Modified PWS Risk Simulation

Contract No: **652.2002.01**

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June 12, 2002

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Introduction

This report outlines additional work performed for the Prince William Sound Regional Citizens' Advisory Council following the Prince William Sound (PWS) Risk Assessment. The work addresses the closure conditions at Hinchinbrook Entrance. In the Final Report of the original study, the proposal of reducing the closure conditions from 45 knots to 30 knots was tested in the PWS System Risk Simulation. The model predicted that although this change does reduce the frequency of drift, and even powered, groundings in Hinchinbrook Entrance, outbound tankers are forced to do circles in the Central Sound more often, increasing the frequency of accidents in this area. The net effect was an increase in the overall frequency of accidents. The question remained whether it was possible to modify these rules to allow for the positive effect without the negative. The case described above with closure conditions at Hinchinbrook Entrance at 45 knots includes 644 round trip transits for tankers. This later case represents operations in 1996 and will be referred to as the Base Case.

The PWS System Risk Simulation has been modified to include the changes to the PWS Oil Transportation system that have occurred since 1996. Specifically we have made changes to the coordination of fishing openers and tanker movements, the current escort system, traffic lanes without the southern dogleg and higher speed limits. In addition, the number of round trips for tankers has reduced from 644 in 1996 to 493 in 2001 (a reduction of 23.45% compared to the Base Case). The current escort system has one close escort through the central sound and available sentinels that can assist disabled tankers. This would have more save capability than one close escort alone, but less than two close escorts when restricted to the outbound tanker (as was the case in the Base Case). However, available sentinels do provide a safe capability for inbound tankers as well. To model this, we perform 2 simulations, one assuming one close escort and one assuming two close escorts. We then use the drift path simulation for disabled tankers, to estimate how often the sentinel escorts would be able to reach and assist disabled tankers. This gives a good estimate of the effect of the modified sentinel escort system. The remaining traffic is modeled the same as the 1996 baseline risk assessment. The modified PWS Risk Simulation as outline above represents operations in 2001 and will be referred to henceforth as the Current Case.

The analysis presented herein attempts to answer the question whether it is possible to modify the closure rules in the Current Case at Hinchinbrook Entrance to allow for a positive effect (a reduction of drift groundings in Hinchinbrook Entrance) without the negative effect (an increased number of cycles of outbound tankers in the Central Prince William Sound) utilizing the PWS Risk Simulation Tool.

Research Design

The PWS Risk Simulation program simulates weather in each location and can look ahead at future weather levels that may informally be interpreted as weather predictions. The categories for wind conditions in the PWS Sound Risk assessment tool are: 0 - 15 knots, 15 - 30 knots, 30 – 45 knots, 45 – 60 knots. To answer the question whether it is possible to modify the closure rules in the Current Case at Hinchinbrook Entrance to allow for a positive effect (a reduction of drift groundings in Hinchinbrook Entrance) without the negative effect (an increased number of cycles of outbound tankers in the Central Prince William Sound) the following cases were designed in cooperation with the Regional Citizen Advisory Council (RCAC):

1. Current (45 knot) Case: If there is an outbound, laden tanker and the winds in Hinchinbrook Entrance are expected to be 45 knots or higher when the tanker reaches Hinchinbrook Entrance, the tanker either stays in dock or does circles in the Central Sound.
2. 30 knot Case: If there is an outbound, laden tanker and the winds in Hinchinbrook Entrance are expected to be 30 knots or higher when the tanker reaches Hinchinbrook Entrance, the tanker either stays in dock or does circles in the central sound.
3. Prerogative Case: If there is an outbound, laden tanker and the winds in Hinchinbrook Entrance are expected to be 30 knots or higher when the tanker reaches Hinchinbrook Entrance, the tanker stays in dock. However, if the tanker is on its way already, it may leave (based on the Captain's prerogative) the Central Prince William Sound as long as the weather will not surpass 45 knots while continuing its transit.

The two additional test cases, the 30-knot Case and the Prerogative Case, will be reported based on the percentage change from the Current Case. A new variable will be introduced to model enhanced save capability of escorts at Hinchinbrook Entrance at the weather limits compared to the Base Case. For each of the three cases above, this save capability will be set at 50%, 70% and 90%. Hence, a total of 9 additional analyses will be conducted utilizing the modified PWS Risk Simulation program. We will start, however, with a comparison of the Base Case from the Final Report of the original study (representing operations in 1996) to the Current Case (representing operations in 2001).

