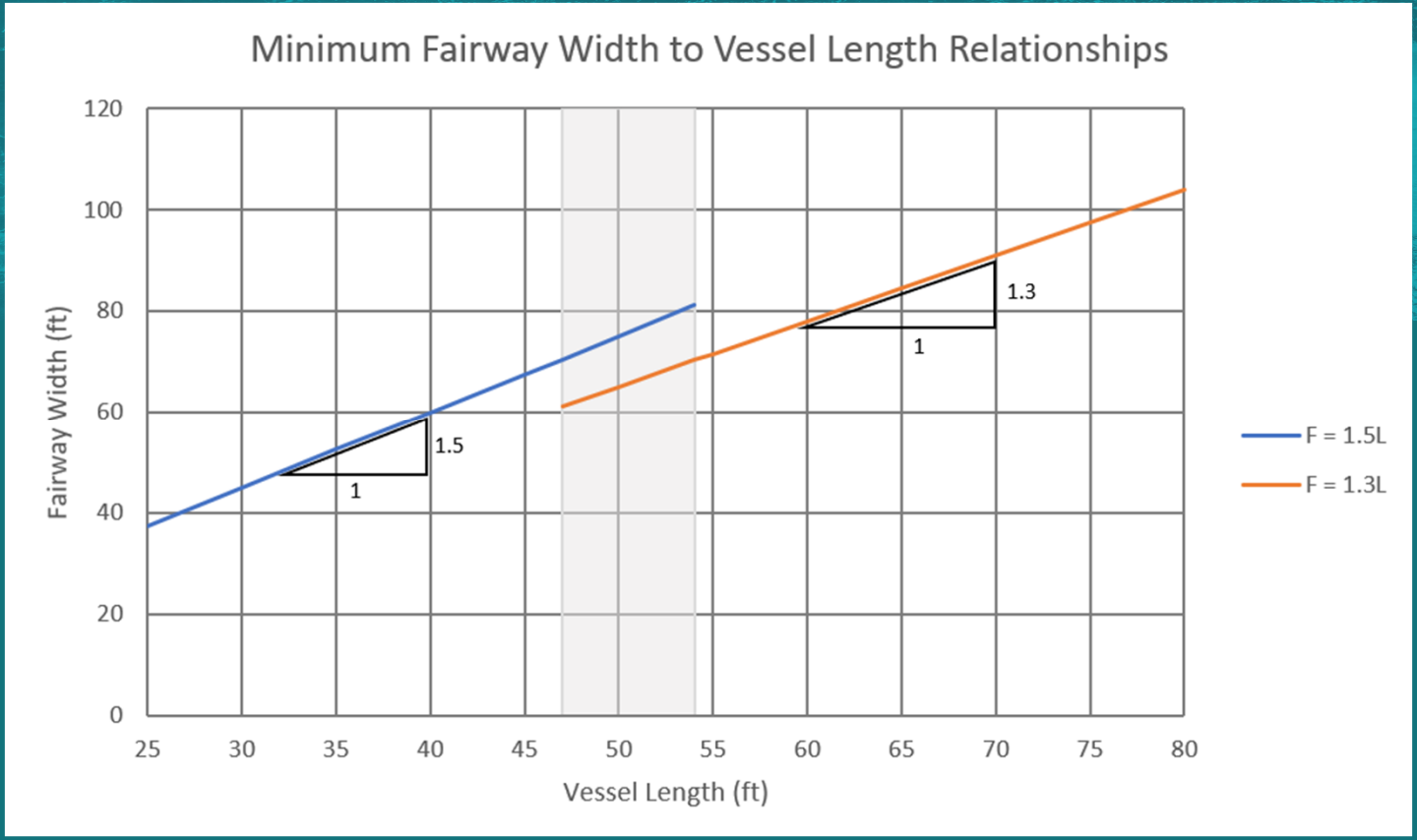
Navigation: Future Fairways?

Aided turn requires fairway = $1.5L$





Navigation: New Fairway Requirements

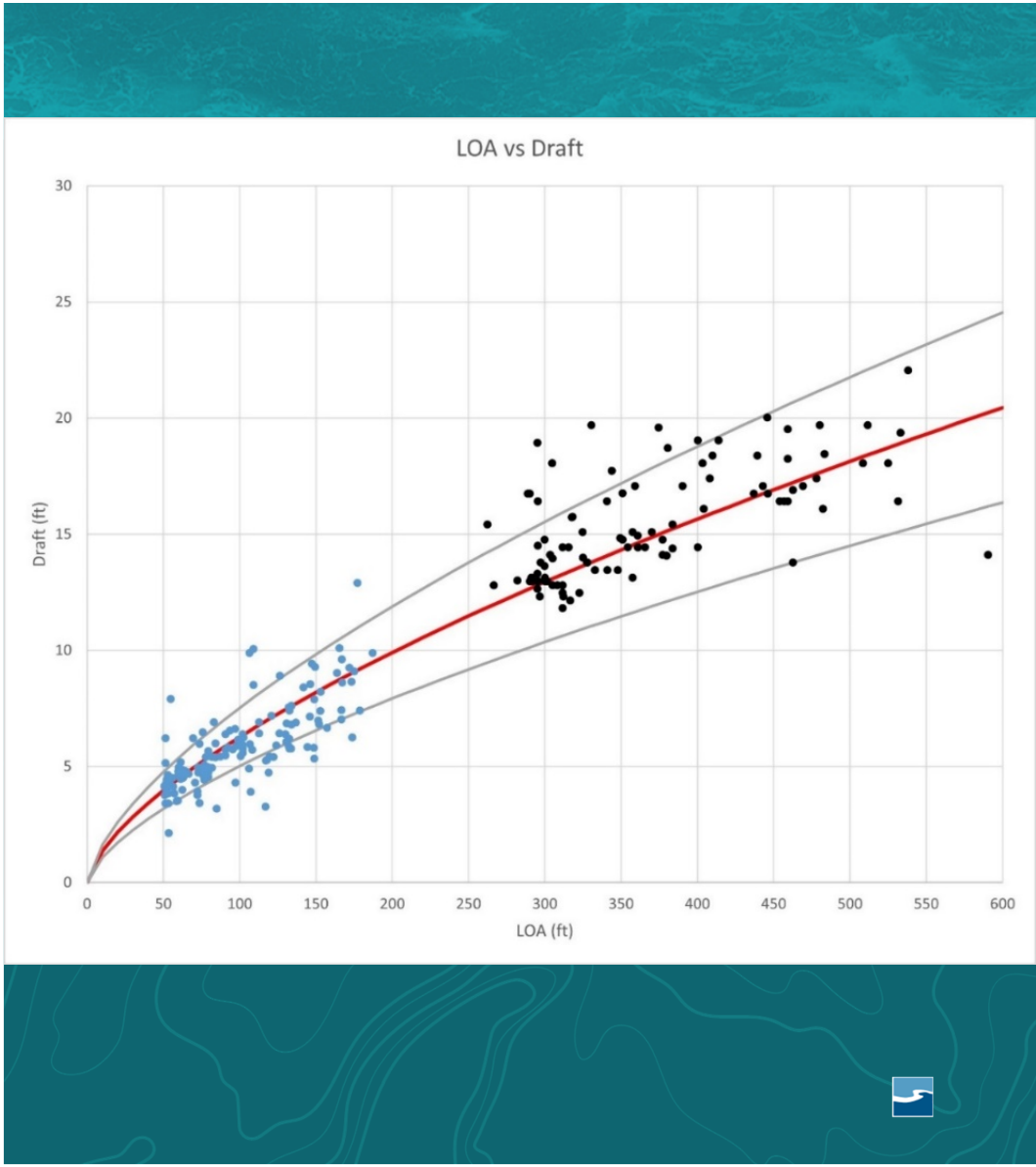


Vessel Characteristics

Navigation: Powerboat Draft to Vessel LOA

LOA vs Draft (D)

