Free Spanning Subsea Pipelines

Discussion Session:

Cook Inlet Area

presented by

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Principal Engineer
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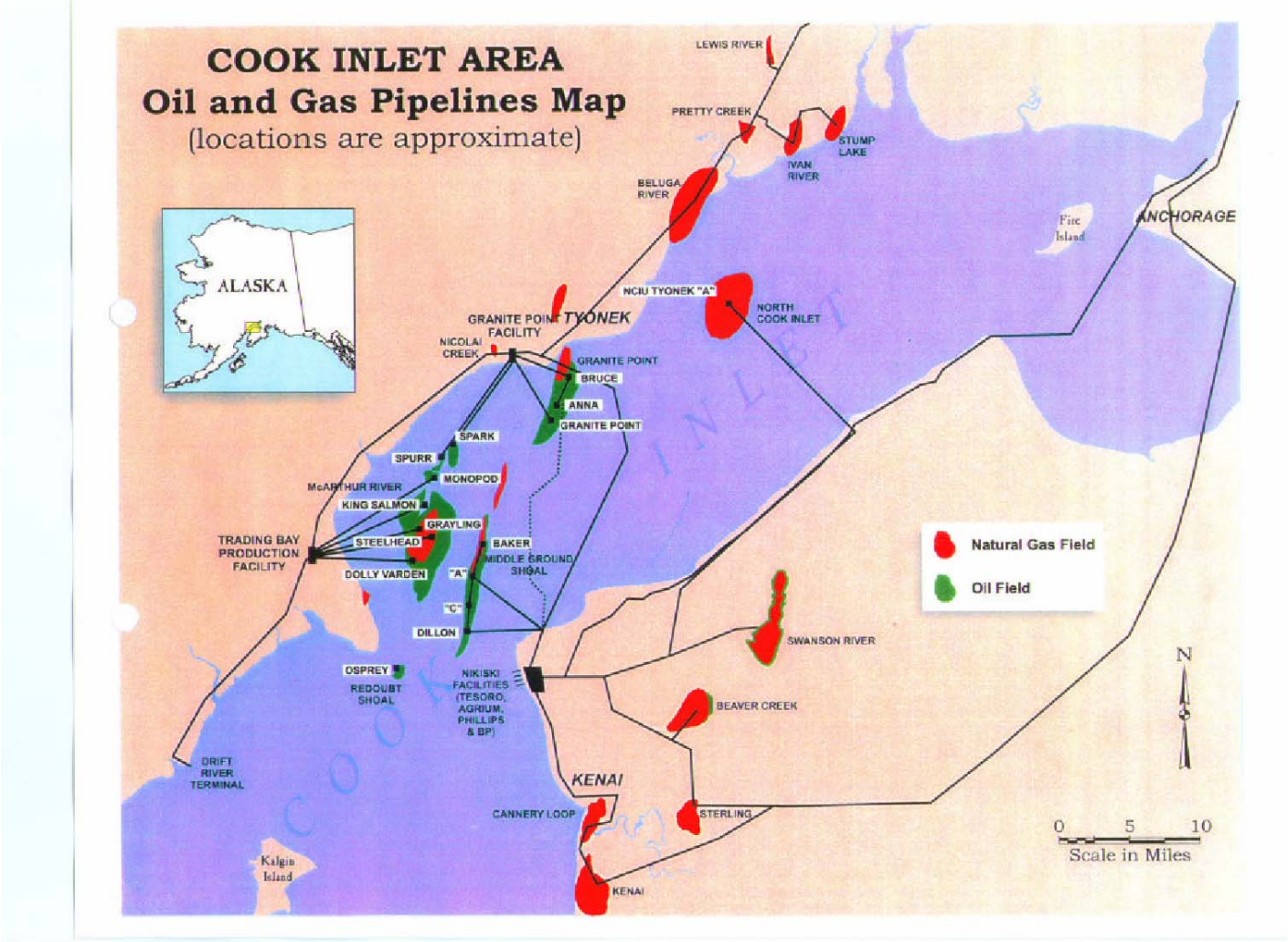
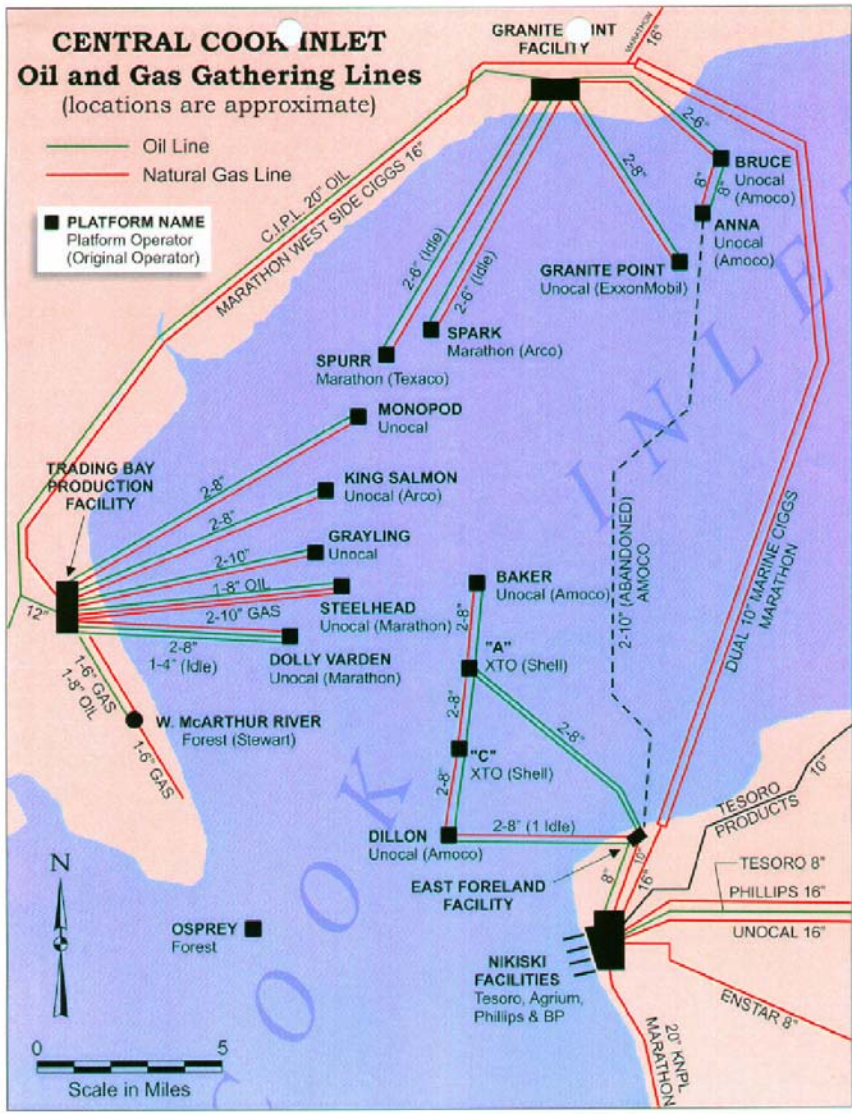
Content of presentation

