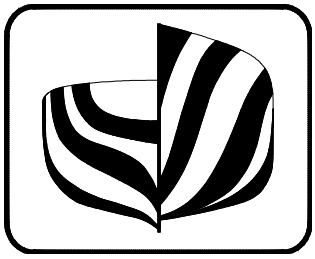
A Summary of Current B.A.T. Requirements for Escort and Rescue Towing Tugs

Project 216-036 Revision 1 October 7, 2016

Prepared for:

Prince William Sound Citizens' Advisory Council
Valdez, AK



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Project 216-036
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Rev. 1

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EXECUTIVE SUMMARY

In light of the imminent change in service provider for towing and escort tug services in Prince William Sound and environs, the PWSRCAC have requested a summary review of the findings of previous studies conducted by this firm with respect to the escort towing services and the "Sentinel" tug services at Hinchinbrook Entrance. The objective is that all the key findings of these studies should be collated into a single reference document in order that the performance requirements for each class of tug are clearly and readily identifiable.

These findings are summarized within the body of this report, and tabulated in the Summary section. For additional context, please refer to the following Robert Allan Ltd. reports:

- ***Escort Winch, Towline, and Tether System Analysis [1]***
- ***A Review of Best Available Technology in Tanker Escort Tugs [2]***
- ***A Review of B.A.T. for a Sentinel Tug Stationed at Hinchinbrook Entrance [3]***
- ***Sentinel Tug Requirements for Golf of Alaska: Ship Drift Study [4]***
- ***Memo RE: Tug BP Requirements for Rescue Towing in Prince William Sound [4A]***

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For: Prince William Sound Citizens' Advisory Council
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1.0 INTRODUCTION

Robert Allan Ltd. has previously conducted the following studies for the Prince William Sound Regional Citizens' Advisory Committee (PWSRCAC) with respect to the subjects of escort and rescue towing in the region of Prince William Sound:

- ***Escort Winch, Towline, and Tether System Analysis [1]***
- ***A Review of Best Available Technology in Tanker Escort Tugs [2]***
- ***A Review of B.A.T. for a Sentinel Tug Stationed at Hinchinbrook Entrance [3]***
- ***Sentinel Tug Requirements for Gulf of Alaska: Ship Drift Study [4]***
- ***Memo RE: Tug BP Requirements for Rescue Towing in Prince William Sound [4A]***

In light of the imminent change in service provider for towing and escort tug services in Prince William Sound, the PWSRCAC have requested a summary review of the findings of each of the above studies conducted by this firm with respect to the escort towing services and the "Sentinel" tug services at Hinchinbrook Entrance. The objective is that all the key findings of these studies should be collated into a single reference document in order that the performance requirements for each class of tug are clearly and readily identifiable.

The salient findings of each of the above reports are therefore compiled into this single document. The different requirements for both the Escort tugs and the Sentinel tug(s) are segregated into two distinct parts in this report in order to avoid possible confusion. The summary with respect to operating procedures is applicable to both tug types. The summary of Best Available Technology (BAT) in both tug types is also treated separately in order to be consistent with the original study [2].

This report also updates some aspects of the original referenced reports where regulatory changes have occurred since the original issue of the report, particularly with respect to EPA requirements. Some line items have also been added to cover aspects not covered in detail by previous reports, such as fire-fighting and pollution response for the Escort tugs.

2.0 ESCORT TUGS

2.1 Operational Requirements

The operational requirements for tanker escort in Prince William Sound (PWS) and environs are defined in the Code of Federal Regulations (CFR) Part 33, Sec. 168.50 "Performance and Operational Requirements", as cited below:

(a) Except as provided in paragraph (c) of § 168.10, at all times during the escort transit each tanker to which this part applies:

(1) Must be accompanied by escort vessels that meet the performance requirements of paragraph (b) of this section (but not less than the number of escorts required by § 168.40).
(2) Must have the escort vessels positioned relative to the tanker such that timely response to a propulsion or steering failure can be effected.
(3) Must not exceed a speed beyond which the escort vessels can reasonably be expected to safely bring the tanker under control within the navigational limits of the waterway, taking into consideration ambient sea and weather conditions, surrounding vessel traffic, hazards, and other factors that may reduce the available sea room.