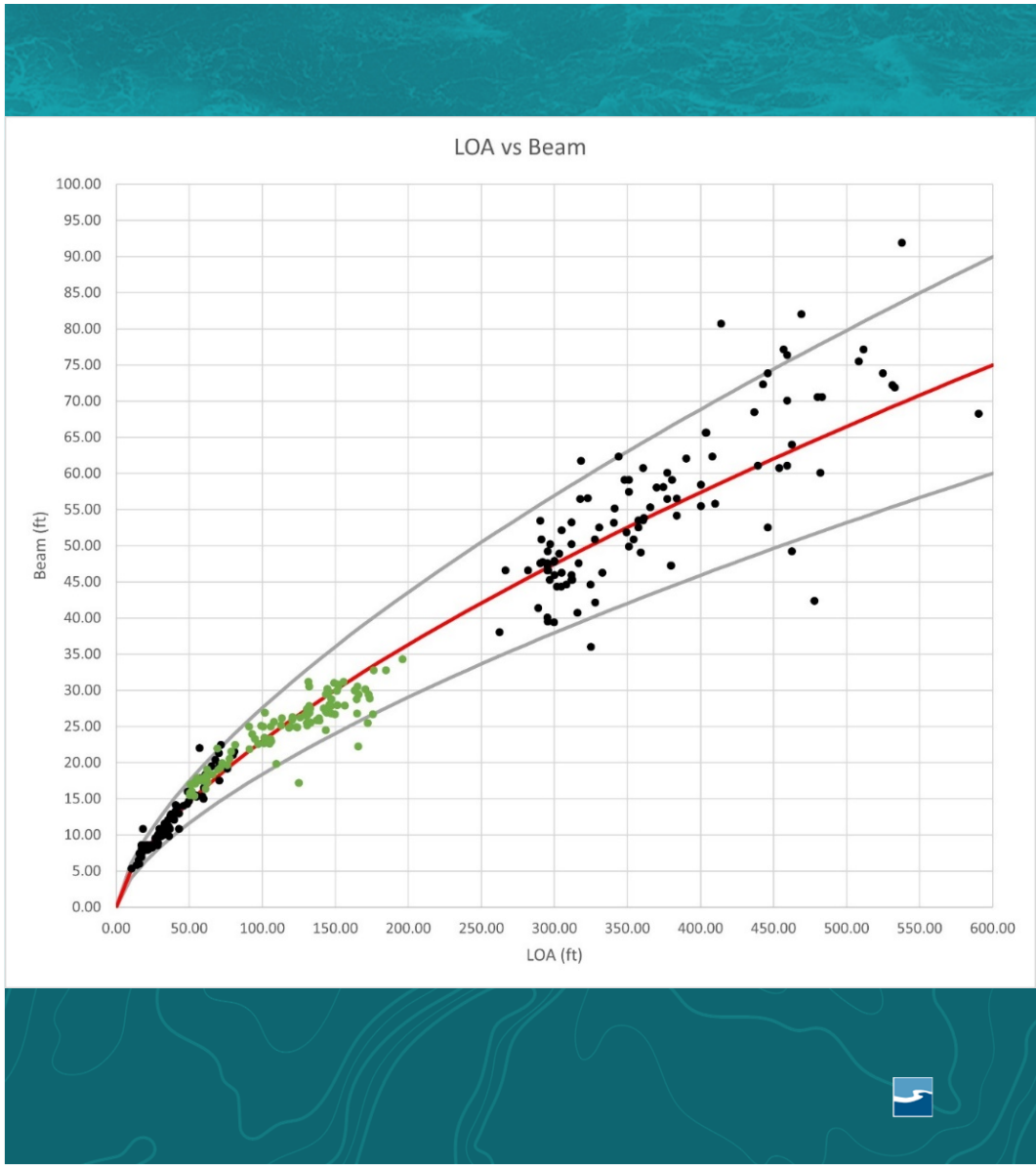
- $D_{max} = 1.3(LOA)^{0.66}$
- $D_{mean} = 1.1(LOA)^{0.66}$
- $D_{min} = 0.9(LOA)^{0.66}$



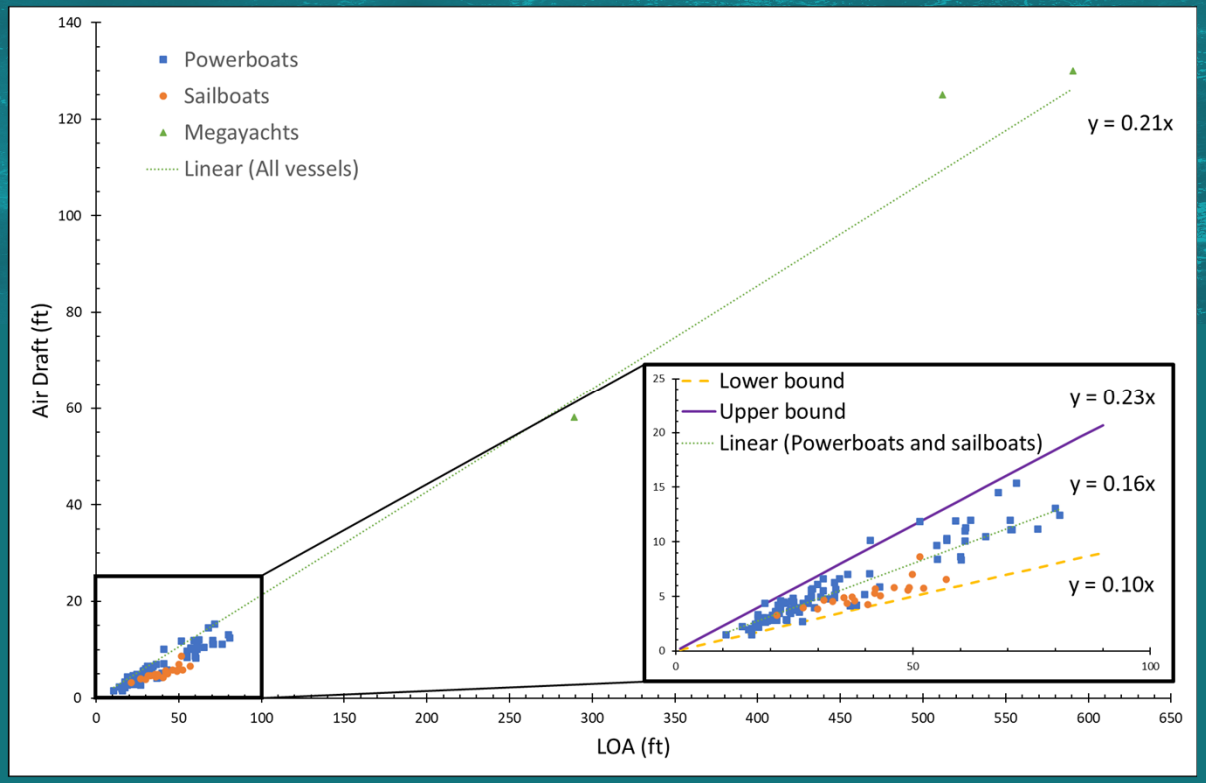
Navigation: Powerboat Beam to Vessel LOA

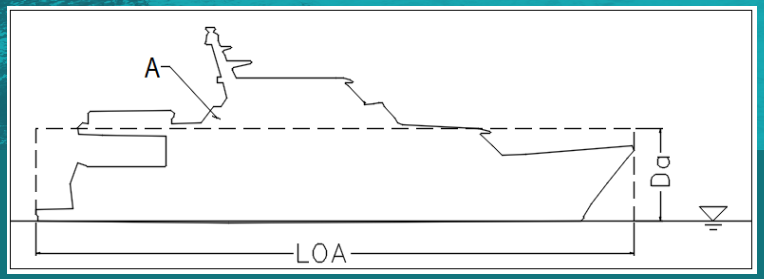
LOA vs Beam (B)

- $B_{max} = 0.35(LOA)^{0.66}$
- $B_{mean} = 0.3(LOA)^{0.66}$
- $B_{min} = 0.25(LOA)^{0.66}$



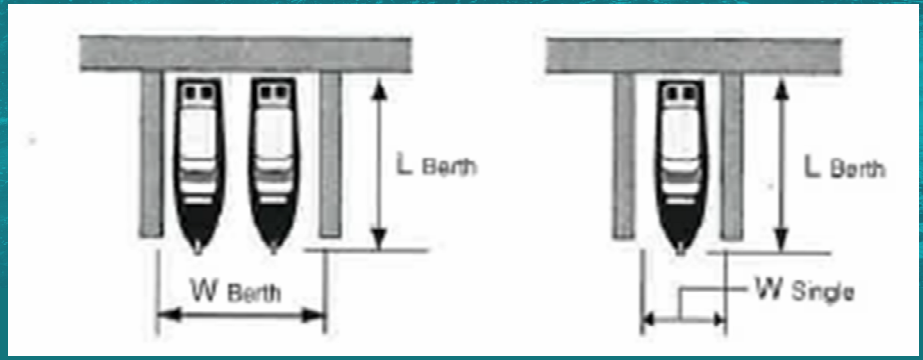
Navigation: Air Draft to Vessel LOA





$$A = D_a * (LOA)$$

Navigation: Slip Sizing



- $W_{Double} = 2B + 2f$ (assumes a typical fender/clearance equates to half the finger width)
- $W_{Single} = B + f$ where B = yacht beam and f = finger width = $0.1L_{Berth}$
- 3ft. < f < 8ft.
- $L_{Berth} = 1.1\ LOA$

