Location and Concept Design Report
Proposed Helicopter Landing Site
Trinity Point Marina

Prepared for: Johnson Property Group

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Glossary

ADF – Australian Defence Forces
ATC – Air Traffic Control
BVI – Blade Vortex Interaction
CAAP – Civil Aviation Advisory Publication
CAO – Civil Aviation Order
CAR – Civil Aviation Regulation (existing rules)
CASA – Civil Aviation Safety Authority
CASR – Civil Aviation Safety Regulation (future rules)
EPA – Environment Protection Authority of NSW
EPL – Environment Protection Licence
FAA – US Federal Aviation Administration
FATO – Final Approach and Take Off Area
GEA – Ground Effect Area
GNSS – Global Navigation Satellite Systems
GPS – Global Positioning System
HAI – Helicopter Association International
HLS – Helicopter Landing Site
ICAO – International Civil Aviation Organization
IFR – Instrument Flight Rules
IMC – Instrument Meteorological Conditions
LLA – Landing and Lift Off Area
NPA – Non-Precision Approach
RNAV – Area Navigation
VMC – Visual Meteorological Conditions
VFR – Visual Flight Rules

Executive Summary

Heli-Consultants were briefed by Johnson Property Group to prepare this report addressing the feasibility of constructing a helicopter landing site (HLS) at the new Trinity Point Marina, considering the best location for that HLS, and setting out the regulatory and design criteria applicable to such a facility.

This report addressed the following topics:-

- Location considerations and options.
- Proposed use of the site.
- Air legislation and state environmental and planning legislation.
- Design considerations.
- Potential hazards from helicopter operations including rotor downwash issues.

We reviewed the state and federal legislation affecting HLS and concluded that there are no licences, certifications, registrations or other site-specific approvals required from the Civil Aviation Safety Authority (CASA) for the proposed HLS at Trinity Point.

CAAP 92-2 contains the most useful and relevant material for the HLS design process – yet there is no single standard or published specification which addresses all matters that need to be considered in the design and development of a structural HLS. We refer to Technical Annex 14 (Volume 2) to the Chicago Convention, 1944, and to the ICAO Heliport Manual 1995 for design details not covered in CAAP 92-2.

In designing HLS which are intended to be used regularly by a cross-section of pilots, designers should select criteria going beyond "minimum specification" to improve safety and reliability. Our recommendations borrow from both Australian and overseas design standards and are intended to provide a facility that can be used reliably, safely and conveniently by a wide range of helicopters and pilots.

A number of preliminary design questions are addressed in order to avoid premature obsolescence of the design:-

- We examined whether the HLS should be designed to accommodate special flight procedures used by modern multi-engine helicopters (known as "Cat-A" or "Performance Class-One") to achieve "engine-out accountability". We concluded that the proposed utilisation by private, corporate, and non-schedule commercial operators would most frequently be done by light- and medium-, single- and twin-engine helicopters. While current rules do not require non-scheduled operations to comply with PC-1 or Cat A performance standards – designing the HLS to incorporate a load-bearing helipad of at least 25 metres x 25 metres will accommodate Cat-A/PC1 by most of the modern twin-engine helicopters up to 5 tonnes maximum weight or 12 seats total capacity.

- We considered whether the facility could be designed as an "IFR heliport" under international rules. We found that the IFR operations usually require larger, twin-engine helicopters – and that the facility is intended to be used mainly by smaller private and corporate operators. We also consider it is unlikely that the air safety authorities would develop and publish an instrument approach procedure specifically for that site. We also noted that instrument approaches are published for RAAF Williamtown, and could be used to allow an IFR helicopter to become "visual" and then proceed under the VFR to Trinity Point Marina.

- We considered whether the proposed HLS should be built to accommodate Australian Defence Force (ADF) helicopters since those helicopters are often used in counter-disaster and counter-terrorist operations. We found that there is very little likelihood of the Trinity Point Marina facility being needed for counter-terrorist or counter-disaster operations as it is not near any major hospitals or other strategic facilities – and there are playing fields and ovals in the general vicinity that could be used for those purposes if required.
- We considered whether we should recommend the inclusion of a "parking position" adjacent to the proposed HLS so that a second helicopter could arrive notwithstanding one helicopter already occupying the helipad. We found that the infrequency of proposed use made it unlikely there would be a conflict between uses – and if a helicopter was parked on the helipad when another helicopter needed to land – the parked helicopter could be repositioned to the Newcastle Regional Heliport (about 15 minutes flying time to the north) or to Warnervale Airport (about 10 minutes flying time to the south) -- to allow the itinerant helicopter movement in and out.

We considered three (3) different locations for the HLS within the marina – and another site south east of the marina at the water's edge. All of the sites could be used successfully – however we recommended the location at the end of Marina Arm A on the eastern side of the breakwater because of the availability of clear flight paths situated approximately 180^{o} apart that are aligned to minimise noise impact off the site. Further details about marking and lighting will be supplied as the design process progresses.

