ROBERT ALLAN LTD.
NAVAL ARCHITECTS AND MARINE ENGINEERS
230-1639 WEST 2ND AVENUE, VANCOUVER, B.C.
CANADA V6J 1H3

April 26, 2016
Ref. 215-067

Prince William Sound Regional Citizens' Advisory Council
P.O. Box 3089
Valdez, AK 99686
USA
ATTN: Mr. Alan J. Sorum
Maritime Operations Project Manager

RE: TUG BOLLARD PULL REQUIREMENTS FOR RESCUE TOWING IN PRINCE WILLIAM SOUND

Alan:

Following our prior discussions on the topic, we have reviewed the required bollard pull requirements for assisting disabled tankers in Prince William Sound in closure conditions of 45 knots wind, and 15 ft (4.6m) significant waves, as measured by the Seal Rocks buoy.

Our original 2014 report (ref. project #212-090), ***A Review of B.A.T for a Sentinel Tug Stationed at Hinchinbrook Entrance***, Rev. 1, recommended the following bollard pull requirements for the Sentinel Tugs:

Table 1: Bollard Pull Requirements in Metric Tonnes (2014 Report, *Towing from the Bow*)

Tug Type	**125,000 t DWT**		**193,000 t DWT**	
	Ballast	*Loaded*	*Ballast*	*Loaded*
Twin Screw or ASD	101 t	-	119 t	-
Tractor	95 t	-	112 t	-

Since the required bollard pull was significantly higher in the ballast condition than in the loaded condition (due to increased windage), the ballast condition was identified as the governing condition. Consequently, results were not provided for the loaded condition.

As part of our current 2016 study, we have re-visited these bollard pull requirements, using additional information gained from the new met-ocean analysis, as well as a careful review of the governing assumptions of the analysis. A summary of results from this new analysis are tabulated in Table 2 below.

TELEPHONE 604-736-9466 WEBSITE www.ral.ca EMAIL info@ral.ca

Table 2: Bollard Pull Requirements in Metric Tonnes (2016 Update, *Towing from the Bow*)

Tug Type	**125,000 t DWT**		**193,000 t DWT**	
	Ballast	*Loaded*	*Ballast*	*Loaded*
Twin Screw or ASD	144 t	121 t	185 t	155 t
Tractor	137 t	115 t	176 t	147 t

There are two principal reasons for the increase in bollard pull requirements, each of which is described below:

- Increased Wave Forces
- Transverse Components of Met-Ocean Forces

INCREASED WAVE FORCES

The drift studies completed as part of our 2016 study (ref. project #215-067) required a detailed analysis of met-ocean data during closure conditions, defined by PWSRCAC as 45 knot winds and 15 ft (4.6m) significant seas as measured by the buoy at Seal Rocks (Hinchinbrook Entrance).

It has been previously acknowledged that due to effects including wave sheltering of the buoy at Seal Rocks, a 45 knot wind as measured by the buoy is in fact equivalent to approximately 57 knots in reality. Our sub-consultant for the met-ocean analysis and drift studies (Tetra Tech) has corroborated that this is indeed likely the case due to the combined effects of:

- Wave Sheltering
- Topographic Sheltering
- Anemometer Height

The 57 knot wind speed has therefore been used throughout our revised analysis of required bollard pull for rescue towing.

Another interesting result of the present met-ocean analysis was the discovery that wave heights are significantly "under-reported" by the Seal Rocks buoy as well. Historical met-ocean data records analyzed by Tetra Tech show that during closure conditions, the buoy at Seal Rocks reports wave heights 25-30% lower than the buoys further offshore at Cape Cleare and Cape Suckling (see Figure 1 below). Since a potential rescue tow operation would take place in these areas further offshore, the significant wave height used for calculating the environmental forces on the tankers due to waves should in fact be those reported by the offshore buoys, rather than Seal Rocks (Hinchinbrook Entrance). For this reason, the revised 2016 analysis assumes a significant wave height of 6.0 m (approx. 20 ft) for the calculations.