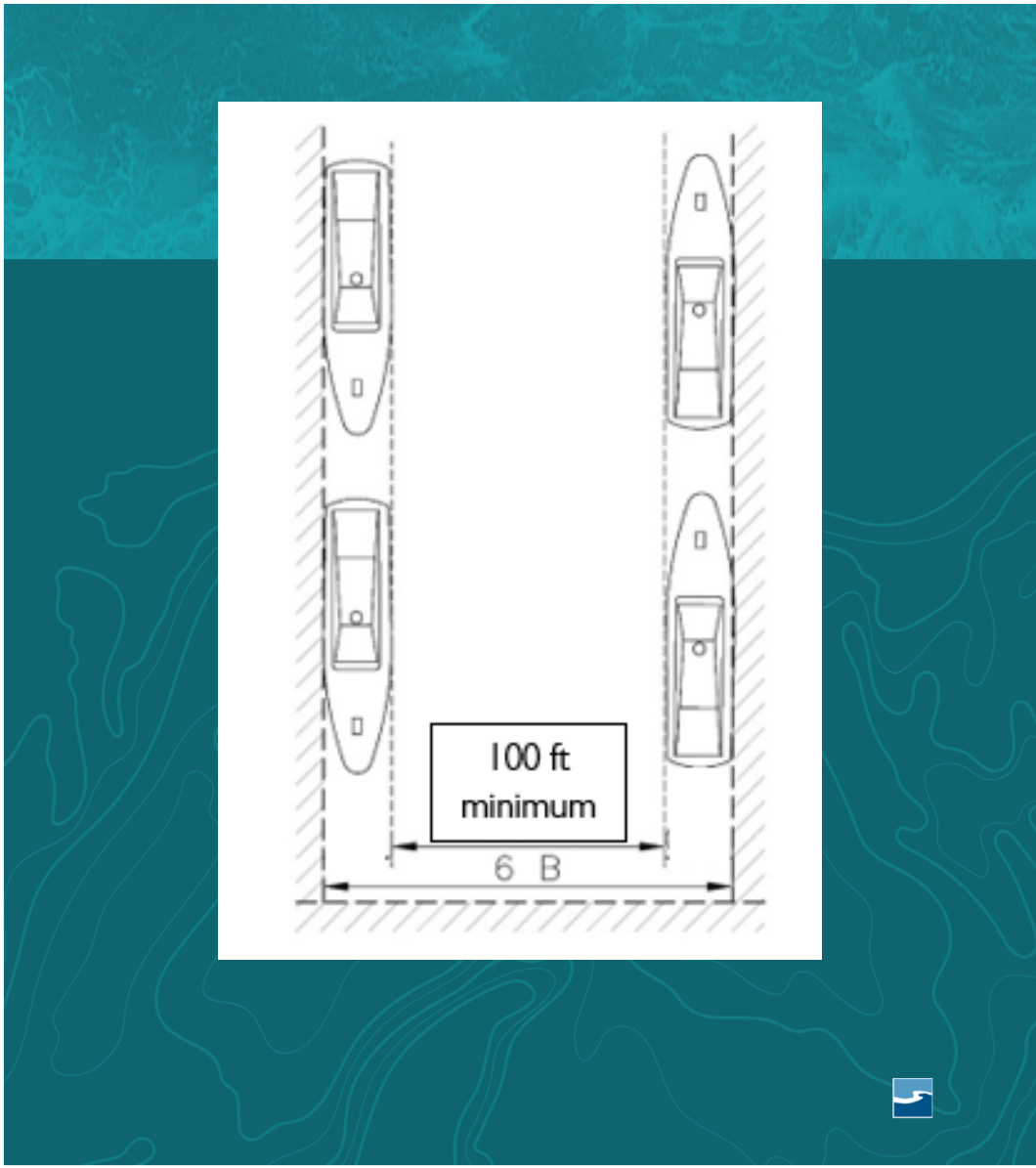
Navigation: Slip Sizing Guidance

SLIP SIZES

Slip Length (S)	Boat Length (LOA)	Boat Beam (B)	Finger width (f)	Double Berth (W_d)	Allowance (+/- 10%)	Single Berth (W_s)	Allowance (+/- 10%)
S	S/1.1	$0.3(LOA)^{0.66}$	0.1S	2B + 2f	0.2B	B + f	0.1B
30	27	10	3	25	2	13	1
34	31	11	3	28	2	14	1
40	36	12	4	32	2	16	1
44	40	13	4	34	3	17	1
50	45	14	5	37	3	19	1
54	49	14	5	40	3	20	1
60	55	15	6	43	3	21	2
64	58	16	6	45	3	22	2
70	64	17	7	48	3	24	2
74	67	18	7	50	4	25	2
80	73	19	8	53	4	27	2
84	76	19	8	55	4	28	2
90	82	20	8	56	4	28	2
94	85	21	8	57	4	29	2
100	91	22	8	59	4	30	2

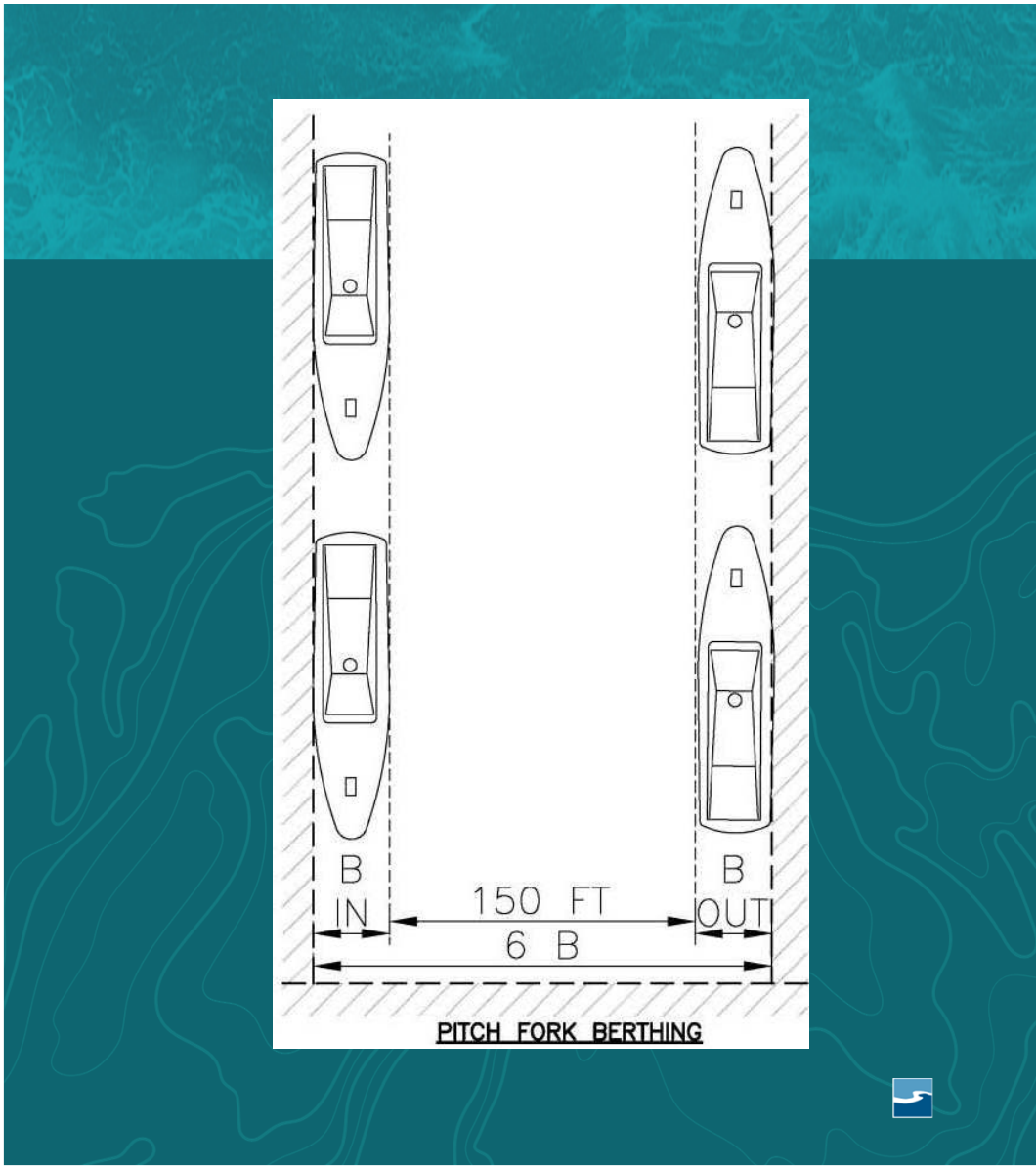
Navigation: Linear Berthing

Minimum clearance between moored vessels = $6B$ or 100ft, whichever is less.