We have reviewed state planning and environmental legislation and consider that the facility does not require an "environment protection licence" because the proposed utilisation falls below the threshold utilisation for "scheduling" under the state's pollution control laws.

The entire development is a "Major Project" within the meaning of Part 3A of the Environmental Planning and Assessment Act, 1979 (NSW) and an environmental assessment (including a specific acoustic study of the proposed helicopter operations) is being prepared.

The project requires development consent. We could find nothing to indicate that inclusion of a helicopter landing site (HLS) ancillary to the residential, tourism and recreation uses proposed for the project would be prohibited under the relevant LEP, REP's or SEPP's.

We note that the land being developed is potentially subject to land slip or subsidence, bushfires, and flooding. We believe that provision of an HLS – either on piers or on a floating pontoon (so as to be relatively immune from any of those risks) -- in itself provides a degree of mitigation in relation to those possibilities on the land in question.

We believe that locating a 25m x 25m floating pontoon on the eastern side of the breakwater near the end of Marina Arm A will allow great flexibility in selecting flight paths with minimal acoustic and rotor wash impact. However, utilising this option necessitates controlling access to the adjacent sections of the breakwater in order to provide the appropriate horizontal separation between manoeuvring helicopters and non-participating personnel. Using that option also entails greater distance from the HLS to the Marina Village compared to other options – however that disadvantage can be mitigated by use of a "golf buggy" style of conveyance for passengers and baggage if needed.

We have calculated the potential wind speed caused by rotor downwash generated by helicopters landing and taking off. We have found that the maximum wind speed likely to be generated by the largest helicopter likely to use the site is just over 30 knots measured just under 30 metres away. This "worst-case" scenario is within the same range as naturally-occurring wind gusts such as those experienced in the coastal environment and therefore unlikely to significantly impact marina operations.

We considered the risk of helicopter mishaps in the local vicinity as a result of helicopter operations being introduced. We projected, based upon published data, that there would be one accident in the vicinity of the heliport each 320 years – with a fatal accident occurring each 2550 years. However these calculations do not necessarily equate to mishaps causing injury or death to non-participants.

Introduction

Heli-Consultants Pty Limited is briefed to assist Johnson Property Group with the establishment of design criteria, identification of air safety requirements and advisory material; and consideration of the planning, environmental, fire and safety issues pertinent to construction of a helicopter landing site (HLS) appurtenant to the proposed marina and tourist development at Trinity Point, Lake Macquarie.

We are asked to identify the most suitable locations for the facility; and to determine the best flight path alignment for helicopter operations at the site.

1 Air Legislation and other sources of Design Criteria for Helicopter Landing Sites (HLS)

A detailed review of air legislation and other relevant design criteria for HLS is contained at Appendix A.

In summary, there are no licences, certifications, registrations or other site-specific approvals required from CASA for the proposed HLS at Trinity Point. The airspace immediately overhead and surrounding Trinity Point and the south western parts of Lake Macquarie is “Class G” (un-controlled) so that helicopter take-off’s, landings, and over-flights up to 8500 feet AMSL DO NOT require any permission or clearance from Air Traffic Control (ATC).

Operations in “Class G” airspace are conducted on a “see and be seen” basis with pilot separation. There are no low-level air routes or other aerodromes in sufficient proximity to the Trinity Point site that would generate any unusual concentration of air traffic likely to affect safe operations at that venue.

Above 8500 feet over the site, the airspace is “Class C” control area for the purposes of regulating arrivals and departures from Sydney (Kingsford-Smith) International Airport. The airspace to the north and north east of Trinity Point is a Military Control Zone serving Williamtown RAAF Base. Associated with RAAF flying activities out of Williamtown, there are parcels of restricted airspace to the north and east of the site. (See Figure 1 below.)

None of the controlled or special use airspace in the vicinity of Trinity Point impacts helicopter operations in any way.

CAAP 92-2 contains the most useful and relevant material for the HLS design process – yet there is no single standard or published specification which addresses all matters that need to be considered in the design and development of a structural HLS. The Building Code of Australia is silent on the issue of structural helipads and heliports.

In designing HLS which are intended to be used regularly by a cross-section of pilots, designers should select criteria going beyond “minimum specification” to promote safety and reduce the number of rejected movements that occur at that site. Our design recommendations borrow from a number of Australian and overseas design standards and are intended to provide a facility that can be used safely in a wide range of conditions.