Comparison of the Current Case to the Base Case

The Current Case is compared to the original Base Case in aggregate form (that is not by location separately). The following tables show the expected values of the accident frequency by accident type for inbound and outbound tankers. As tanker transits reduced by 23.45% (from 644 in 1996 to 493 in 2001) a similar reduction can be expected in accidents frequencies simply due to a reduction in tanker transits alone. However, the overall accident frequencies have been reduced by approximately 55.5%[1] with the major reductions in drift groundings, powered groundings and collisions due to the new escort system, traffic lanes without the southern dogleg, higher speed limits and the fishing vessel rules.

Table 1. Average # of Accidents (Outbound) per year

	Drift Grounding	Powered Grounding	Foundering	Structural	Collision	Total
Base Case	8.3E-03	5.4E-03	5.1E-04	1.0E-03	4.0E-02	5.5E-02
Current Case	6.0E-03	2.9E-03	3.6^{E}-04	7.3E-04	1.5E-02	2.5E-02
Current Case	-4.2%	-4.6%	-0.3%	-0.5%	-45.8%	-55.3%

Table 2. Average # of Accidents (Inbound) per year

	Drift Grounding	Powered Grounding	Foundering	Structural	Collision	Total
Base Case	3.1E-02	1.2E-02	6.5E-04	1.1E-03	5.8E-02	1.0E-01
Current Case	1.9E-02	5.3E-03	4.3E-04	7.3E-04	2.0E-02	4.5E-02
Current Case	-11.6%	-6.1%	-0.2%	-0.3%	-37.3%	-55.6%

The following tables show the expected values of oil outflow by accident type for inbound and outbound tankers. The reductions in oil outflow are over 40%[2].

[1] With an enhanced save capability of 90% at Hinchinbrook Entrance the overall accident frequency has been reduced by 58.1% from the Base Case to the Current Case.

[2] With an enhanced save capability of 90% at Hinchinbrook Entrance the overall Oil Loss has been reduced by 44.5% from the Base Case to the Current Case.

Table 3. Average # of KDWT Oil Loss (Outbound) per year

	Drift Grounding	Powered Grounding	Foundering	Structural	Collision	Total
Base Case	1.5E-01	9.6E-02	1.7E-02	3.6E-02	1.8E-01	4.8E-01
Current Case	1.1E-01	5.2E-02	1.2E-02	2.5E-02	8.9E-02	2.9E-01
% Reduction	-8.6%	-9.2%	-1.0%	-2.2%	-19.5%	-40.4%

Table 4. Average # of KDWT Oil Loss (Inbound) per year

	Drift Grounding	Powered Grounding	Foundering	Structural	Collision	Total
Base Case	1.4E-02	5.4E-03	5.3E-04	9.1E-04	8.3E-03	2.9E-02
Current Case	8.9E-03	2.5E-03	3.5E-04	6.1E-04	3.2E-03	1.6E-02
% Reduction	-18.0%	-9.7%	-0.6%	-1.0%	-17.2%	-46.5%

Comparison of the 30 Kts and Prerogative Case to the Current Case

The 30 knots Case and the Prerogative Case are compared relatively to the Current Case. The following tables show the % changes for outbound tankers as compared to the total accident frequency in the Current Case assuming the same save capability at Hinchinbrook Entrance as in the Base Case. The results for the 9 other additional analyses (50%, 70% and 90% save capability applied to the Current Case, 30 Kts Case and Prerogative Case) are analogous to these results. The explanation for this phenomenon is that if an enhanced save capability is assumed in the Current Case the same assumption must be applied to the 30 Kts Case and the Prerogative Case as well. The relative % changes in the 30 Kts and Prerogative Case compared to the Current Case are therefore robust regardless the assumed % enhance save capability at Hinchinbrook Entrance. Accessibility to complete analysis results for these 9 additional analyses is described in the Appendix.