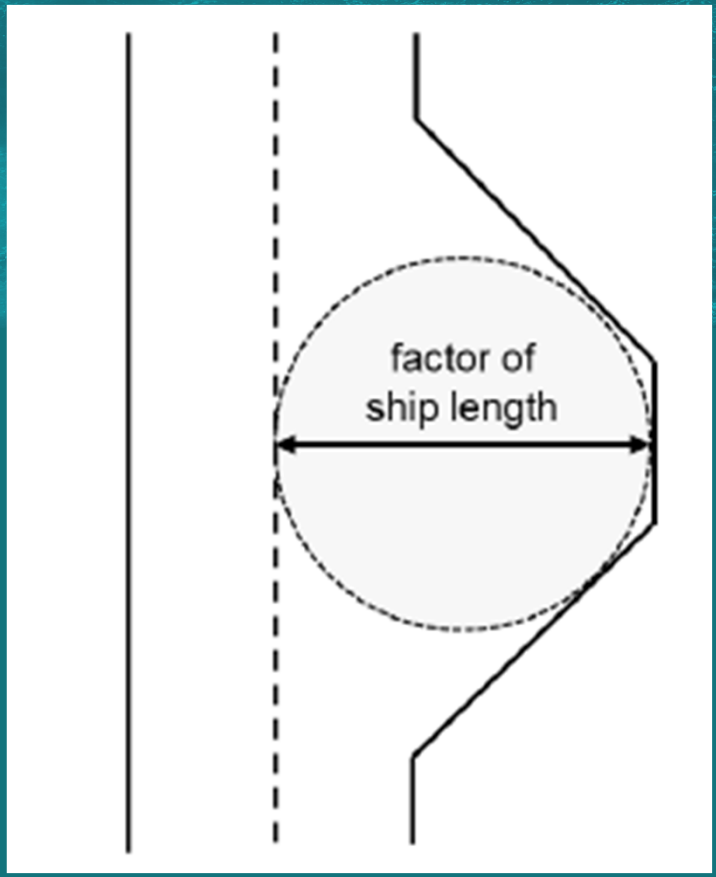


Navigation: Side Tie Berthing and Turning Circle Fairway Needs

Clearance between moored vessels = 6B or 45m, whichever is less.