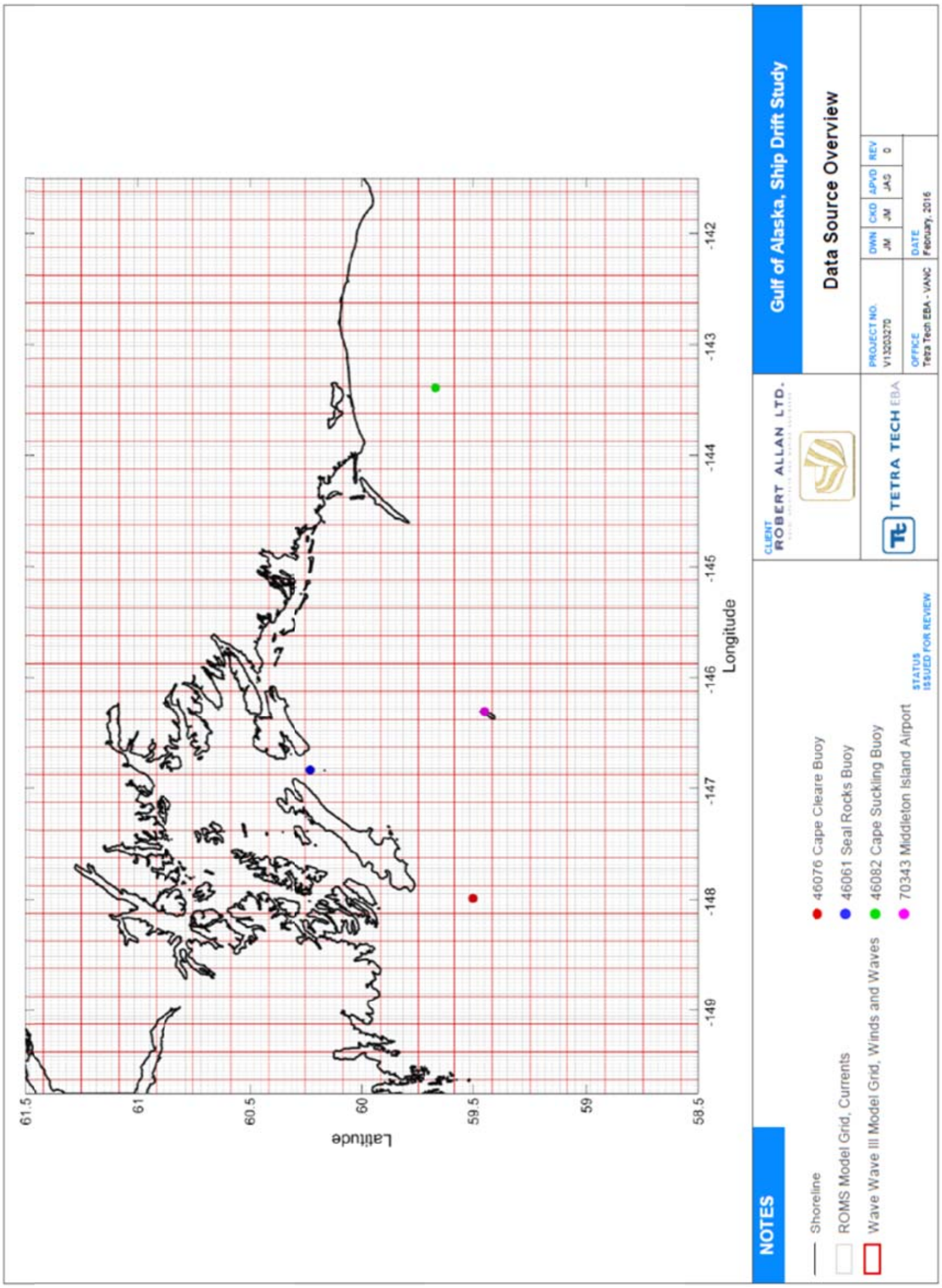

Figure 1: Buoy Locations

TRANSVERSE COMPONENTS OF MET-OCEAN FORCES

The 2014 report accounted for the lateral components of the met-ocean forces by adding 20-25% to the calculated dead ahead forces. This general adjustment factor was based on our experience from similar reference studies. Since that time, Robert Allan Ltd. has made significant advancements in its ability to predict met-ocean forces on tankers, based on *any* angle of attack relative to the tanker bow.

A tanker, particularly when towed backwards, has little or no directional stability and the presence of the deckhouse to windward will induce yaw (see Figure 2). Since lateral forces increase very rapidly with increasing yaw angle, the key question becomes what angle of yaw should be considered as the design case? This choice of angle is subjective, and admittedly difficult to make. Based on recent exchanges on the topic between Robert Allan Ltd. and Captain Mark Hoddinott, General Manager of the International Salvage Union, a yaw angle of 20° has been nominated as a reasonable angle for typical slow speed towing of a tanker by the stern. When towing from the bow, the tanker is more directionally stable, and the yaw angles are typically lower. Robert Allan Ltd. therefore uses a yaw angle assumption of 15° for such situations.

Using these new assumptions of yaw angle does however have the effect of increasing the lateral components of the met-ocean forces (and hence resultant required bollard pull) in the present analysis, when compared to the 2014 report.

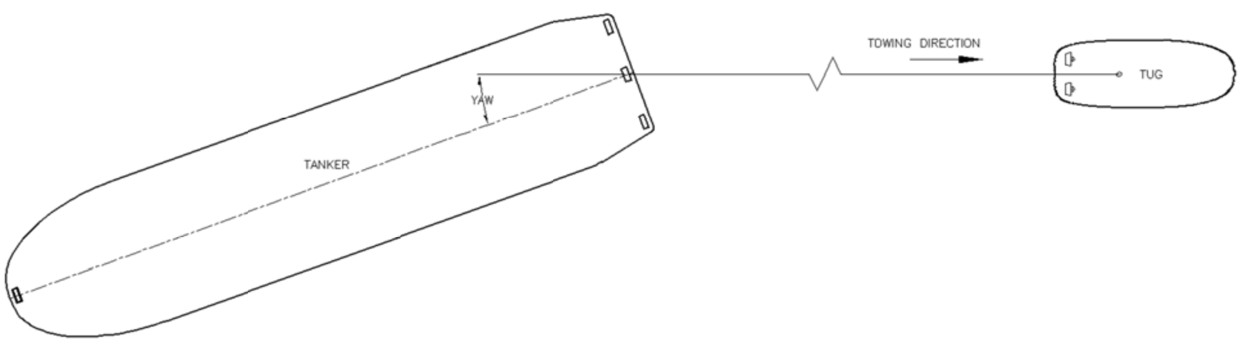