- Subsea pipelines in Cook Inlet
- Current distribution
- XTO pipelines
- Osprey pipelines
- Remarks

Cook Inlet Area



Cook Inlet Area - Pipelines

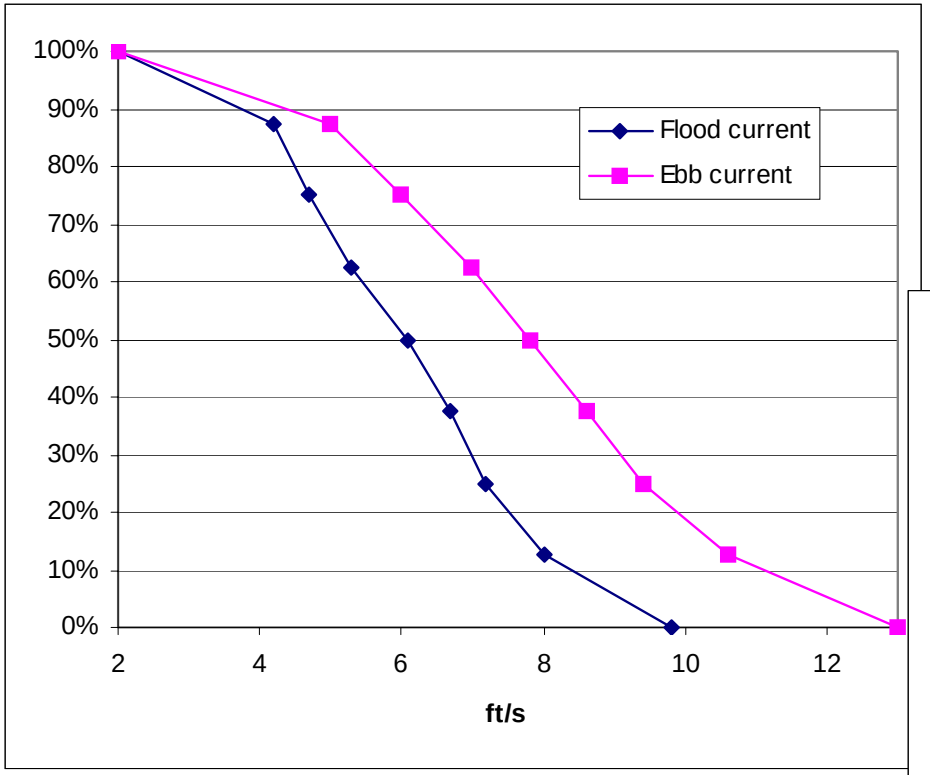


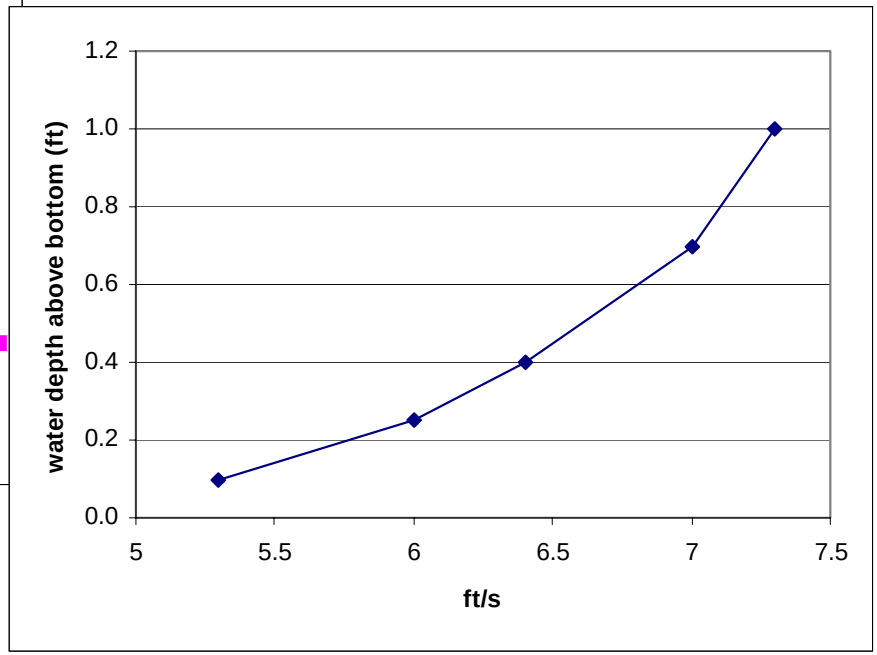
MANAGING RISK

Subsea Pipelines in Cook Inlet

- Aging pipelines (installed late 60ties)
- “Thick walled” (thicker than needed from pressure containment)
- Significant corrosion in some oil lines
- Strong tidal current
- Seabed conditions are very dynamic
- Scouring giving span gaps of less than a foot
- Annual inspection for free spans (side scan sonar?)
- Spans longer than 50’ and 1’ gap intervened to avoid VIV damage
- Spans of 100 ft may fail due to VIV
- 14 failures due to VIV 1965-1976??