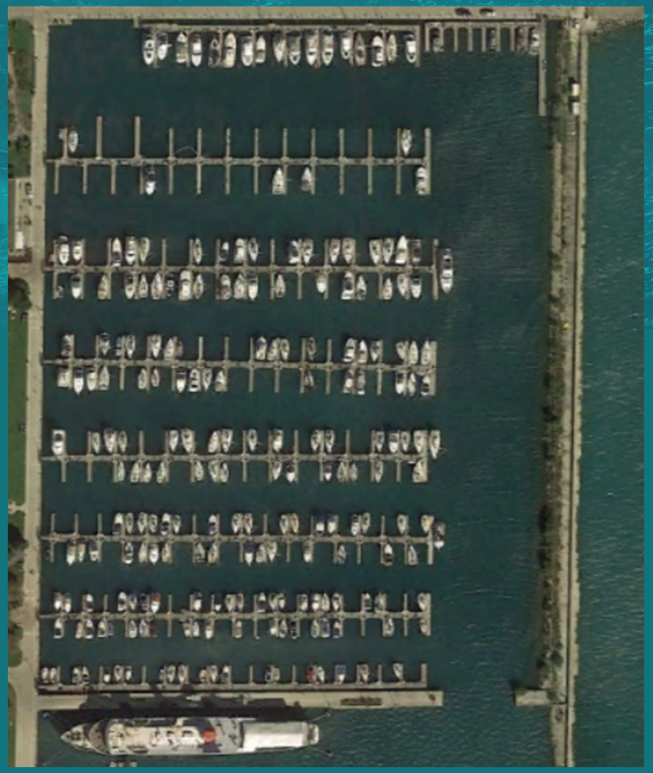
Navigation: Turning Basins



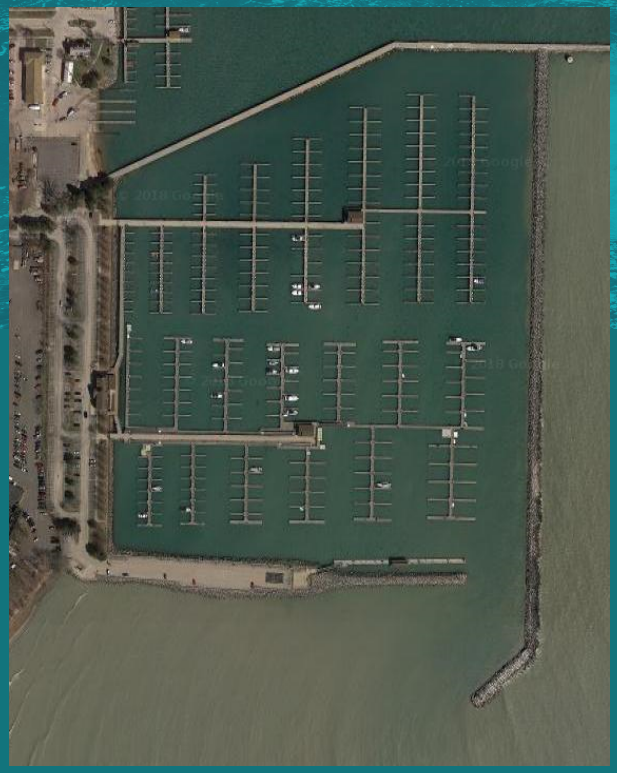
$$S = 1.3L - \frac{W}{2}$$

Facility Layout

Facility Layout: Dockage Configuration Options

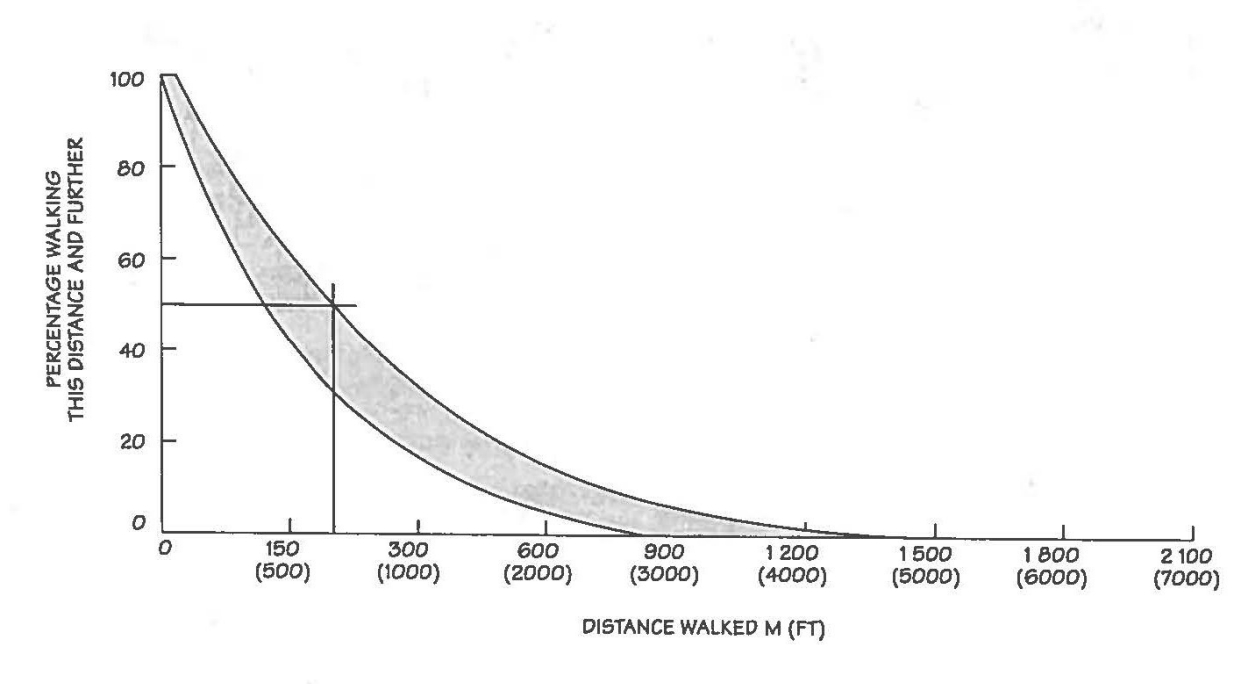


Forest



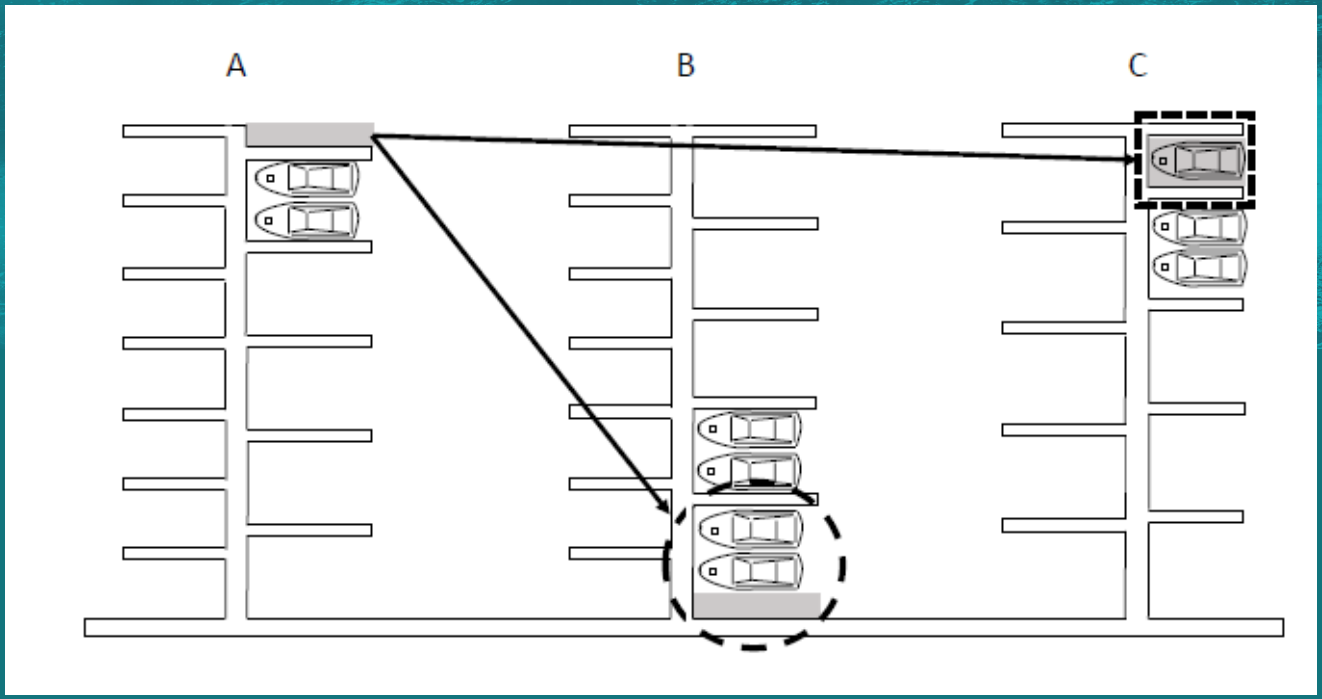
Tree

Facility Layout: Access and Walking Distance



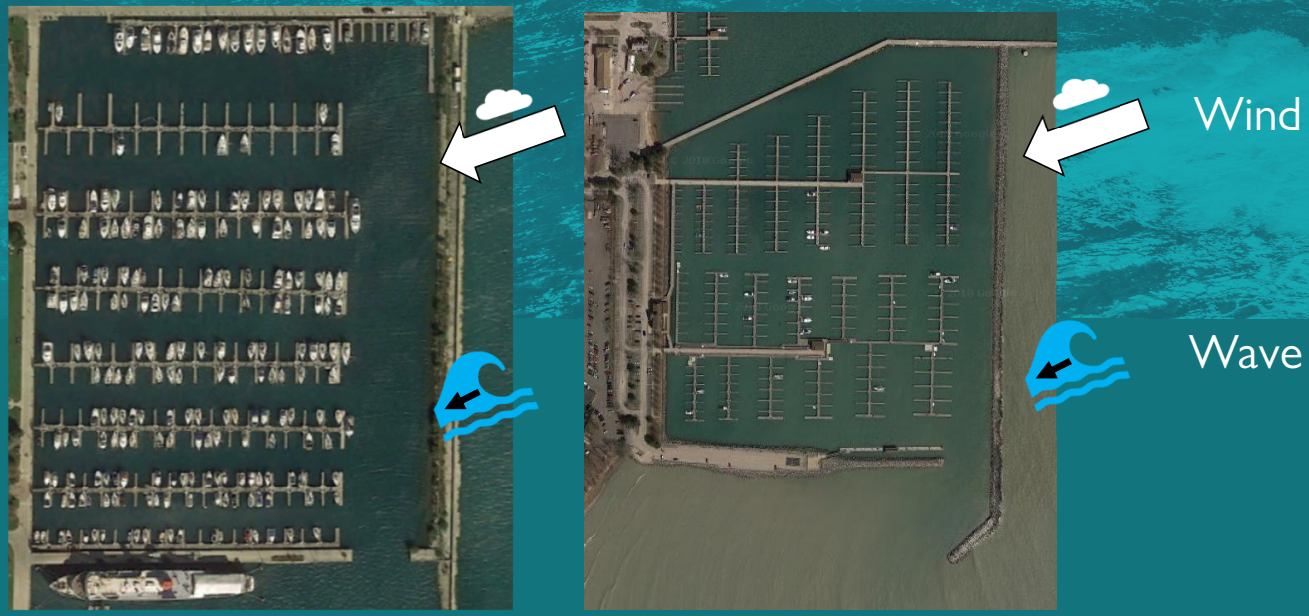
50% of people are not willing to walk distances greater than 220m (700ft.)

Facility Layout: Optimizing Berth Use

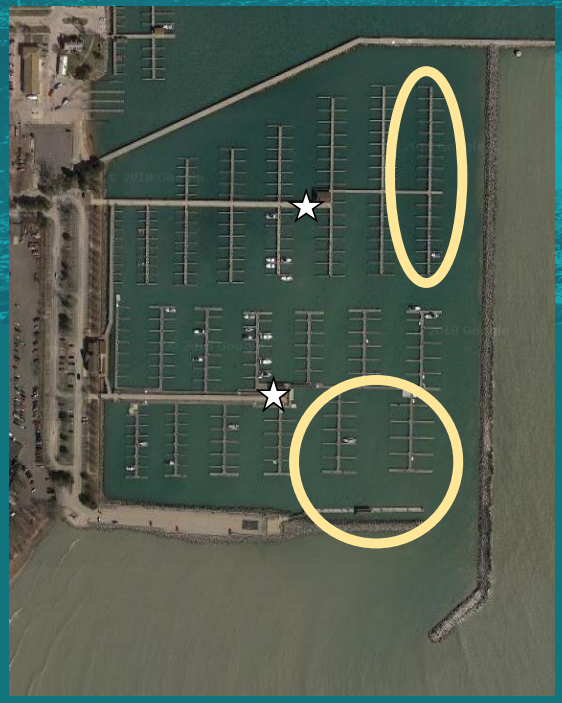


- Single end slips are the most desirable.
- Inner end slips require extra maneuvering room.

Facility Layout: Environmental Influences

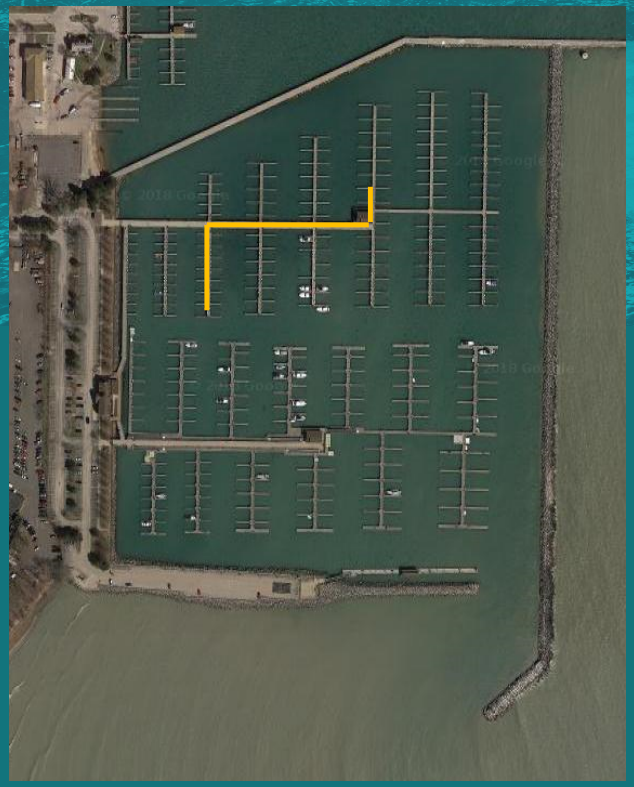


Facility Layout: Capital Costs

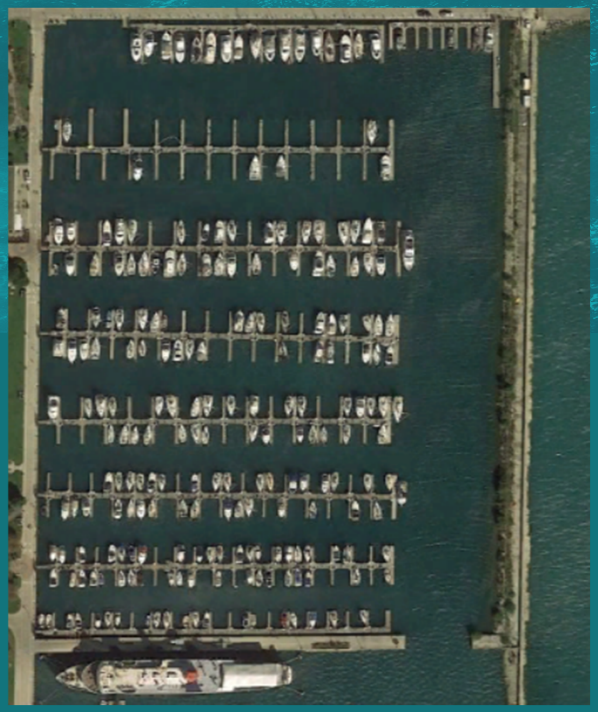


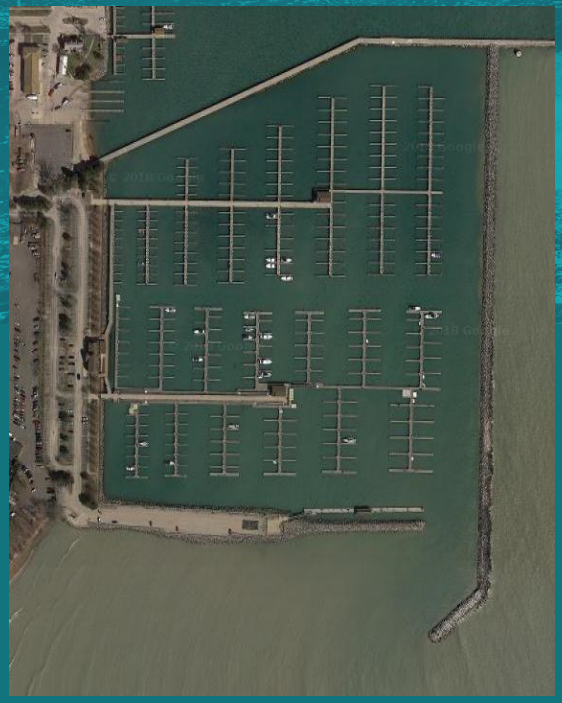
Power distribution versus power “hogs”