(b) The escort vessels, acting singly or jointly in any combination as needed, and considering their applied force vectors on the tanker's hull, must be capable of—

(1) Towing the tanker at 4 knots in calm conditions, and holding it in steady position against a 45-knot headwind;
(2) [Reserved]
(3) Holding the tanker on a steady course against a 35-degree locked rudder at a speed of 6 knots; and
(4) Turning the tanker 90 degrees, assuming a free-swinging rudder and a speed of 6 knots, within the same distance (advance and transfer) that it could turn itself with a hard-over rudder.

These requirements apply to the following waters, as defined in 33 CFR Sec. 168.40

(a) Prince William Sound: *Each tanker to which this part applies must be escorted by at least two escort vessels in those navigable waters of the United States within Prince William Sound, Alaska, and the adjoining tributaries, bays, harbors, and ports, including the navigable waters of the United States within a line drawn from Cape Hinchinbrook Light, to Seal Rocks Light, to a point on Montague Island at 60°14.6' North, 146°59' West, and the waters of Montague Strait east of a line between Cape Puget and Cape Cleare.*

The requirements above, specifically those of 33CFR 168.50 (b) Items (1), (3) and (4), are however not explicit in terms of tugboat performance. To date it has not been possible to identify any document which translates these system performance objectives into specific measurable tug performance requirements such as Bollard Pull and escort steering and braking forces. What has been done are a series of full-scale tests [6] and computer simulations [7] which identify what the ETT class tugs and others are capable of doing in various conditions with specific tankers within the fleet. Those results then appear to be translated into the operational standards defined in the Vessel Escort & Response Plan (VERP) [5].

Accordingly, without extensive additional analysis, which is outside the terms of reference for this study, not every performance requirement for the subject vessels can be explicitly defined. Therefore the present bollard pull, indirect steering and braking forces, and free running speed performance of the ETT Class tugs is taken as an acceptable minimum standard of performance for a tanker escort tug, and the elements of this are indicated as such in the following section by insertion in parentheses {__}.

2.2 Performance Requirements

The following summarizes the essential performance requirements for the PWS escort tugs:

- Speed - {14 knots}at 90% MCR
- Bollard Pull - {86.2 tonnes (190,000 lbs)}
- Escort Performance - {141 tonnes} Steering Force (Fs) at 10 knots
  - 70 tonnes Steering Force (Fs) at 6 knots
- Seakeeping - vessel to be fully operational in up to defined closure conditions
- Manoeuvrability - tug should be able to turn 360 degrees within no more than 1.5 times own length
- Range & Endurance - assuming operations are limited to within PWS, fuel capacity should support escort operations for not less than 4 weeks, assuming 2 round-trip escorts per week. That translates to about 120 hours of operation at an average power demand of approximately 75% MCR, so minimum usable fuel capacity = app. 150 tonnes

- Stability:
  - Intact - compliant with 46 CFR 174.145 and ABS 5.8.A1
  - Towing - compliant with 46 CFR 173.095 and ABS 5.11.A1
  - Damaged - no specific regulatory requirement, but a one compartment standard of subdivision is strongly recommended to ensure survivability of the vessel in the event of engine room flooding (*this was added to be consistent with current (2016) best practice*)
  - Escort - Presently the requirements of ABS for escort towing are in state of flux. The newly introduced requirements of Bureau Veritas (BV), as part of a move to harmonize regulations for tugboats among major IACS members, are strongly recommended

- Safety:
  - Safety Management Systems - per IMO International Safety Management (ISM) Code or equal
  - Lifesaving - per 46 CFR 199

2.3 Major Equipment Specifications

In order to satisfy the performance requirements defined in Sec. 2.2 above, the critical machinery components must have the following performance / technical specifications:

- Propulsion engines must:
  - Have sufficient power to develop not less than 86.2* tonnes BP with drive system defined below {* to match current ETT performance}
  - Be compliant with EPA Tier IV regulations (for any new construction)

- Propulsion system / drives must:
  - Be able to deliver 86.2 tonnes thrust in a bollard pull condition (zero speed)
  - Be omnidirectional (able to direct thrust through 360 degrees)