Figure 2: Definition of Tanker Yaw during a Tow

TOWING FROM THE STERN

The 2014 analysis considered the required bollard pull to tow a tanker to safety at slow speed in the defined closure conditions. Due to directional stability considerations as described above, this type of tow is preferentially performed over the tanker's bow. Despite this, in most locales, it may initially be necessary to make fast to the tanker's stern due to differences in the emergency towing gear fitted on a tanker forward and aft. Table 3 below summarizes the required equipment for a typical tanker, per SOLAS:

Table 3: Required Emergency Towing Arrangements for Tankers > 20,000 DWT

(reproduced from OCIMF Mooring Equipment Guidelines, 3rd Edition, 2008)

Component	Forward	Aft
Towing Pennant	Optional	Required
Pick-up Gear	Optional	Required
Chafing Gear	Required	Dependent on design
Fairlead	Required	Required
Strong Point	Required	Required
Roller Pedestal Lead	Required	Dependent on design

Since the priority with a disabled tanker is to gain control of the vessel and arrest its drift, for practical operational considerations, it must typically be assumed that tug forces would initially be applied to the stern of a disabled tanker, as that is where the more rapidly deployable emergency towing gear is typically located. Our memo of March 22nd therefore calculated the tug forces, assuming towing from the stern. Table 4 summarizes the calculated values of required tug bollard pull, including an allowance for a tug's propulsive efficiency loss in heavy seas, which the results quoted in the memo of March 22nd *did not* include.