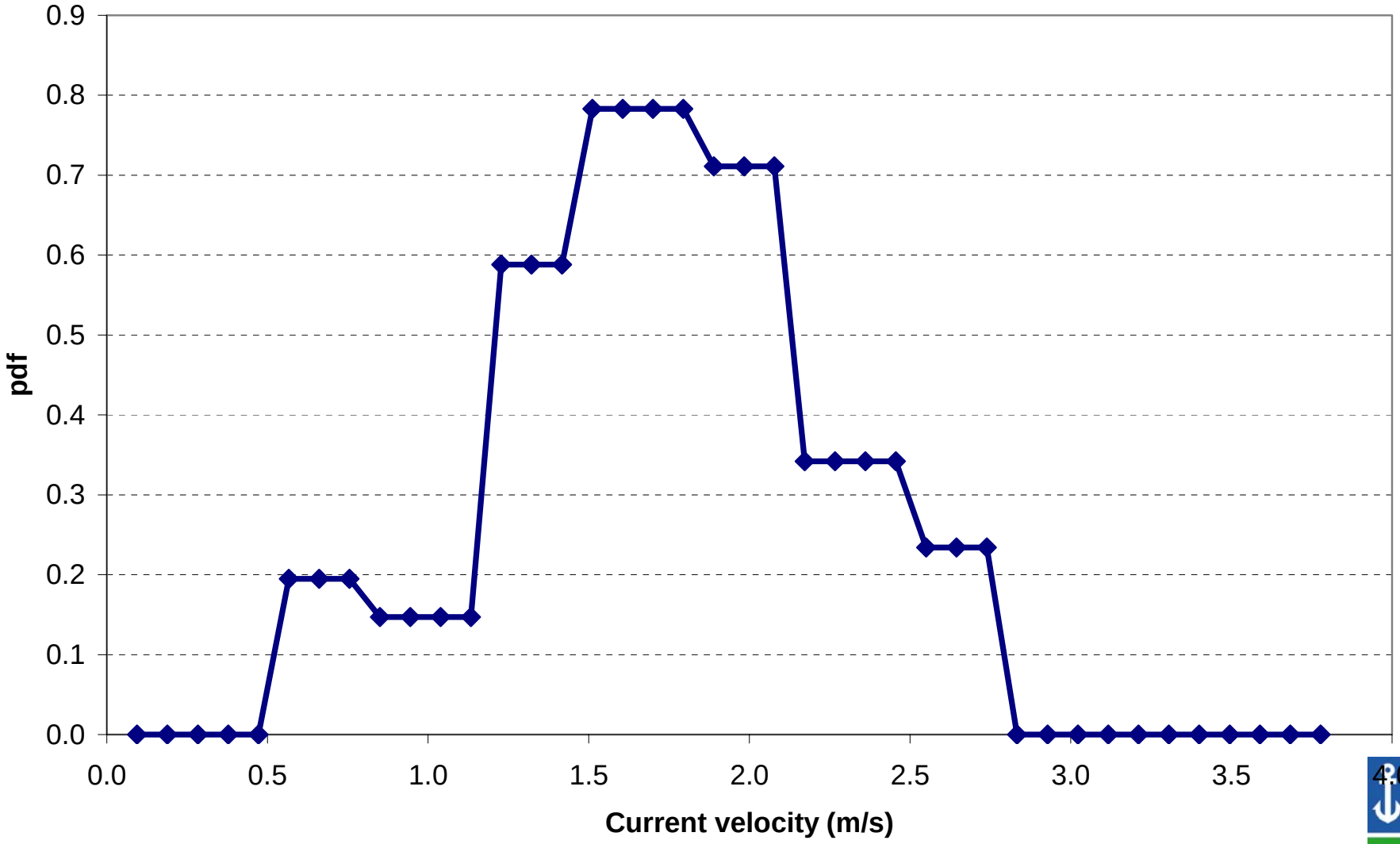
Current distribution – West Foreland





MANAGING RISK

Current distribution



XTO pipelines

- A line dry oil (Plt. A to East Forelands) 2 leaks in in 1966 (year 1) + one in 1976 due to VIV
- B line wet oil (Plt. A to East Forelands) 3 leaks in in 1966-68

- 8” lines, 1-2.5” concrete
- 160-280 psig operating pressure
- Long spans, sandbag supports

LEVEL 1 SPANS | OPTIONS
LEVEL 2 SPANS | USER HELP
LEVEL 3 SPANS | PRINT RESULTS

FATFREE Current Vers. 9.0

FATIGUE ANALYSIS OF FREE SPANNING PIPELINES

DNV version *Expiry date: 31/12/2004* *Release Note*

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FATFREE COMPLETED
No Wave Case

Project: **Date:** 21/05/2004 **Calculations by**
References: XTO pipeline from plt A to East Foreland **Verified by**