- Winches:
  - Compliant with Class requirements for an Escort Towing Notation, namely:
    - Hold rated line force under power, not on the winch brake
    - Able to render (i.e. pay out at controlled speed) under full-rated load

- Able to recover line under full-rated load at a specified line speed
- Have a level-wind system that prevents the towline from burying into lower layers under tension, and
- Ideally be electrically driven to reduce risk of pollution and improve performance

The following was the recommended specification for a winch for a PWS escort tug in order to be considered BAT:

- *Configuration - all mounted above deck*
- *Drive - variable frequency electric*
- *Drum capacity- 1,000' of 3-7/8" diameter HMWPE towline*
- *Split drum configuration is recommended so that a spare line can be stowed for immediate deployment in event of a line failure*
- *Heavy duty level-wind, designed to "cross-lay" the towline*
- *Brake capacity (slip brake) = 3 x BP (app. 630,000 pounds) at bare drum*
- *Approximate performance:*
  - *line pull at barrel layer = 4 x BP at 0–12 ft./min. (stall rating)*
  - *= 3 x BP at 0 –12 ft./min. (continuous)*
  - *= 0.35 x BP at app.100 ft/min line pull at top layer (continuous)*
  - *= 10 tonnes at 0–app. 250 ft/min*
  - *= 1 tonne at 0–app. 750 fpm*
- *Render-recover capability at full rated line speed and line tension*
- *Instrumentation and controls:*
  - *remote (from wheelhouse) and local controls*
  - *mode selection: automatic render-recover; auto render only, manual*
  - *line tension display for all modes*
  - *line length paid out monitor*
  - *tension adjustment capacity*
  - *emergency abort*

- Towlines: as the critical link between tug and tow, the towlines must be
  - Of an appropriately rated line strength for escort service; with a minimum breaking load (MBL) not less than 4 x BP of the tug, and ideally about 5 x BP in order to ensure adequate line strength at the end of the towline duty cycle
  - Of HMWPE fibre

- Jacketed in areas of contact with fairleads and chafing points
- Inspected and tested routinely to determine residual strength, and replaced when residual strength fails to satisfy stated strength criteria

- Towing and related fittings: fittings in contact with HMWPE ropes under tension should have:
  - a diameter not less than 8x rope diameter
  - a polished stainless steel (or equivalent) surface finish of 300 micro-inches or better
  - Sufficient strength in all attitudes so as not to deform under any expected load, including dynamic effects
  - Means of lubrication with water to avoid over-heating of rope fibres (*This note was added to be consistent with current (2016) best practice*)

2.4 Ancillary Equipment and Services

- Spill response/recovery:
  - As likely first responders to any incident involving an oil spill, the Escort tugs should be equipped with no less than the equipment on the current ETT class, including:
    - 3,300 feet of offshore-rated oil containment boom, all on a hydraulic powered reel
    - 2 deployable oil skimmers
    - 70,000 gallons of recovered oil storage capacity
    - Dispersant spray arm systems

- Fire Fighting:
  - Equipped to ABS Fi-Fi 1 Notation requirements (2,400 m^3/hr water streams, range 120 metres, height 45 metres, self-protecting water spray system, 24 hour fuel capacity)

3.0 SENTINEL TUGS

3.1 Operational Requirements

The requirements for the Sentinel Tug are defined in the VERP as follows:

"Hinchinbrook Tug – A vessel (PWS, PRT, or Theriot Class) capable of ocean escort and rescue service. The vessel is stationed in the vicinity of Hinchinbrook Entrance to provide assistance as a Sentinel escort for tankers in ballast transiting Hinchinbrook Entrance, and laden tankers transit-

ing into or out of the Gulf of Alaska to 17[1] miles of Cape Hinchinbrook. This vessel may also be utilized as a close escort for laden tankers transiting through Hinchinbrook Entrance."

To this was added a Mission Statement prepared by PWSRCAC, as follows:

"…[To perform] tanker/ship rescue towing operations in open ocean conditions [up to] 200 miles into the Gulf of Alaska from Hinchinbrook Entrance.