Table 5. % Change in Average # of Accidents (Outbound) per year for 30 kts Case Relative to Total Average # Accidents in Current Case

30 kts Case

	Drift Grounding	Powered Grounding	Foundering	Structural	Collision	Total
Port	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%
Narrows	0.0%	0.0%	0.0%	0.0%	0.1%	0.2%
Arm	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%
Central Sound	0.1%	0.0%	0.0%	0.0%	0.2%	0.4%
Hinchinbrook	-0.2%	-0.1%	0.0%	0.0%	0.0%	-0.2%
Gulf	-0.1%	0.0%	0.0%	0.0%	0.0%	-0.1%
Anchorage	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total	-0.1%	0.0%	0.0%	0.0%	0.5%	0.4%

Table 6. % Change in Average # of Accidents (Outbound) per year for Prerogative Case relative to Total Average # Accidents in Current Case

Prerogative Case

	Drift Grounding	Powered Grounding	Foundering	Structural	Collision	Total
Port	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%
Narrows	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Arm	0.0%	0.0%	0.0%	0.0%	-0.1%	-0.1%
Central Sound	0.0%	0.0%	0.0%	0.0%	-0.1%	-0.1%
Hinchinbrook	-0.2%	-0.1%	0.0%	0.0%	-0.1%	-0.3%
Gulf	-0.1%	0.0%	0.0%	0.0%	0.0%	-0.1%
Anchorage	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total	-0.2%	-0.1%	0.0%	0.0%	-0.2%	-0.6%

In both the 30 knots and Prerogative Cases, the drift grounding accident frequency is reduced in Hinchinbrook and even the Gulf (the positive effect) as the weather there is likely to be the same as in Hinchinbrook. The powered grounding accident frequency is also reduced in Hinchinbrook.

However, the cases differ in their effect on the collision accident frequency. Outbound tankers do more cycles in the 30 knots Case waiting for the winds in Hinchinbrook to die down and thus they interact with more vessels in this area. This is the same negative effect found in the original study. In the Prerogative Case, however, where tankers are allowed to leave when the winds are under 45 knots, this increase in cycles is not as predominant. Furthermore, in the 30 knots Case, a small reduction in collisions with fishing vessels in the Port, Arm and Narrows is offset by an increase in collisions with inbound tankers. In the Prerogative Case, the reduction in collisions with fishing vessels is more significant, leading to a net reduction in collisions in these areas as well.

The following tables show the % changes for inbound tankers as compared to the total accident frequency in the Current Case.

Table 7. % Change in Average # of Accidents (Inbound) per year for 30 kts Case Relative to Total Average # Accidents in Current Case

30 kts Case

	Drift Grounding	Powered Grounding	Foundering	Structural	Collision	Total
Port	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Narrows	0.0%	-0.1%	0.0%	0.0%	-0.3%	-0.4%
Arm	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%
Central Sound	0.1%	0.0%	0.0%	0.0%	0.1%	0.2%
Hinchinbrook	0.0%	0.0%	0.0%	0.0%	-0.1%	-0.1%
Gulf	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Anchorage	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total	0.2%	0.0%	0.0%	0.0%	-0.4%	-0.2%

Table 8. % Change in Average # of Accidents (Inbound) per year for Prerogative Case relative to Total Average # Accidents in Current Case

Prerogative Case

	Drift Grounding	Powered Grounding	Foundering	Structural	Collision	Total
Port	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%
Narrows	-0.1%	0.0%	0.0%	0.0%	0.0%	-0.1%
Arm	0.0%	0.0%	0.0%	0.0%	0.2%	0.2%
Central Sound	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Hinchinbrook	0.0%	0.0%	0.0%	0.0%	-0.2%	-0.2%
Gulf	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Anchorage	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%
Total	-0.1%	0.1%	0.0%	0.0%	0.1%	0.0%

In the 30 knots Case, tankers spend more time in dock waiting for the wind speed in Hinchinbrook Entrance to reduce. However, they also spend more time in dock waiting for the escort tug that is doing cycles in the Central Sound with another outbound tanker. This means that inbound tankers have to slow through the Central Sound more often for a dock to open up. This increases the exposure of inbound tankers in the Central Sound as shown by the increases in drift grounding and collision accident frequencies in that area. However, it also makes the coordination of fishing openers with inbound tankers a little easier, thus reducing collisions with fishing vessels and powered groundings steering around them in the Narrows.

In the Prerogative Case, while tankers are held in dock waiting for winds the same as in the 30 knots Case, other outbound tankers are not doing as many cycles, meaning that tankers are held in dock less waiting for tugs and thus less overall. This means that tankers can proceed in to dock without slowing as much. In terms of collision accident frequency, there is a similar reduction in collisions with fishing vessels and powered groundings steering around them, but this is offset by an increase in collisions of with tankers and SERVS vessels. This is due to a change in the timing of some tankers leaving dock in the simulation, so they interact with other tankers and SERVS vessels.