Calculation Options	Current Modelling	Free Span Scenario		Response Data		Damping		SN-Curves		Safety Factors	
Analysis Level 2	Uc Histogram	Pipe in trench		RP-F105 Span		Sand - Medium		F1 (air)		NORMAL	
Code		h [m]	20	f_o(in-line)	2.840	ζ_{struc}	0.005	m_1	3	γ	0.50
RP-F105		L [m]	14	f_o(cr-flow)	2.918	ζ_{soil} (in-line)	0.015	m_2	5	γ_k	1.30
Return Period Values	Directionality	e [m]	0.30	A_{in} (in-line)	438	ζ_{soil} (cr-flow)	0.012	Log(C_1)	11.699	γ_f	1.20
Automatic Generated	Discrete - C dir.	d [m]	0.3	A_{cr} (cr-flow)	459	$\zeta_{h,RM}$	0.000	Log(C2)	14.832	γ_s	1.05
UPDATE SHEET	Environmental Data	ζ_{pipe}	20.0	ζ_{max}	2010			logN_{sw}	7.00	γ_{on}	1.10
		D [m]	0.281	ζ/D	0.13	K_S(in-line)	0.67	S_0 [MPa]	0.00		
CALCULATE	Current-template	L/D	50	S_{eff}/P_E	-0.02	K_S(cr-flow)	0.56	SCF	1.00		
				$L_{eff,vs}$/L	1.45	**Soil stiffness**				γ_R	1.00
				$L_{eff,v}$/L	1.17	Sand - Medium					
						K_V	2.246E+07			☐ Well Defined Span	
						K_L	1.685E+07				
						$K_{V,S}$	5.300E+05				

FATIGUE LIFE

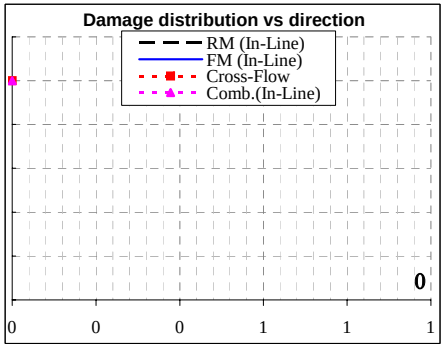
In-line (Response Model)	2.45E+02 yrs
	-
	-
Cross-Flow	1.00E+06 yrs

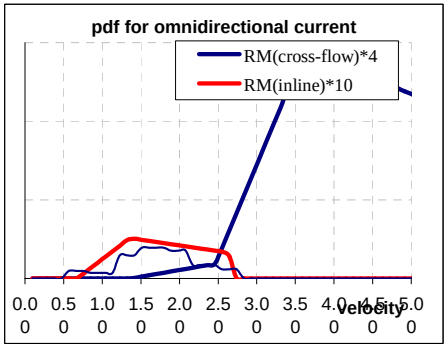
cross-flow direction DYNAMIC STRESS [MPa] in-line direction

	Peak Stress	V. Mises Stress		Peak Stress	V. Mises Stress
ζ_x(1 year)	0.0	19.3	ζ_x(1 year)	9.3	18.1
ζ_x(10 year)	0.0	19.3	ζ_x(10 year)	9.3	18.1
ζ_x(100 year)	0.0	19.3	ζ_x(100 year)	9.3	18.1