…PWSRCAC further believes a dedicated deep-sea style vessel whose primary mission is standby rescue, salvage and towing is preferable as the Hinchinbrook Entrance vessel. PWSRCAC assumes this type of vessel would have to provide rescue towing assistance and preliminary salvage while acting alone in cold weather conditions. As such, this vessel would need to possess extremely high bollard pull and horsepower, a deep draft and high freeboard, excellent seakeeping characteristics, an elevated working deck aft, tow winch(es) with suitable cable and gear for ocean towing, and excellent manoeuvrability including bow thrusters and multiple propulsion systems. This vessel would be capable of attaching a line and turning a fully loaded, disabled 125,000[2] deadweight ton tanker into the wind and sea during extreme sea conditions and either tow or hold the vessel in position until conditions improved for towing."

Regulations, both National and State, are silent on the requirements for such a vessel.

3.2 Performance Requirements

The performance requirements for the Sentinel tug were calculated or estimated using published references, and are summarized as follows:

- In order to hold a tanker against the combined met-ocean forces of the defined closure condition, the Sentinel Tug would need to have the ability to develop a total calm water BP of 185 tonnes for a 193,000 t DWT tanker, or 144 tonnes BP for a 125,000 tonne DWT tanker. If the tug is of a proper tractor configuration (with drives forward) the BP requirements would reduce to 174 and 135 tonnes respectively. The defined closure condition is taken as the design case for the ideal Sentinel Tug

- HOWEVER; it must be recognized that a single tug with this much power becomes a very large and in some cases a rather unwieldy machine. It should therefore be considered that rescue tows in such extreme conditions would be performed by two tugs each of at least 100 tonnes BP. This approach then allows a single tug of still high capability to respond to

[1] It recommended that this distance be increased to 30 nautical miles, as per ship drift studies completed in 2016 [4].
[2] It is recommended that the mission statement be updated to include the tanker class comprised of **Alaskan Frontier, Alaskan Explorer, Alaskan Navigator,** and **Alaskan Legend**

something in the order of 95% of conditions and only in more extreme situations would the combined performance of two tugs be required

In order to satisfy current BAT, the Sentinel Class tug should be designed and equipped to perform as follows:

- Per the Mission Statement, NOT perform any indirect escort towing
- Have a free running speed in calm water at full load displacement, of about 16 knots
- Have an operating range not less than 2,000 n. miles at full power, and endurance at full power, at an assumed towing speed of 6 knots, of not less than 15 days
- For crew safety and comfort, have motions-related accelerations not exceeding 0.07G (lateral) and 0.15G (vertical) in the 90th percentile of wind and sea conditions encountered in the Gulf of Alaska (Sea State 6 or lower)
- Fully satisfy the requirements of the US Coast Guard Towing Stability Criteria (46 CFR 173.095). There should be sufficient margin specified in meeting these criteria that the tug will continue to do so throughout its operating life. Although there is no specific regulatory requirement, a one compartment standard of subdivision is strongly recommended to ensure survivability of the vessel in the event of engine room flooding
- Have omni-directional propulsion and be able to execute a zero speed, 360 degree turn within no more than 150% of its own length, and within no more than 60 seconds
- Have a combination of main propulsion and lateral thrusters which can hold it at a 45° attitude to a 57 knot wind and the effects of 20 foot significant seas
- Have any type of propulsion system which, in combination with lateral thrusters would satisfy the requirements for manoeuvrability and position-keeping described above. B.A.T. would constitute those omni-directional drive systems which incorporate some form of "tractor" configuration (namely VSP, Z-Tractor, or Rotor Tug) which are recommended due to better manoeuvrability, safer towing characteristics and less loss of effectiveness in heavy seas

In addition, the following are recommended:

- Have main towing gear with components rated with a Design Load of at least 3 x Bollard Pull

- That the offshore tanker transit distance during which the Sentinel Tug should standby be increased from 17 to 30 nautical miles, per the findings of the Ship Drift Study [4]

- The use of a towing winch with an automatic rendering capability at a prescribed tension is worth serious consideration for this application

The Sentinel Tug should also be fully equipped with a significant fire-fighting capability (Fi-Fi 2 Rating for B.A.T.) and for an active pollution response role (Ref. Sec 3.5)

3.3 Vessel Particulars

A single tug which can satisfy all the defined operational criteria above will have approximately the following principal particulars:

• Bollard Pull	=	185 tonnes for 193,000 tonnes DWT, or 144 tonnes for 125,000 tonnes DWT
• Power	=	16,000 bhp (for 185 t BP) or 12,000 bhp (for 144 t BP)
• Length overall	=	50–52 metres
• Beam	=	16-17 metres
• Draft	=	> 6.5 metres
• Deadweight	=	app. 700-800 tonnes min.