Figure 1 below summarizes combines the analysis results described in the tables above. It may be observed that in case of the Prerogative Case a reduction in accident frequency (inbound and outbound) is observed in all accident types. In the 30Kts Case the positive effect of reduction in power grounding is outweighed by the increases in the other accident types.

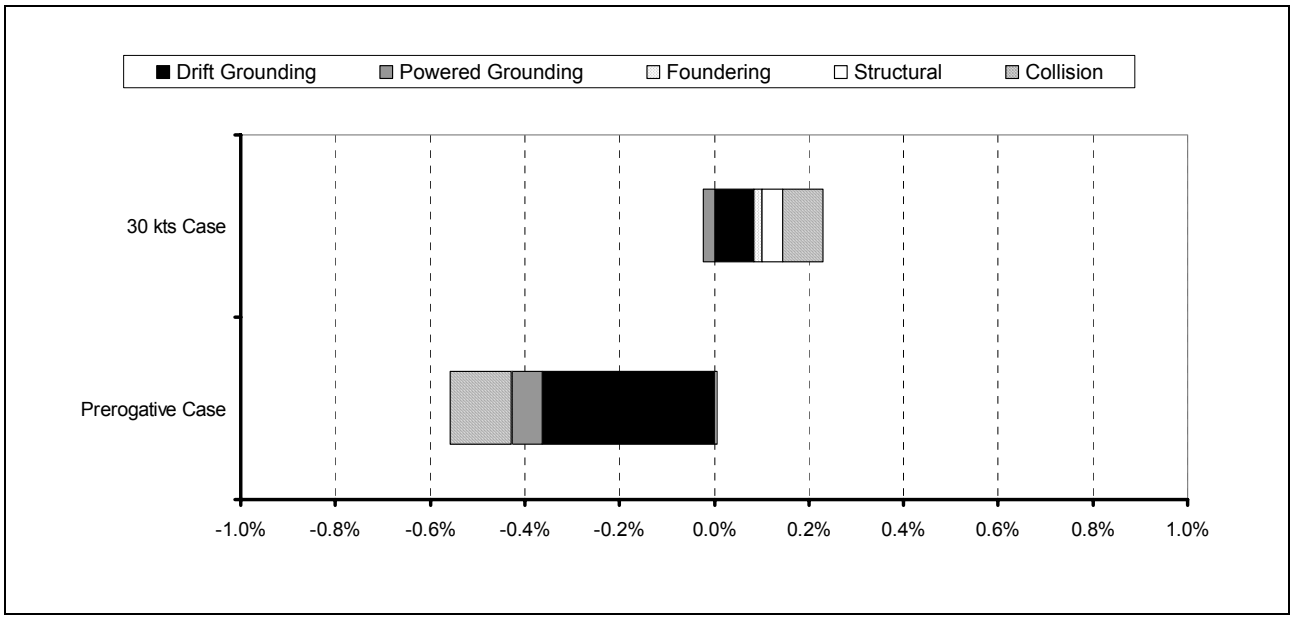

Figure 1. Relative % Change of Total Number of # Accidents per year (Inbound and Outbound) in the 30Kts Case and Prerogative Case compared to the Current Case

Similar results like can be presented for relative % change in oil loss compared to the average total oil loss in the current case. Accessibility to full results is described in the appendix. We suffice by providing Figure 2 which summarizes the overall effect for inbound and outbound tankers.