Table 4: Bollard Pull Requirements in <u>Metric</u> Tonnes (2016 Update, *Towing from the Stern*)

Tug Type	**125,000 t DWT**		**193,000 t DWT**	
	Ballast	*Loaded*	*Ballast*	*Loaded*
Twin Screw or ASD	190 t	157 t	244 t	201 t
Tractor	181 t	149 t	232 t	190 t

Subsequent discussions with PWSRCAC revealed that tankers serving the Valdez Marine Terminal are required to carry emergency towing gear in excess of the requirements prescribed by SOLAS and as quoted in Table 3 above. The key difference for tankers serving Valdez is that they must carry the same emergency towing equipment at the bow as required by SOLAS for the stern. This additional equipment is referred to as the Prince William Sound Emergency Towing Package.

Given the presence of this additional equipment, we *<u>do not</u>* view the operation of towing from the stern (and the resulting required bollard pulls quoted in the table above) to be a logical design case. Instead, we suggest that the design case assume towing from the tanker bow (ref. Table 2)

SUMMARY

The 2016 study identifies higher bollard pull requirements for rescue towing of disabled tankers in Prince William Sound than those given in the report on the topic in 2014. As discussed above, this is due to a combination of the following two factors, both of which have the impact of increasing the required tug bollard pull.

- Increased Wave Forces
- Transverse Components of Met-Ocean Forces

The following recommended tug static bollard pull requirements are therefore reproduced from Table 2:

Tug Type	**125,000 t DWT**		**193,000 t DWT**	
	Ballast	*Loaded*	*Ballast*	*Loaded*
Twin Screw or ASD	144 t	121 t	185 t	155 t
Tractor	137 t	115 t	176 t	147 t

These new bollard pull values are noteworthy in that they are almost all in excess of the capabilities of any single tug in the current SERVS fleet. The 2016 report, ***Sentinel Tug Requirements for Gulf of Alaska: Ship Drift Study***, states that the Sentinel Tug standby distance of 17 nautical miles is possibly already marginal, notwithstanding the met-ocean forces exceeding the bollard pull of even the PRT class of tugs. Due to this deficiency of available bollard pull from a single tug, it is reasonable to assume that even a PRT class tug would not be able to completely arrest a disabled tanker's drift at the peak of a closure condition storm, and therefore further "sea room" is required. It is therefore recommended that the standby distance be increased to at least 30 miles.

This measure will give a Sentinel Tug some sea room to surrender during a potential rescue of a disabled tanker in a storm approaching the closure conditions. Since the duration of storms of this magnitude have been identified by Tetra Tech as being typically in the order of 6 hours, the additional room should be adequate allowance for the slow drift that will remain after the rescue tow has been initiated, until either the storm begins to abate or a second tug arrives to provide further assistance.

This new recommended standby distance of 30 nautical miles assumes that a tug with a bollard pull equivalent to that of the current PRT class of tugs (123 t) is stationed at Hinchinbrook Entrance as the Sentinel Tug. Should a tug with a different rated bollard pull be stationed as the Sentinel Tug, then this standby distance may need to be adjusted.

Yours truly,

ROBERT ALLAN LTD.

Michael Phillips

Mike Phillips, P.Eng.
Project Manager / Naval Architect

MP

cc: Robert G. Allan
Executive Chairman of the Board
Robert Allan Ltd.