Or alternatively, one of a PAIR of tugs which together can satisfy all the defined operational criteria above will have approximately the following principal particulars:

• Bollard Pull	=	app. 100 tonnes for 193,000 tonnes DWT, or app. 75 tonnes for 125,000 tonnes DWT
• Power (assuming screw propellers)	=	9,370 bhp (for 100 t BP) or 6,000 bhp (for 75 t BP)
• Length overall	=	50–52 metres
• Beam	=	13-15 metres
• Draft	=	> 6.5 metres
• Deadweight	=	app. 500-600 tonnes min.

For purely practical reasons it makes much more sense to have two tugs of 100 tonnes BP. Each

tug is smaller and more manageable in all the other duties required of it, and would be considerably less expensive than a single much larger vessel. This provides a level of redundancy within the system, and any single tug can manage events well above the 90th percentile of conditions. Only in the more extreme events would two tugs have to respond to an incident.

3.4 Major Equipment Specifications

In order to satisfy the performance requirements defined in Sec. 3.2 above, AND, assuming that the use of two Sentinel Class tugs is the most practical solution, the critical machinery components should have the following performance / technical specifications:

- Propulsion engines must:
  - Have sufficient power to develop not less than 100 tonnes BP with drive system defined below
  - Be compliant with EPA Tier IV (for any new construction)

- Propulsion System / Drives must:
  - Be able to deliver 100 tonnes thrust in a bollard pull condition (zero speed)
  - Be omnidirectional (able to direct thrust through 360 degrees), OR
  - Be a conventional twin-screw arrangement, supplemented with lateral thrusters sufficient to give the degree of steering and position-keeping control required for the mission

- Towing Equipment:

  Using the USN Towing Manual as perhaps the most comprehensive publication on the subject, the following can be considered as a basic list of requirements for emergency/rescue towing:
  - Towing winch
  - Towing bitt
  - Stern towline roller and tow pins
  - Main towline/hawser:
  - Steel wire rope (SWR)
  - Synthetic spring line element
  - Lead chain or wire pendant
  - Chain bridle/chafing gear
  - Connecting hardware
  - Spare components:
  - Secondary SWR towline

The rated strength of the various elements of the towing system should be as follows:

Component	***Rated Breaking Strain of Component*** *(multiple of rated bollard pull)*
Design Load	3.00
Winch Brake	3.00
Towline	3.15
Towing Bitt	3.00
Stern Tow Pins	3.00
Norman Pins	2.00
Surge Gear / Spring	3.25
Lead Wire Pendant	3.25
Chafing Gear	3.25
Connecting Hardware	3.25

3.5 Ancillary Equipment and Services

- Spill response/recovery
  - As likely first responders to any incident involving an oil spill, these tugs should be equipped with:
    - 3,300 feet of offshore-rated oil containment boom, all on a hydraulic powered reel
    - 2 deployable oil skimmers
    - 70,000 gallons of recovered oil storage capacity
    - Dispersant spray arm systems

- Rescue/Salvage
    - equipped per Class requirements for “Salvage” Notation

- Fire Fighting
    - equipped to ABS Fi-Fi 2 Notation requirements (7,200 m^3/hr water streams, range 150 metres, height 70 metres, 30 minutes foam production, 96 hour fuel capacity)

4.0 OPERATIONS

4.1 Standard Operating Procedures

Standard procedures for escorting of tankers within Prince William Sound are defined in the VERP [5]. Offering comment on these procedures was outside the terms of reference of any of the studies performed, however the following were reviewed:

(a) Towing Connection Operating Procedures - procedures were reported to be satisfactory for all operations,
(b) Towline Maintenance Procedures - The towline maintenance procedures described by the operators follows best industry practice.