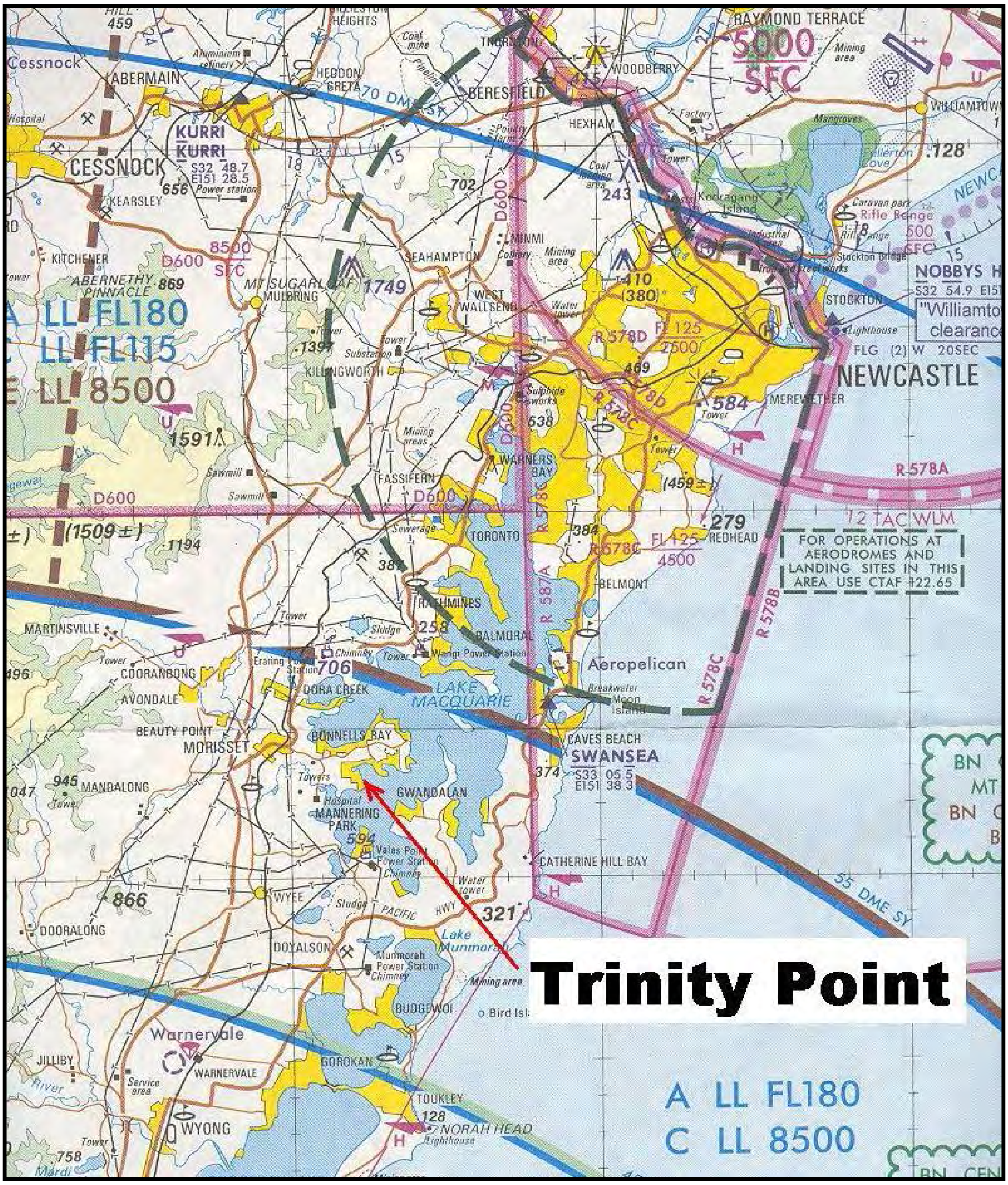

Figure 1 -- Excerpt from Sydney-Newcastle VTC

2 State Planning and Environmental Regulations

A summary of State Planning and Environmental Regulations relating to HLS in NSW is contained at Appendix B.

The proposed HLS is part of major development, therefore an Environmental Assessment is being prepared. A study of the acoustic impact of helicopter operations is being conducted and the findings will be incorporated into the EIS.

There will be no requirement to obtain an Environment Protection Licence (EPL) from the Environmental Protection Authority (EPA) so long as use of the HLS is kept below the threshold for licensing under the pollution control legislation (i.e. less than 30 non-emergency movements per week).

3 Preliminary Design Issues

Not all HLS are created equal. Before advancing the Trinity Point Marina HLS design, it is necessary to consider a range of preliminary issues that will define the project. To decrease the risk of premature obsolescence, both future technology and evolution of operating rules must be considered in the project definition. The fundamental aim is to make the tourist development and adjacent residential estate directly-accessible to air transport with the greatest margin of safety and the least environmental impact.