EXTREME CONDITIONS

Current	
U_C(1 year)	1.09 0.00
U_C(10 year)	1.09 0.00
U_C(100 year)	1.09 0.00

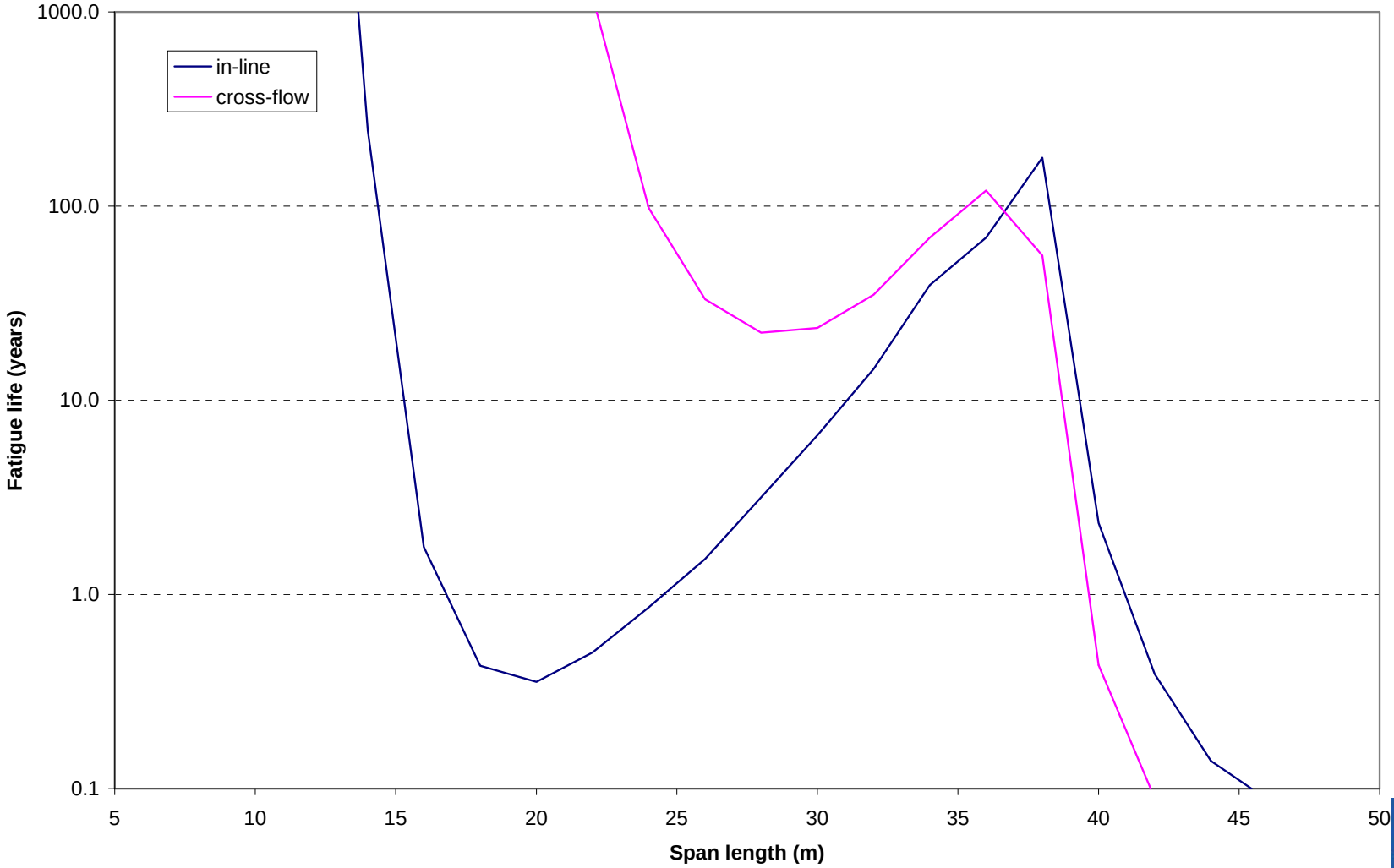




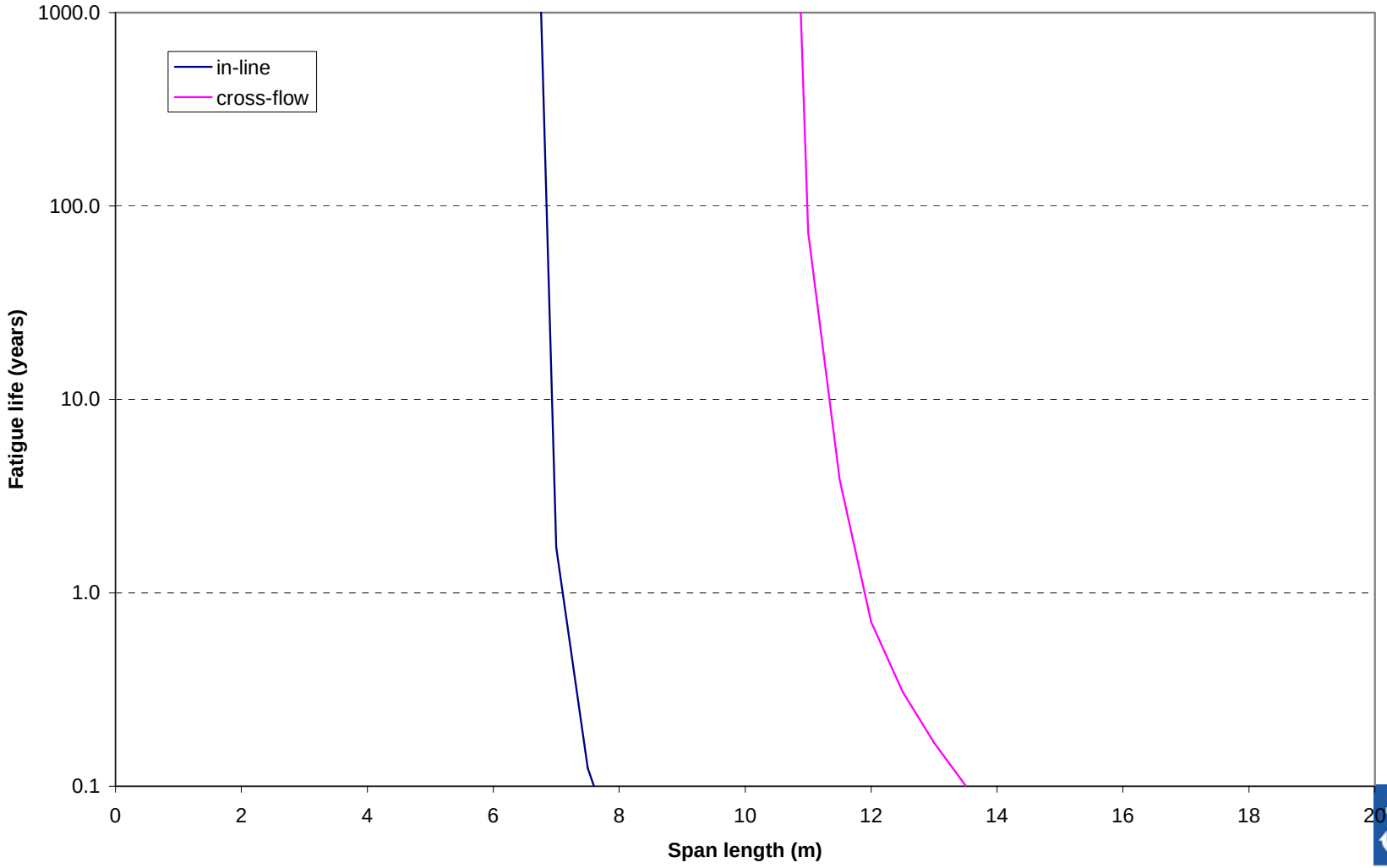
STRUCTURAL MODELLING

Static Stress [MPa]		Transfer values		Areas [m^2]		Functional Loads		Pipe Dimensions [m]		Constants		Densities [kg/m^3]	
ζ_h	8.8	EI_{steel}	1.04E+07	ζ_i	0.02806	H_{eff} [N]	0.00E+00	D_s	0.2190	α	0.30	ρ_{steel}	7850
ζ_N	1.3	m_e	216	ζ_{steel}	0.00961	p [bar]	15	t_{steel}	0.0150	α_T [$^oC^{-1}$]	1.17E-05	$\rho_{concrete}$	2250
$\zeta_{M,cr}$	14.6	q	868	$\zeta_{coating}$	0.00424	ζT [^oC]	0	$t_{concrete}$	0.0250	E [N/m^2]	2.07E+11	$\rho_{coating}$	1600
$\zeta_{M,in}$ (100y)	4.0	S_{eff}	-1.68E+04	$\zeta_{concrete}$	0.02011	**Coating data**		$t_{coating}$	0.0060	C_D(current)	1.00	ρ_{cont}	880
		C_a	1.00	A_e	0.06202	k_c	0.00					ρ_{water}	1027
		CSF	0.00			f_{cn} (MPa)	45						

Example – 20deg current flow



Example – 90deg current flow



Osprey pipelines

- Surface current 13 ft/s, bottom 7 ft/s
- 3 x 8” lines, no concrete coating
- Wet oil, gas & water injection lines
- Design code for VIV – DNV (RP-F105 or CN30.5, DNV81?)

Remarks

- VIV dominated by strong current
- Pipeline heading important
- Frequency important – stiffness and mass
- Most pipelines 8”, some 10”
- Acceptable span length depends more on pipeline heading than other parameters


DNV