4.2 Limitations / Met-Ocean limits

Very few places in the world have such structured escort services as the system that exists in Prince William Sound, especially with regard to the dedicated tanker fleet. The latter ensures that all vessels are part of a single system and as such it is much easier to coordinate equipment requirements and operating procedures throughout the fleet. However it is fair to say that Valdez/Prince William Sound is certainly one of the longest escort operations in terms of distance, and presents probably the most demanding environmental challenges of all of these, save the fact that the European terminals are generally much busier.
In view of the generally severe climate in which these operations take place, it is important that the prescribed closure conditions are understood and respected. The following are the prescribed closure conditions as defined in the VERP [5]:

"…45 knots combined with 15 foot (4.6 metre) waves, *as measured by the Seal Rocks buoy*"

When met-ocean conditions meet the closure condition criteria, tanker traffic is no longer permitted to enter or leave Prince William Sound.

It is important to note however that the real-time wave buoy data referenced above is likely to under-report the actual sustained wind speeds. An analysis by Tetra Tech EBA Inc. as part of the drift studies [4] confirmed that this phenomenon is indeed very likely due to the wave sheltering effects and due to the height of the anemometer on the buoy. Taken together, these factors probably result in a multiplication factor of 1.23 to 1.28 to the wind speeds reported by the Seal Rocks buoy to get the correct wind speed at a standard elevation of 10 metres. This means that a 45 knot wind as reported by the buoy is more likely in the range of 55 to 58 knots at a 10 metre

elevation. Ship anemometers may (and would be expected to) report even higher wind speeds due to their greater height above the surface, but for analysis, the 10 metre wind speed value is the pertinent one. Therefore in the final analysis it is justifiable to evaluate the closure condition as a **57 knot** wind speed which is well above the 99th percentile condition.

Similarly the Seal Rocks buoy location is sheltered from open ocean sea conditions, so more severe wave conditions occur in the open gulf. Analysis of data in the area revealed that wave height reported during a typical closure condition at Hinchinbrook Entrance is significantly lower (25-30%) than that reported by buoys slightly further offshore. For this reason, a significant wave height of 6.0 m (approx. 20 ft.) was assumed in the analysis of Sentinel tug capabilities.

4.3 Reliability

The escort system must be designed to ensure reliable performance in the full range of environmental operating conditions during which escorts take place.

The active haul-in / pay-out capability of the Escort tugs' winches must therefore be fully controllable according to prevailing conditions and the rated loads of the fittings in use, and be fully reliable. An effective active haul-in / pay-out winch capability has the impact of significantly raising the overall capability of these tugs for service in more severe conditions, and increasing the reliability of the towing system in poor weather and sea conditions.
Similarly, the use of a towing winch with an automatic rendering capability at a prescribed tension is worth serious consideration for the Sentinel tugs as well.

5.0 BAT ASSESSMENT OF THE CURRENT SERVS FLEET

Although the primary focus of this report is to summarize the requirements for the Escort and Sentinel tugs in anticipation of the upcoming change in the towing services provider, a summary assessment of the current SERVS fleet provides some additional context.

- The ETT tugs are very typical of a standard large Voith Water Tractor. The ETT tugs are large, powerful, and perform well. However design developments in the past decade have led to a new generation of VSP-propelled tugs with superior performance in all respects. These new tugs are more efficient, faster, and develop more steering force per unit size and per unit of power than do the ETT Class. That said, the spread in performance between the ETT and BAT today is not great (less than 8%). The lack of a fully capable render-recover winch on the ETT tugs is a major shortcoming.

- The PRT tugs are large and powerful Azimuthing Stern Drive (ASD) tugs, and are well-equipped for ocean towing. They are not however well-configured to function as a proper escort tug performing indirect or powered indirect towing, taking maximum advantage of the size and power of these tugs. They have no skegs or comparable appendages with which to efficiently generate indirect steering or braking forces. The indirect force generating capability of the PRT Class is about half that of the best ASD escort tugs operating today. The PRT tugs lack a render-recover escort winch forward, and the towing staple position is too far forward.

- The ETT tugs as presently configured lack the power, speed and towing gear to perform the Sentinel Tug role effectively.