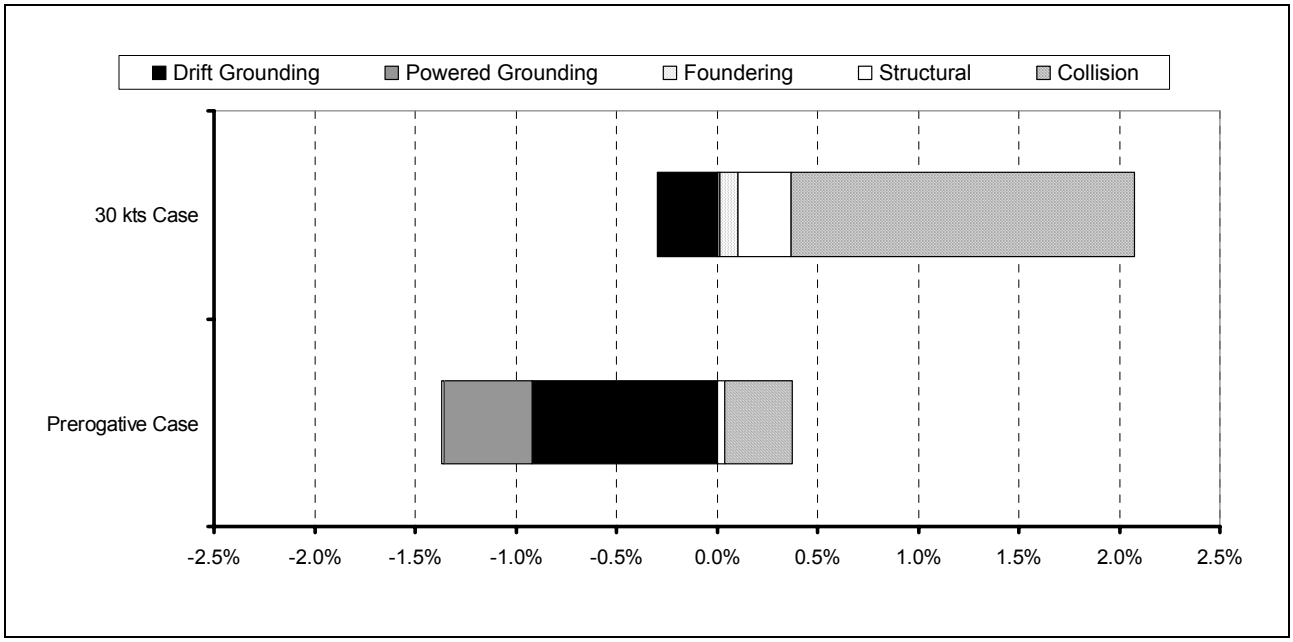

Figure 2. Relative % Change of Total Number of # Accidents per year (Inbound and Outbound) in the 30Kts Case and Prerogative Case compared to the Current Case

Note that in the 30Kts case an overall negative effect is in terms of oil loss observed of approximately 1.8% (0.3% reduction due to drift groundings against a 2.1% increase due to all other accidents types). In the Prerogative Case an overall positive effect is observed in terms of oil loss of 1.0% (1.3% reduction in drift groundings and powered groundings and a 0.3% increase in collisions). The 0.3% increase of oil loss in the Prerogative Case occurs can be attributed to a 0.7% increase due to collision in the Port, Valdez Arm and Central Sound against a reduction of 0.4 % due to collisiona in Hinchinbrook Entrance and the Gulf. It is worth noting, however, that overall accident frequency has reduced in the Prerogative Case by 0.1%. This indicates a redistribution of collisions in the Prerogative Case from smaller vessels (that do not puncture a tanker) to those vessels that have the potential of causing Oil Loss.

Conclusions

Significant reductions in risk have been made since the PWS Risk Assessment in 1996 compared to the Current Case (2001). Accident Frequency has been reduced by 55%; while expected oil outflow has been reduce by over 40%. Changing the closure conditions the Current Case for Hinchinbrook from 45 knots to 30 knots continues to predicted a net increase in accident frequency, primarily due to the increased number of cycles performed by outbound tankers and thus the increased exposure time. However, if the 30 knot rule is only used while tankers are waiting in dock, allowing outbound tankers to proceed through Hinchinbrook even if the winds pick up above 30 knots but below 45 knots, this negative effect is avoided, while maintaining the reduction in grounding accident frequency in Hinchinbrook. It should be noted, however, that with all the other changes made since the PWS Risk Assessment in 1996, these changes are relatively small.

Appendix

Full analysis results for this the Final report are available in four separate Excel Workbooks that accompany this report. The spreadsheet file names are:

"CaseComparisons Contract 652.2002.01.xls", "CaseComparisons 50% Contract 652.2002.01.xls", "CaseComparisons 70% Contract 652.2002.01.xls","CaseComparisons 90% Contract 652.2002.01.xls".

The first workbook contains analysis results with the same save capability at Hinchinbrook Entrance as the 1996 Base Case. The latter workbooks contains the results with an enhanced save capability at Hinchinbrook Entrance. Each workbook contains full results for the Base Case, Current Case, 30Kt Case and Prerogative Case in six different worksheets. The names of the worksheets within a workbook are:

"By Location (Acc)", "By Location In (Acc)", "By Location Out (Acc)", "By Location (Oil)", "By Location In (Oil)", "By Location Out (Oil)".

These worksheets provide analysis results in terms of average number of accidents per year (overall, inbound, outbound) and results in terms of Average # of KDWT Oil Loss per year (overall, inbound, outbound).