3.1 Performance Class One (Category A) or Performance Class Two/Three (Category B)?

CAAP 92-2, at Pp. 3-4 under the heading “Factors that should be considered prior to using an HLS”, provides:

“The pilot of a helicopter operating to, from or at an HLS should ensure that:

. . . where a helicopter may be required to be operated with a rejected take off or landing capability, and the performance requirements of the particular flight manual detail greater or additional requirements concerning the FATO, GEA, LLA or the approach and departure paths than those set out in these guidelines, then the greater and/or additional requirements should be met.”

Thus, one preliminary design consideration for a Trinity Point Marina HLS is whether to accommodate Category A (Performance Class One) operations.

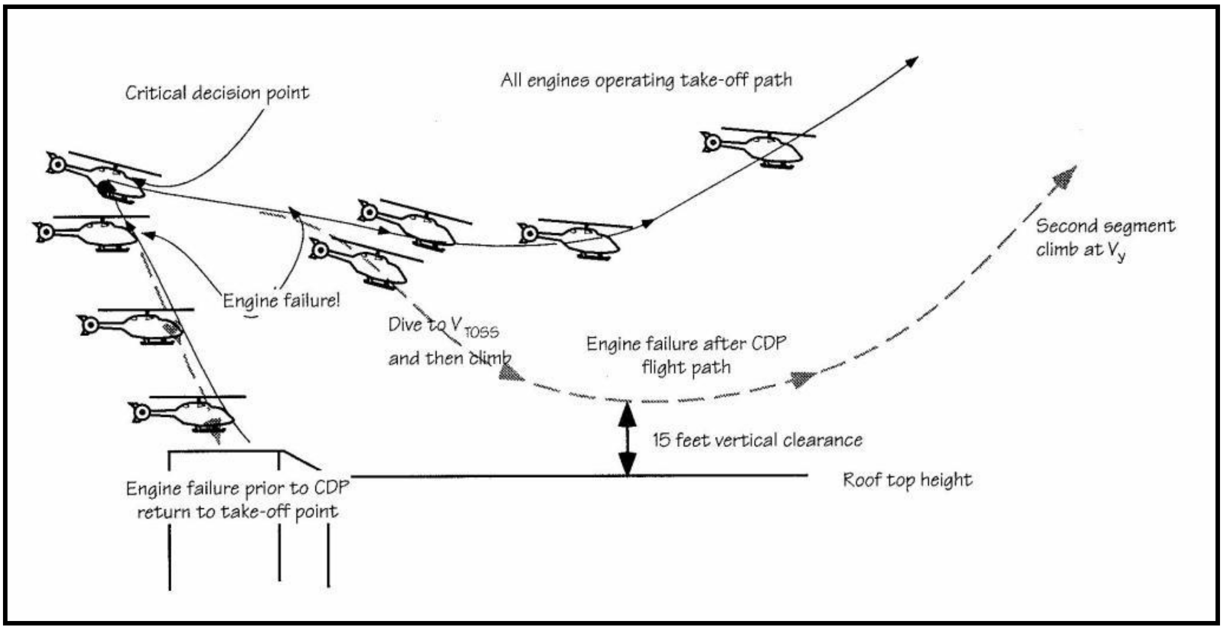

Figure 2 -- Illustration of Cat-A/PC1 Concepts

As can be seen in Figure 2 above, Category A (US FAA Standard) or Performance Class-One (equivalent European Standard) require a multi-engine helicopter to be operated in such a way as to ensure that, in the event of an engine failure at any point during a flight, the aircraft can EITHER land back upon the departure heliport OR safely fly away and land at another suitable heliport or airport – on the remaining engine(s).

Table 1:- Critical weights, capacities and dimensions of popular turbine helicopters

Manufacturer and Model	**Crew + Pax Seats**	**M/R Diameter (m)**	**Overall Length (m)**	**Wheelbase (m)**	**Tread (m)**	**MAWU (kg)**	**Fuel Capacity (l)**	**FATO Diameter (m)**	**LLA (m)**	**Cat. A/PC1 GEA/LLA**
Agusta										
A119 Koala	8	10.83	13.01	3.34	2.10	2720	870	26.02	5.4x4.1	N/A
A109E Power & Elite	8	11	13.04	3.54	2.15	2850	870	26.08	5.6x4.2	20x20
A109E Grand	8	10.83	12.96	3.74	2.15	3175	809	25.92	5.8x4.2	20x20
Bell Helicopter										
BH206L3 & L4	7	11.28	13.02	3.01	2.35	2019	419	26.04	5.1x4.4	N/A
BH407	7	10.7	12.7			2268	484	25.4		N/A
BH427	8	11.3	13.06			2880	770	26.12		Unk.
BH430	9	12.8	**15.30**	3.72	2.77	4218	935	30.6	5.8x4.9	Unk.
Eurocopter										
AS350BA	6	10.69	12.94	1.43	2.16	2250	540	25.88	3.5x4.2	N/A
AS355F2	6					2600	730			Unk.
SA365C2	11	11.7	13.41	**7.23**	1.98	3500		26.82	9.3x4	Unk.
AS365N2/3	11	11.94	13.73	3.61	1.9	4250	1135	27.46	5.7x4	**25x25**
B0105	5	9.84	11.86	2.53	**2.53**	2600	570	23.72	4.6x4.6	N/A
BK117B2	11	11	13.03	2.5	1.9	3350	707	26.06	4.5x3.9	20x20
EC135	7	10.2	12.19	2.6	2	2835	717	24.38	4.6x4	20x20
EC145/BK117C2	11	11	13.03	2.9	2.4	3585	866	23.72	4.9x4.4	20x20
EC155B1	11	**12.6**	14.3	3.91	1.9	4850	1257	28.6	6x3.9	22 Dia