- The PRT class tugs are sufficiently large for the Sentinel Tug role when evaluated against USCG criteria. Individually they do not have adequate power to hold a 193,000 t DWT tanker in the defined closure conditions however as a pair they would satisfy that requirement. They are powerful enough to individually deal with a 125,000 t DWT tanker in the defined closure conditions. The main towlines of the PRT Class tugs are not quite as strong as recommended.

There are some significant gaps between the SERVS vessels and what is considered BAT in escort tugs today. The major deficiencies are:

a. Neither class of tug has a formal "Escort" notation issued by a Classification Society (Class).

b. The ETT tugs do not have a render-recover winch which satisfies Class standards for an escort notation.

c. The PRT tugs do not have a render-recover winch which satisfies Class standards for an escort notation.

d. The PRT hull form is not configured to generate indirect line forces, and lacks appendages such as a skeg or bilge keels which would enhance this capability, and in fact the skeg it has detracts from this capability

e. The PRT Class tugs are limited in their ability to generate indirect forces sufficient to represent the equivalent tanker rudder force for the larger tankers in the system. They do however by virtue of their size and power have sufficient capability to control tankers of 125,000 tonnes DWT or less.

6.0 SUMMARY

The following tables provide a quick-reference summary of the key requirements for the Prince William Sound Escort and Sentinel tugs:

B.A.T. for ESCORT TUGS

Criteria	*units*	BAT Requirement
Bollard Pull	*tonnes*	≥ 86.2
Indirect Escort Steering Force (F_S)	*tonnes*	≥ 141 @ 10 knots ≥ 70 @ 6 knots
Speed	*knots*	≥ 14 @ 90% MCR
Manoeuvrability		
Turn Radius	*ship-lengths*	≤ 1.5
Stability		
Damaged Stability	-	One compartment standard
Propulsion Machinery		
Emissions (new vessels)	-	EPA Tier 4
Configuration	-	Omni-Directional
Winch		
Configuration	-	all mounted above deck
Drive	-	variable frequency electric
Auto-Tension (active haul-in / pay out)	-	at full rated line speed and tension
Drum Capacity	-	for 2 x towline specified below (split drum)
Level-Wind	-	Recommended
Brake Capacity	*tonnes*	≥ 3 x BP
Line Pull at Barrel Layer	*tonnes*	≥ 4 x BP at 0-12 ft/min (stall rating) ≥ 3 x BP at 0-12 ft/min (continuous) ≥ 0.35 x BP at 100 ft/min (top layer, continuous) ≥ 10 at 0-250 ft/min ≥ 1 at 0-750 ft/min

Instrumentation	-	- Remote and local controls - Haul-in / pay-out mode selection - Line tension display (all modes) - Line length paid out monitor - Tension adjustment capacity - Emergency abort
Towline & Fittings		
Towline Length, Type	*type / feet*	≥ 1,000' HMWPE, jacketed in contact areas, routinely inspected and tested
Towline Minimum Breaking Load	*tonnes*	4-5 x BP
Fittings	-	- Min. fitting diameter ≥ 8x rope diameter - Polished S.S. or equal surface, ≤ 300 micro-inches - Water lubrication
Range	*escort trips*	8 round-trips
Endurance	*hours*	≥ 120
Fire-Fighting		
Class Notation	-	Fi-Fi 1
Total Capacity	m^3/hr	≥ 2,400
Monitor Range	*metres*	≥ 120
Monitor Height	*metres*	≥ 45
Fuel Oil Capacity	*hours*	≥ 24
Water Spray System	-	Required
Pollution Response		
Offshore Rated Oil Containment Boom	*feet*	≥ 3,300
Oil Skimmers (crane deployed)	*#*	2
Recovered Oil Capacity	*gallons*	≥ 70,000
Dispersant Spray System	-	Recommended