Facility Layout: Social Patterns



Facility Layout: Which is best value?

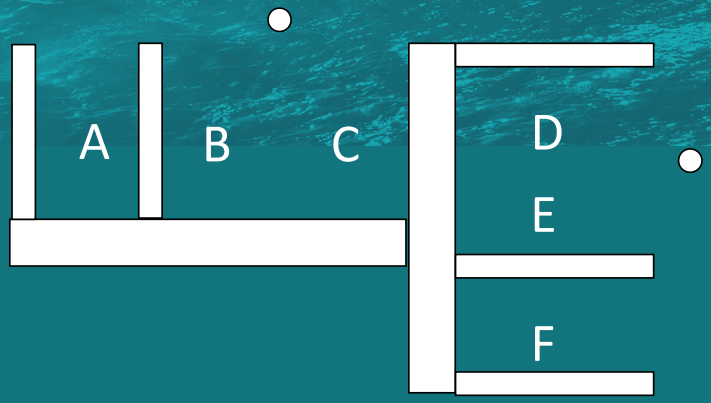




Need to consider performance, economics, and user preferences.

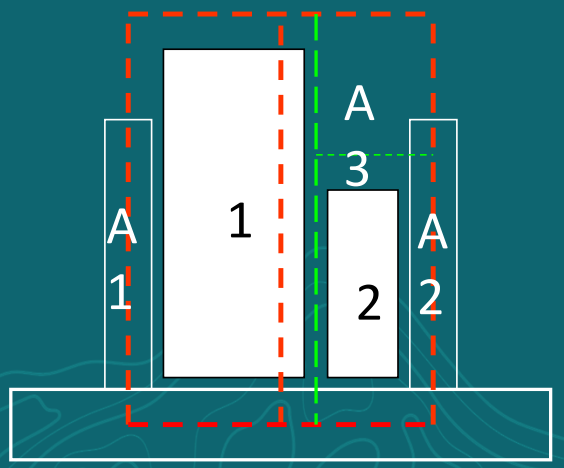
Facility Layout: Slip Valuation

Which Slip Has The Greatest Value To The Customer?



Facility Layout: Cost/ft. Versus Cost/sq. ft

- If you charge by the boat length, your monthly income would be $820. **(Boat 1 $500, Boat 2 $320)**
- If you charge by the greater of boat length or slip length, your monthly income would be $1,100: a 34% increase. **(Boat 1 $550, Boat 2 $550)**
- If you charge $0.77/ sq. ft. ($20.00/26) of boat size your monthly income would be $910: an 11% increase. **(Boat 1 $655, Boat 2 $222)**
- If you charge $.77/sq. ft. for the total rentable square footage (1,003 per slip,) your monthly income would be $1,545 an 88% increase. **(Boat 1 $954, Boat 2 $591)**
- If you associate unusable area A3 with A1: **(Boat 1 $1,090, Boat 2 $455)**



Known Slip Information

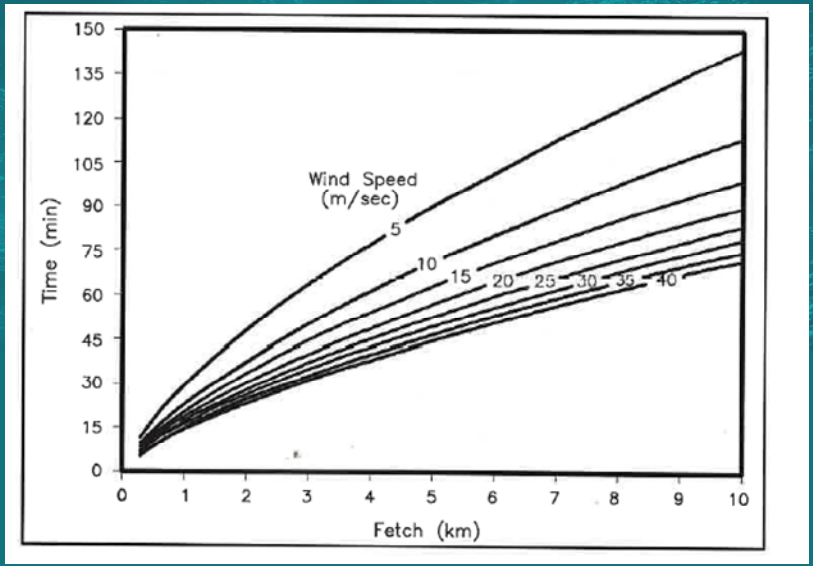
Slip	Opening Size	Rate Per Month
A1	15'x 55' = 825 Sq. Ft.	$10.00/Ft.
A2	15'x 55' = 825 Sq. Ft.	$10.00/Ft.

Known Boat Information

Boat	Length/Width
1	50'x17' = 850 Sq. Ft.
2	32'x 9' = 288 Sq. Ft.

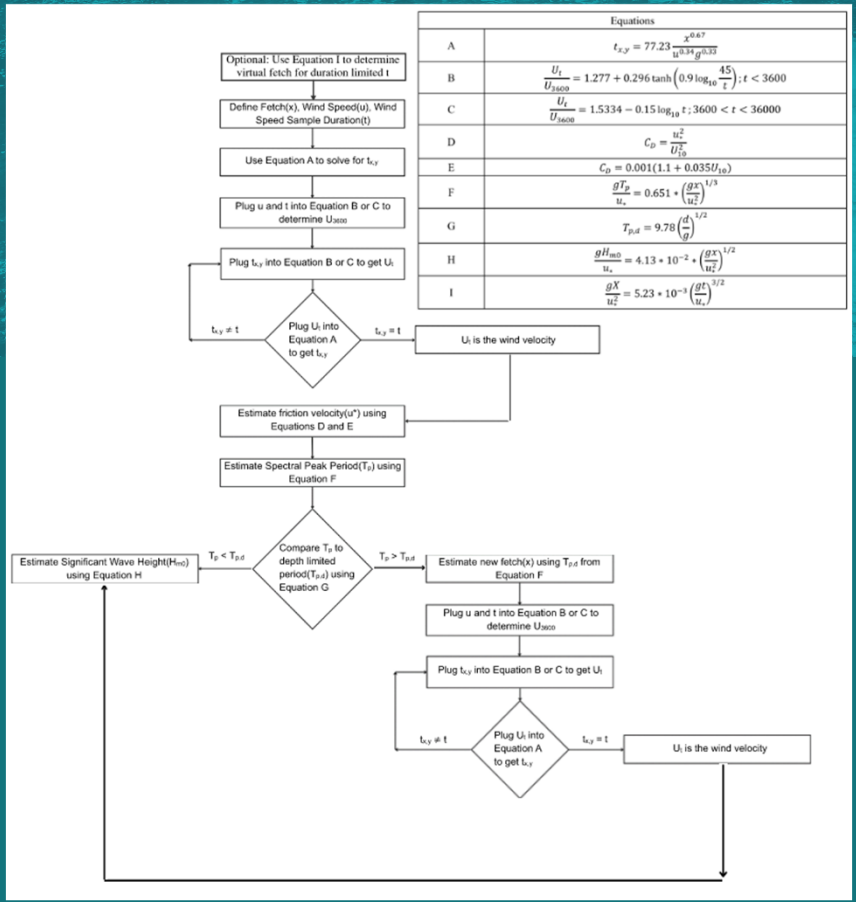
Design Criteria Development

Proper Wave Hindcasting Using CERC Methods



To correctly estimate fully developed wave properties:

- Duration of wind speed must match storm duration
- Adjust wind duration from the reported wind duration (typically a 2-minute wind)