Historically, only scheduled air services have been required to operate with that highest level of engine-out accountability. Private, corporate, and non-scheduled commercial operations in Australia are currently permitted in single-engine helicopters and in multi-engine helicopters that have not demonstrated the ability to continue flight in the event of one engine failing.

There is, however, a trend in Europe toward requiring multi-engine, PC1 for all commercial transport (formerly known as “charter category”) operations. Australian air legislation is currently under review, and there remains the possibility that non-scheduled commercial operations in Australia could in future require the use of multi-engine helicopters operated with engine-out accountability.

The main impact that accommodating Cat-A/PC1 procedures has upon heliport design is to ensure that the helipad dimensions meet the criteria specified in the flight manual for the particular helicopters to be operated there under those specific procedures. Different manufacturers specify different heliport criteria depending upon such things as cockpit visibility and descent angle with one-engine inoperative (OEI) for that particular craft. Generally, the larger the helicopter, the greater the area required for Cat-A/PC1 operations.

As we will discuss below, CAAP 92-2 recommends that any “standard HLS” should include both a “ground effect area” (GEA) and a “landing and lift off” area (LLA). The US FAA and ICAO combine these components into a “take off and landing area” (TLOF).

In Australia, for practical purposes, any HLS located on a structure that is elevated above the surface should incorporate a combined, load-bearing GEA/LLA. For Cat-B/PC2 or 3 operations – the minimum size of the GEA and LLA are “main rotor diameter” (GEA) and “undercarriage tread and wheelbase plus one metre on all sides” (LLA).

In most cases, the helipad size specified for Cat-A/PC1 operations will exceed the criteria for Cat-B/PC2 or 3.

Table 1 above contains a list of light- and medium- single- and twin-engine turbine helicopters that might (subject to meeting environmental criteria) use the proposed site. The table sets out their respective weights, fuel capacities, critical dimensions for heliport design purposes, and (if available) the helipad requirements for Cat-A/PC1 operations.

We have only included helicopters with maximum all-up-weight less than 5 tonnes and seating capacity less than 12. Few helicopters larger than that size are involved in non-scheduled operations in Australia – other than those involved in off-shore oil rig support work.

Some smaller single-engine turbine and piston helicopters are not included in the table above because their dimensions are clearly smaller all around than other models listed This does not mean those smaller helicopters will not operate at the site – only that their design requirements are clearly less onerous than those listed above.

Cat A/PC1 -- Summary and Conclusion

Although we do not envisage Australian air legislation changing so much as to require Cat A/PC1 performance for private and corporate flying, it is possible that Cat A/PC1 standards could be applied to non-scheduled commercial transport (i.e. charter category) operations in the future.

<u>Therefore we recommend that the HLS should incorporate a combined, load-bearing GEA/LLA of at least 25 metres by 25 metres – to ensure that the HLS will not become prematurely obsolete due to such a rule change.</u>

3.2 VFR, IFR (non-precision) or IFR (precision) Heliport?

3.2.1 VFR/IFR Background

The Standard HLS criteria in CAAP 92-2 are expressed to be applicable only to Day and Night Visual Flight Rules (VFR) operations. There are no guidelines currently published in Australia for HLS to be used under the Instrument Flight Rules (IFR). However, both the US FAA Heliport Design Advisory Circular and the ICAO Heliport Manual contain airspace, lighting and marking requirements for IFR heliports—with different criteria applicable to precision and non-precision approaches.

Precision approaches require both horizontal track guidance and vertical flight path guidance – and are generally aligned with a runway. Where only track guidance is available, "non-precision" approaches can be flown. The weather minima (ceiling and visibility) are inevitably higher for a non-precision approach.

Recently, "Global Positioning Systems" (GPS) that determine position by reference to satellites in geostationary orbit have come into widespread use. GPS navigation systems do not require signals from ground-based navaids, and have been approved for use in "non-precision" instrument approaches – such as the Newcastle Westpac Base instrument approach procedure or those into Westmead, Gosford, Merriwa, Lithgow and Wollongong Hospitals.