B.A.T. for a HINCHINBROOK ENTRANCE SENTINEL TUG

Criteria	*units*	BAT Requirement	
		Dual Tugs (per tug)	*Single Tug*
Length Overall	*metres*	≥ 50	≥ 50
Bollard Pull (125,000 t DWT Tankers)	*tonnes*	≥ 75	≥ 144
Bollard Pull (193,000 t DWT Tankers)	*tonnes*	≥ 100	≥ 185
Speed	*knots*	≥ 16	≥ 16
Manoeuvrability			
Turn Radius	*ship-lengths*	≤ 1.5	≤ 1.5
Turn Rate	*degrees / second*	≥ 6	≥ 6
Position-Keeping			
In 57 knot winds at 20 foot seas	-	Hold Position @ 45°	Hold Position @ 45°
Seakeeping			
Lateral Accelerations in Sea State 6 or lower	*g*	≤ 0.07	≤ 0.07
Vertical Accelerations in Sea State 6 or lower	*g*	≤ 0.15	≤ 0.15
Stability			
Damaged Stability	-	One compartment standard	One compartment standard
Propulsion Machinery			
Emissions (new vessels)	-	EPA Tier 4	EPA Tier 4
Configuration (for maximum towing effectiveness and safety)	-	Omni-Directional (VSP tractor, Z-tractor or Rotortug)	Omni-Directional (VSP tractor, Z-tractor or Rotortug)
Towing System			
Design Load	*tonnes*	≥ 3 x BP	≥ 3 x BP
Winch Configuration	-	Double Drum	Double Drum
Auto-Tension (active haul-in / pay out)	-	Recommended	Recommended
Towline Length, Type	*type / feet*	≥ 3,000' SWR	≥ 3,000' SWR
Towline Minimum Breaking Load	*tonnes*	3.15 x BP	3.15 x BP

Other components:	-	- Pendant - Chafing Gear - Connecting Hardware - Stern Towline Roller - Tow Pins & Hold-Down Block - Norman Pins - H-Bitt	- Pendant - Chafing Gear - Connecting Hardware - Stern Towline Roller - Tow Pins & Hold-Down Block - Norman Pins - H-Bitt
"Salvage" Class Notation	-	Recommended	Recommended
Range	*n.miles*	≥ 2,000 @ full power	≥ 2,000 @ full power
Endurance	*days*	≥ 15	≥ 15
Fire-Fighting			
Class Notation	-	Fi-Fi 2	Fi-Fi 2
Total Capacity	m^3/hr	≥ 7,200	≥ 7,200
Monitor Range	*metres*	≥ 150	≥ 150
Monitor Height	*metres*	≥ 70	≥ 70
Fuel Oil Capacity	*hours*	≥ 96	≥ 96
Foam Delivery	*minutes*	≥ 30	≥ 30
Pollution Response			
Offshore Rated Oil Containment Boom	*feet*	≥ 3,300	≥ 3,300
Oil Skimmers (crane deployed)	#	2	2
Recovered Oil Capacity	*gallons*	≥ 70,000	≥ 70,000
Dispersant Spray System	-	Recommended	Recommended

In addition, it is recommended that the offshore tanker transit distance during which the Sentinel Tug should standby be increased from 17 to 30 nautical miles, per the findings of the Ship Drift Study [4]

for **ROBERT ALLAN LTD.**

Robert G. Allan, P.Eng.
Executive Chairman of the Board

RGA/MP:kb

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[1] ***Escort Winch, Towline, and Tether System Analysis,*** Robert Allan Ltd., Rev. 4, August 2012 (RAL ref. 212-030)

[2] ***A Review of Best Available Technology in Tanker Escort Tugs***, Robert Allan Ltd., Rev. 3, November 2013 (RAL ref. 212-090)

[3] ***A Review of B.A.T. for a Sentinel Tug Stationed at Hinchinbrook Entrance***, Robert Allan Ltd., Rev. 3, August 2016 (RAL ref. 212-090ST)

[4] ***Sentinel Tug Requirements for Gulf of Alaska: Ship Drift Study***, Robert Allan Ltd., Rev. 1, May 2016 (RAL ref. 215-067)

[4A] ***Memo RE: Tug BP Requirements for Rescue Towing in Prince William Sound***, Robert Allan Ltd., Rev.2, April 2016 (RAL ref. 215-067)

[5] ***Vessel Escort & Response Plan***, Prince William Sound Tanker Owners / Operators, January 2007

[6] ***Safety Guidelines for Design, Construction and Operation of Tugs***, Guidance Note NI 617 DT R00 E, Bureau Veritas, July 2014