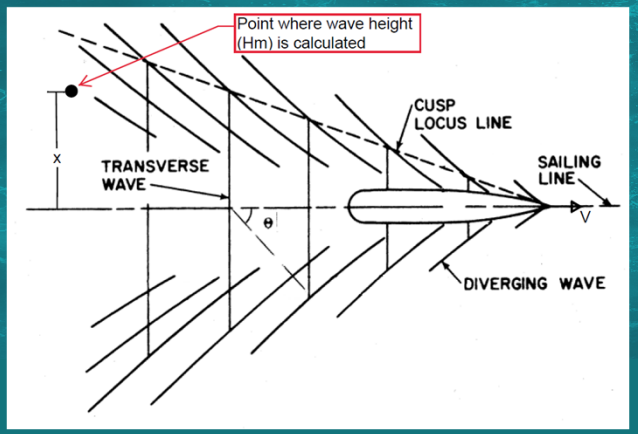


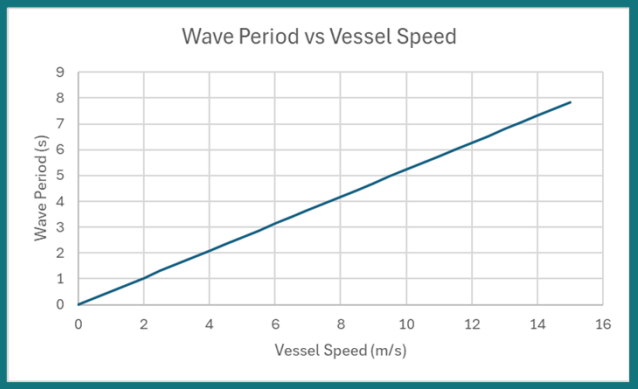
Equations	
A	$t_{x,y} = 77.23 \frac{x^{0.67}}{u^{0.34} g^{0.33}}$
B	$\frac{U_t}{U_{3600}} = 1.277 + 0.296 \tanh\left(0.9 \log_{10} \frac{45}{t}\right); t < 3600$
C	$\frac{U_t}{U_{3600}} = 1.5334 - 0.15 \log_{10} t; 3600 < t < 36000$
D	$C_D = \frac{u_*^2}{U_{10}^2}$
E	$C_D = 0.001(1.1 + 0.035 U_{10})$
F	$\frac{gT_p}{u_*} = 0.651 * \left(\frac{gx}{u_*^2}\right)^{1/3}$
G	$T_{p,d} = 9.78 \left(\frac{d}{g}\right)^{1/2}$
H	$\frac{gH_{m0}}{u_*} = 4.13 * 10^{-2} * \left(\frac{gx}{u_*^2}\right)^{1/2}$
I	$\frac{gX}{u_*^2} = 5.23 * 10^{-3} \left(\frac{gt}{u_*}\right)^{3/2}$

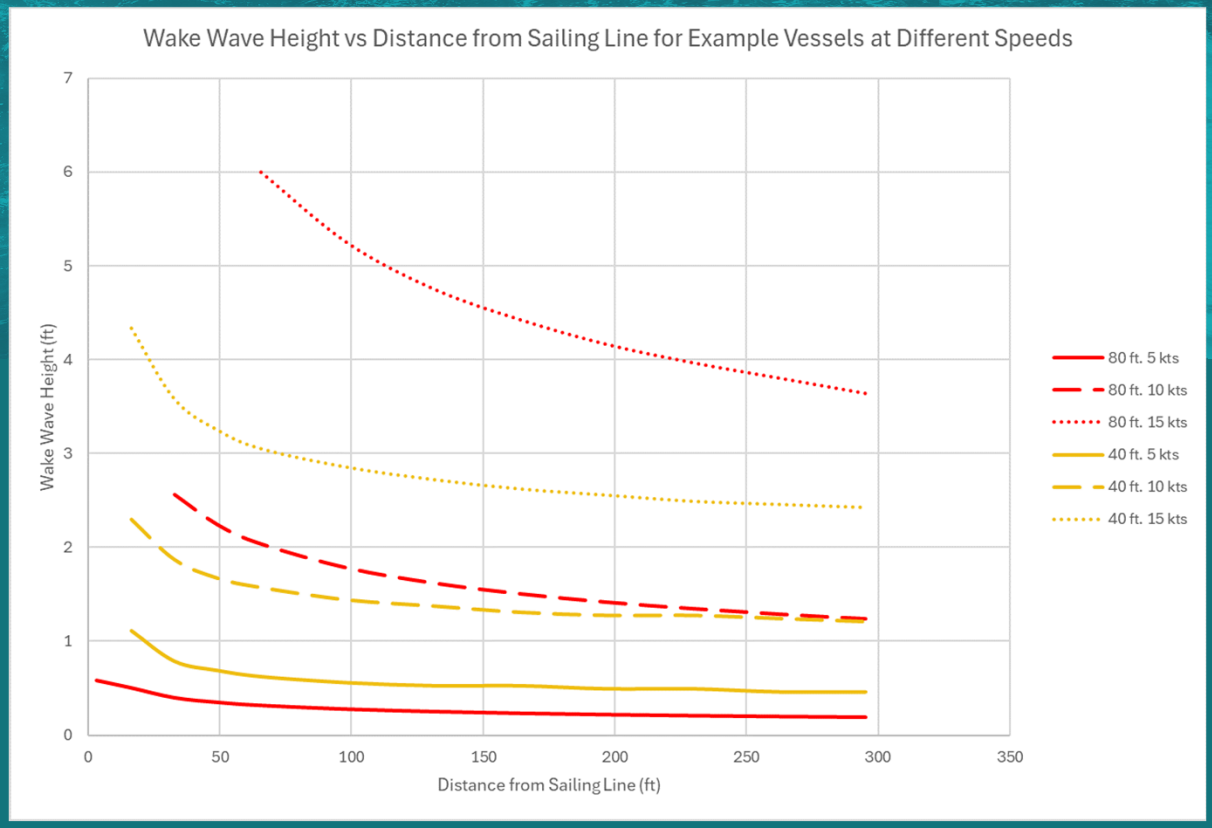
Fully Developed Seas with Sustained Wind Equivalents

Fetch (miles)	2-minute Wind Speed (mph)	Water Depth (ft)	Fully Developed Wind Duration	Equivalent Wind Speed at Wind Duration (mph)	Wave Height (ft)	Wave Period (s)
1	20	40	42-min	17.2	0.49	1.26
1	40	40	34-min	34.6	1.09	1.64
1	60	40	29-min	52.0	1.77	1.93
2	20	40	68-min	17.0	0.69	1.58
2	40	40	54-min	34.3	1.52	2.06
2	60	40	47-min	51.5	2.47	2.42
3	20	40	90-min	16.7	0.83	1.80
3	40	40	71-min	33.8	1.84	2.35
3	60	40	61-min	51.2	3.00	2.77
5	20	40	128-min	16.3	1.04	2.11
5	40	40	100-min	33.1	2.31	2.76
5	60	40	87-min	50.1	3.77	3.25
10	20	40	205-min	15.7	1.42	2.63
10	40	40	161-min	32.0	3.14	3.43
10	60	40	140-min	48.5	5.13	4.04
15	20	40	271-min	15.42	1.70	2.99
15	40	40	213-min	31.39	3.76	3.90
15	60	40	185-min	47.55	6.13	4.59
20	20	40	331-min	15.20	1.93	3.28
20	40	40	260-min	30.95	4.27	4.27
20	60	40	226-min	46.89	6.96	5.03