A fundamental design aim is to maximise the availability of an HLS irrespective of weather. However that objective is usually considered more important in medical and rescue operations. Usage of the proposed site at Trinity Point is anticipated to be for business, recreation or leisure. We do not think the air safety authorities would expend public funds to develop instrument approach procedures for use in non-emergency operations at a low-usage facility.

Designing an HLS specifically for IFR operations (precision approaches) requires an extensive survey of obstacles within an area of several kilometres, and also requires construction and maintenance of a sophisticated lighting "array" to provide visual guidance in low-visibility.

IFR aircraft bound for Trinity Point Marina can still conduct an instrument approach using published procedures at Williamtown RAAF Base – and then fly visually to the site – provided the cloud ceiling and visibility in the local area are sufficient for a visual approach.

3.2.2 VFR/IFR Conclusions and Recommendations

The majority of helicopters likely to use Trinity Point Marina will be certified for operation under the Visual Flight Rules (VFR) only. For that reason, and in light of the relatively low level of traffic at the site, the non-emergency nature of flights to and from the site, and the availability of published instrument approach procedures at Williamtown for any IFR-capable helicopters – we do not believe that Airservices Australia would fund the development and publication of an instrument approach procedure specifically serving the Trinity Point HLS in the foreseeable future.

We do not recommend that the Trinity Point HLS be designed specifically to accommodate either precision or non-precision instrument approaches.

3.3 Should the HLS be designed to accommodate Australian Defence Force (ADF) Helicopters (major disaster scenario)?

The widespread use of military helicopters in counter-terrorism and disaster-relief operations has prompted heliport designers to accommodate those (generally larger) helicopters when developing landing facilities at large hospitals and major public venues.

The proposed development does not incorporate any public health care facilities and is not considered a major public venue in the sense of becoming a terrorist target.

The possibility of accidents, critical illness, bushfires or flooding at the site or in the near vicinity, supports the concept of having the venue "helicopter-accessible" by civil rescue and emergency service helicopters.

In the unlikely event of a major occurrence requiring the involvement of large ADF helicopters, there are open spaces reserved in the vicinity that could be secured and utilised for that purpose.

Summary -- We do not believe it is necessary to design the HLS specifically to accommodate the larger ADF helicopters.

3.4 Should the HLS incorporate a "parking position" to allow simultaneous use by two helicopters?

Most passengers traveling to Trinity Point Marina by helicopter will undoubtedly be dropped off for an extended stay. However, in some cases, a party may arrive by helicopter intending to stay for a short period (two or three hours). In those circumstances it is more economic and less environmentally intrusive for the helicopter to shut down on the HLS to await the passengers return.

Unless a “parking position” is provided clear of the manoeuvring area of the HLS, parking one helicopter on the HLS will prevent another helicopter from using the site.

It is not possible to quantify with any accuracy the likelihood of a conflict or the need for simultaneous operation of the HLS by two helicopters – other than to say that a projected utilization of less than 30 movements (15 flights in and out) per week make conflicts rare.

Warnervale Airport (about 10 minutes flying time south of the site) is available for helicopter movements and provides some short-term parking. Newcastle Regional Heliport is less than 15 minutes flying time north of the site – and also has some capacity for helicopter parking.

On those rare occasions when helicopter movements conflict, temporary relocation of a parked helicopter to Warnervale or Newcastle Regional Heliport will allow access to the site by an itinerant helicopter.

Summary -- We do not feel that it is necessary to provide an additional parking position within the proposed HLS.

4 Recommended Design Features For Trinity Point Marina HLS

4.1 Determining the "Design Helicopter" and Critical HLS Dimensions

4.1.1 Design Helicopter -- Discussion

CAAP 92-2 describes a "Standard HLS" as comprising, at least:-

- Final Approach and Take-Off Area (FATO) = 2 x Overall Length (rotors turning)
- Ground Effect Area (GEA) = Main Rotor Diameter
- Landing and Lift-Off Area (LLA) = Undercarriage dimensions plus 1 metre on all sides
- Approach and Departure Paths = FATO width widening at 10^{o} splay to 4 x rotor diameter with 1:8 obstacle-free gradient

Each feature of a Standard HLS (described in more detail below) is a function of particular helicopter dimensions. Where more than one type of helicopter will use a site, the "design helicopter" will be a composite of the critical dimensions of all types using the site and any particular flight manual requirements for Cat A/PC1 operations.

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4.1.2 Design Helicopter -- Summary

Table 1 above contains a list of helicopters we consider to be potential users of the site, along with their critical dimensions.