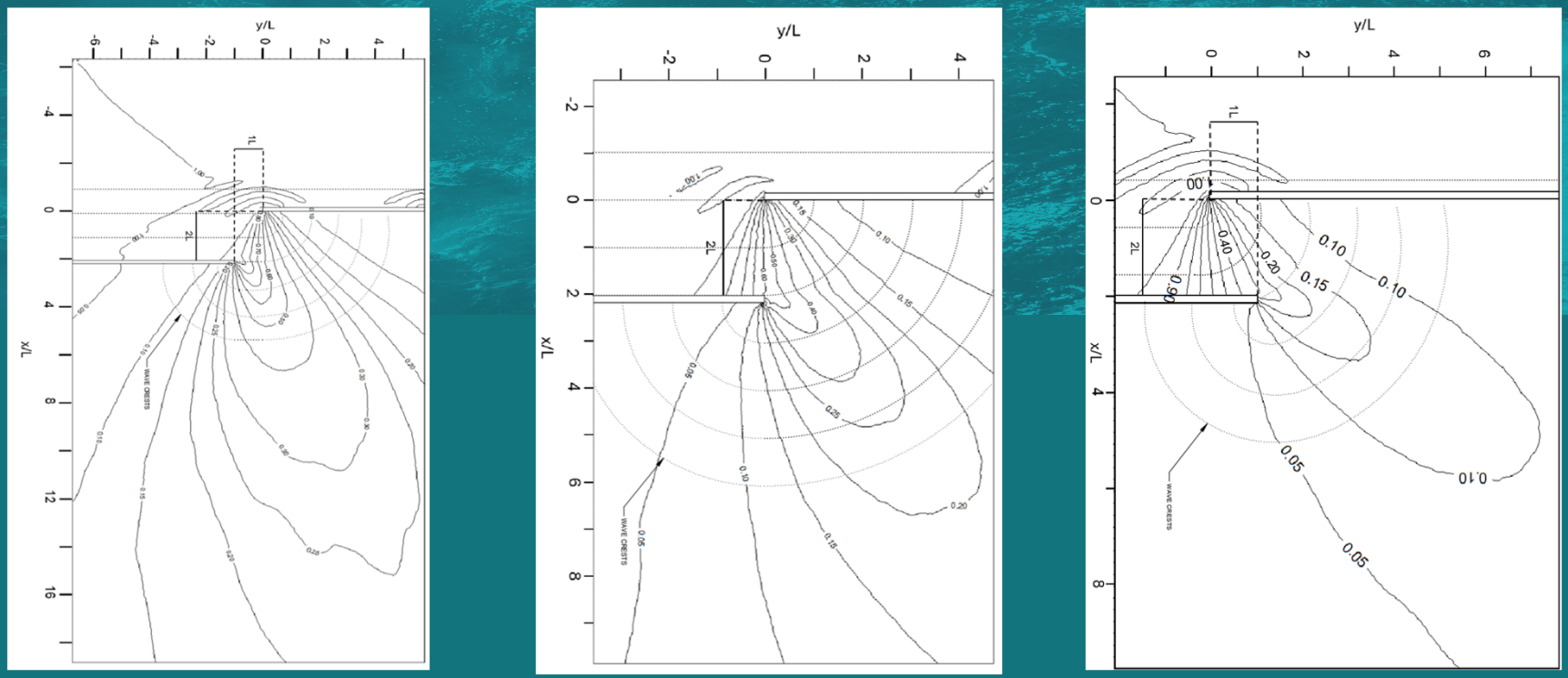
Boat Wake Estimating





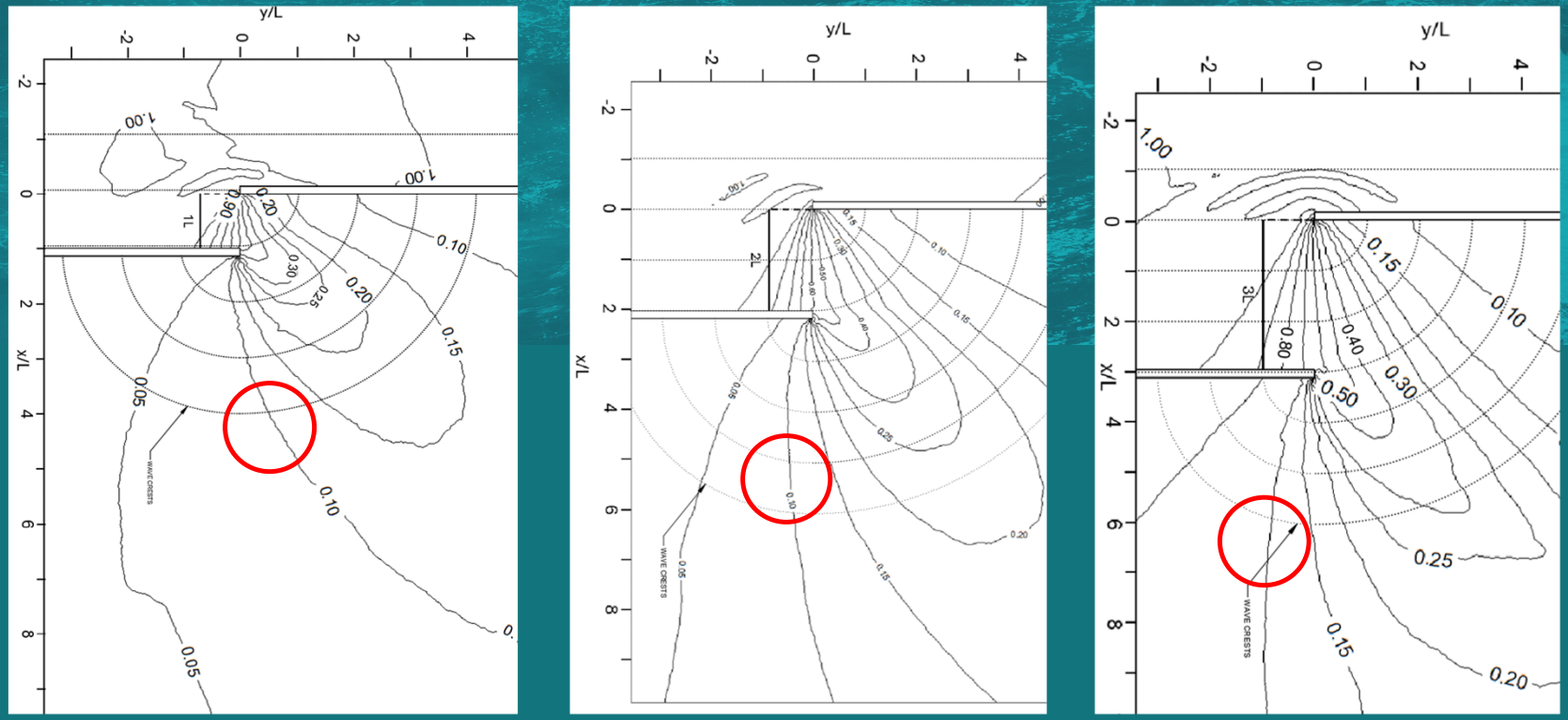


Overlapping Entrance Breakwater Transmission



Ideal overlap is $1L$ where L is the design wavelength.

Trailing Entrance Breakwater Transmission

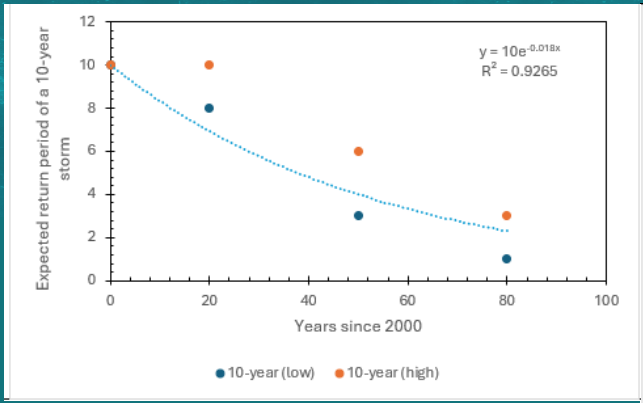


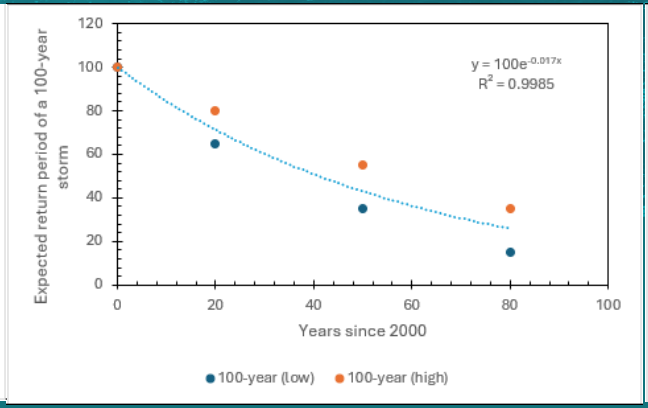
1 Wavelength (L) stepback ($\updownarrow$)= $\frac{1}{2}L$ translation ($\leftrightarrow$) of same transmission value.

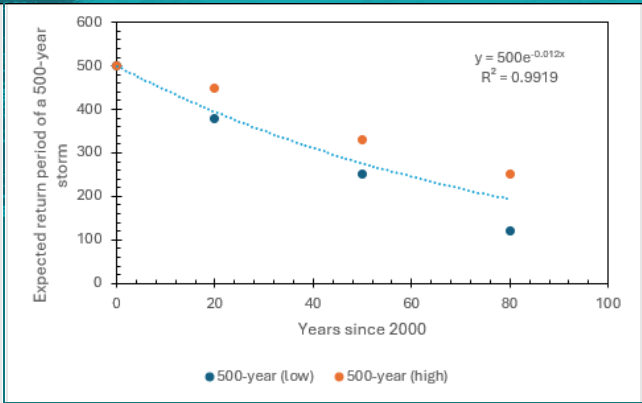
Harbor Protection: Optimized Entrance Considerations

Harbor Entrance Design: Best Practice Examples

Climate Change Adaptation: Storm Intensity Shift







$$RP_{future} = (RP_{2000}) * e^{(-a*years)}$$

a = 0.012 @ 500-year

a = 0.017 @ 100-year

a = 0.018 @ 10-year

Best Practice Forms of Harbor Designs Reimagined by Considering "Engineering with Nature"

Manual 50 4th Edition Updates

1.) Planning and Designing Your Marina

Jack C. Cox, P.E.; BC.CE, BC.PE, BC.NE

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