It can be seen that the most critical dimensions are:-

- Overall Length – Bell 430 – 15.30 metres
- Main Rotor Diameter – Bell 430 – 12.80 metres
- Undercarriage length – SA365C – 7.23 metres
- Undercarriage width – BO105 – 2.53 metres
- Max All-up-weight – EC155 – 4850 kg
- Max fuel capacity – EC155 -- 1257 litres
- Cat A/PC1 heliport size – SA365N2/3 – 25 metres x 25 metres

4.2 HLS Components

4.2.1 Final Approach and Take Off Area (FATO)

This is defined in CAAP 92-2 as ". . . an area over which the final phase of the approach to a hover or landing is completed and from which the take off manoeuvre is commenced." CAAP 92-2 recommends that the FATO of a standard HLS should be "a circular area with a diameter equal to twice the length of the helicopter when the rotors are turning . . . which is free of obstacles likely to interfere with the manoeuvring of the helicopter."

The FATO is a notional, obstacle-free plane in space and does not necessarily require a physical "deck" of the same size. What constitutes an "obstacle likely to interfere with the manoeuvring of the helicopter" is not specified in that document, however other heliport design guides limit the height of light fixtures and fittings in the vicinity of the FATO to 25cm above the level of the landing area, which is a good guide to what constitutes an "obstacle". The flight path obstacle-free gradients originate at the same level as the FATO.

CAAP 92-2 requires a minimum 30.6 metre diameter FATO for the composite design helicopter. However, it must be realised that the FATO is a notional, obstacle-free plane in space – not necessarily a load-bearing surface.

4.2.2 Ground Effect Area (GEA)

The GEA is defined in CAAP 92-2 as ". . . an area that provides ground effect for a helicopter rotor system." CAAP 92-2 recommends that the GEA of a standard HLS should be "a circular area with a diameter equal to the diameter of the main rotor of the helicopter . . . within the FATO with the overall slope not to exceed 7.5 degrees (1:8 vertical to horizontal).”

CAAP 92-2 requires a 12.8 metre diameter GEA for the composite design helicopter – but this dimension is subsumed in our recommendation for a larger 25 metre x 25 metres load-bearing surface (see below).

4.2.3 Landing and Lift-Off Area (LLA)

The “LLA” for a structural HLS normally corresponds to the entire ground effect area (GEA). “Tie-down” provisions are normally built into maritime helidecks where pitch, roll and deck heave make it necessary to secure a parked helicopter.

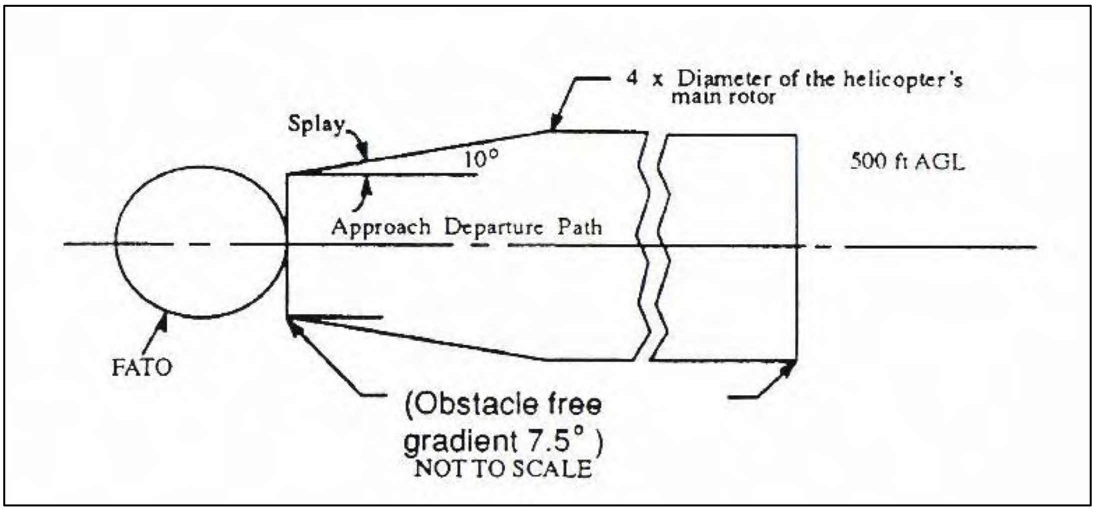
In the relatively calm waters of Lake Macquarie, we would not expect significant deck heave, pitch or roll on a moored pontoon HLS – however, as a precaution, we recommended flush-mounted tie downs be incorporated in the surface of the LLA.

CAAP 92-2 requires a 9.23 metre long x 4.53 metre wide “LLA” for the composite design helicopter – but these dimensions are subsumed in our recommendation for a larger 25 metre x 25 metres load-bearing surface (see below).

4.2.4 Flight Paths

CAAP 92-2 requires at least one flight path for all HLS which should start at the edge of the FATO and extend upward at a 8:1 gradient. The flight path is the same width as the FATO but expands at a 10^{o} splay to a width of four rotor diameters and to a height of 500 feet above HLS level. **For the composite design helicopter, the final width is at least 51.2 metres.**

Figure 3:- Depiction of Flight Paths per CAAP 92-2



CAAP 92-2 says the flight paths can curve to avoid obstacles but does not specify the maximum rate of curvature. ICAO Annex 14 and the *Heliport Manual 1995* recommend two flight paths for approach and departure not less than 150^{o} apart to facilitate operations in all wind conditions – and those documents prescribe a maximum rate of curvature.

We believe it is important to provide (at least) two flight paths notwithstanding that it is permissible in Australia to use a "one-way in – one-way out" configuration. Helicopters perform better into wind than out of wind. Operating with a tailwind component reduces climb performance on take-off, and increases ground speed on landing – thus making deceleration to land a more critical manoeuvre.

While respective rotorcraft flight manuals may not place a "flight limitation" on downwind operations – virtually all manufacturers recommend take-off's and landings as much into wind as possible. With a "one-way pad" – unless the wind is absolutely calm or exactly 90^o to the direction of the flight path – there will always be some element of tail wind either on take-off or landing.

Having at least two flight paths directly opposed (i.e. 180^o apart) ensures that, at worst, there may be a 90^o cross-wind but never a tailwind – at a particular HLS. It is rarely possible for surface-level sites to provide 8:1 obstacle-free flight paths that are directly opposite – so ICAO recommends a minimum separation of 150^o between flight paths.

We recommend two flight paths at least 150^o apart – each with 8:1 obstacle-free gradient across their 51.2 metre width. Because helicopters can operate over non-populous areas at 500 feet above the surface – it is not necessary to "validate" the approach and departure paths above that height. This corresponds to about 1200 track metres from the edge of the HLS.

We draw attention to the distinction between the obstacle-free plane in space recommended for a "flight path" and the actual "path" travelled by helicopters on take-off or landing. While the obstacle-plane starts at the edge of the FATO and slopes up at 8:1 (about 7.13^o) a line projected from the centre of the HLS along the flight path centreline and inclined up between about 9^o (normal approach) and 12^o (steep approach) is more likely to be the actual path flown. The obstacle-free gradient is to cater for "worst-case scenario" in relation to climb performance. See Figure 4 below.

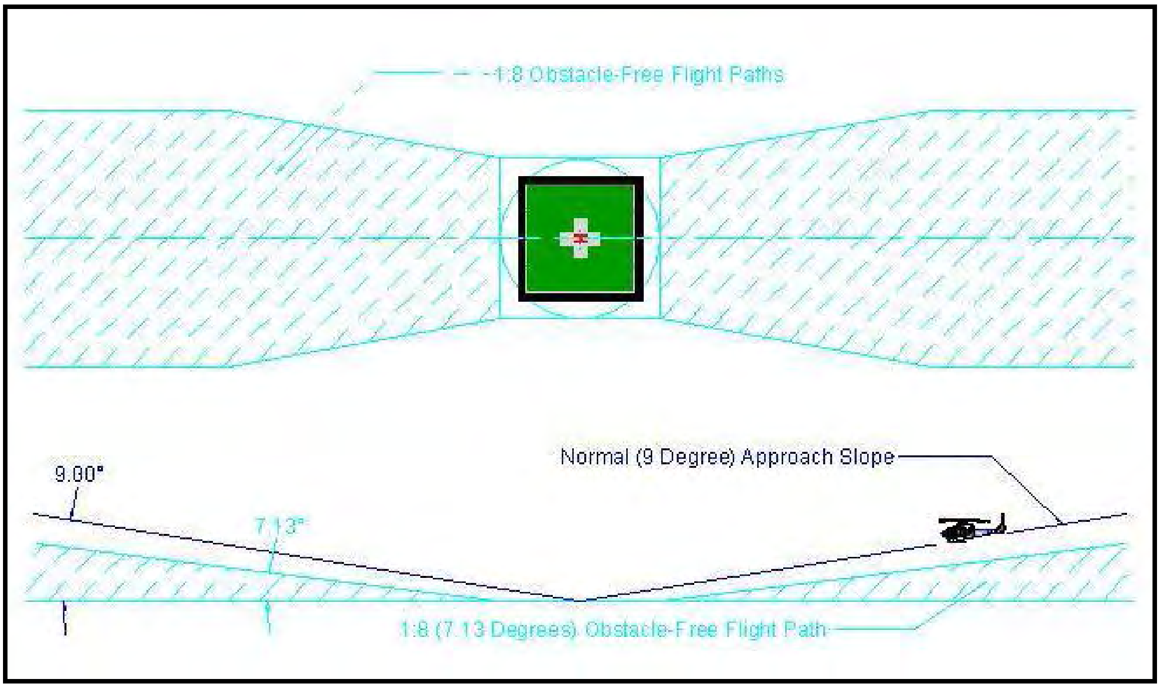


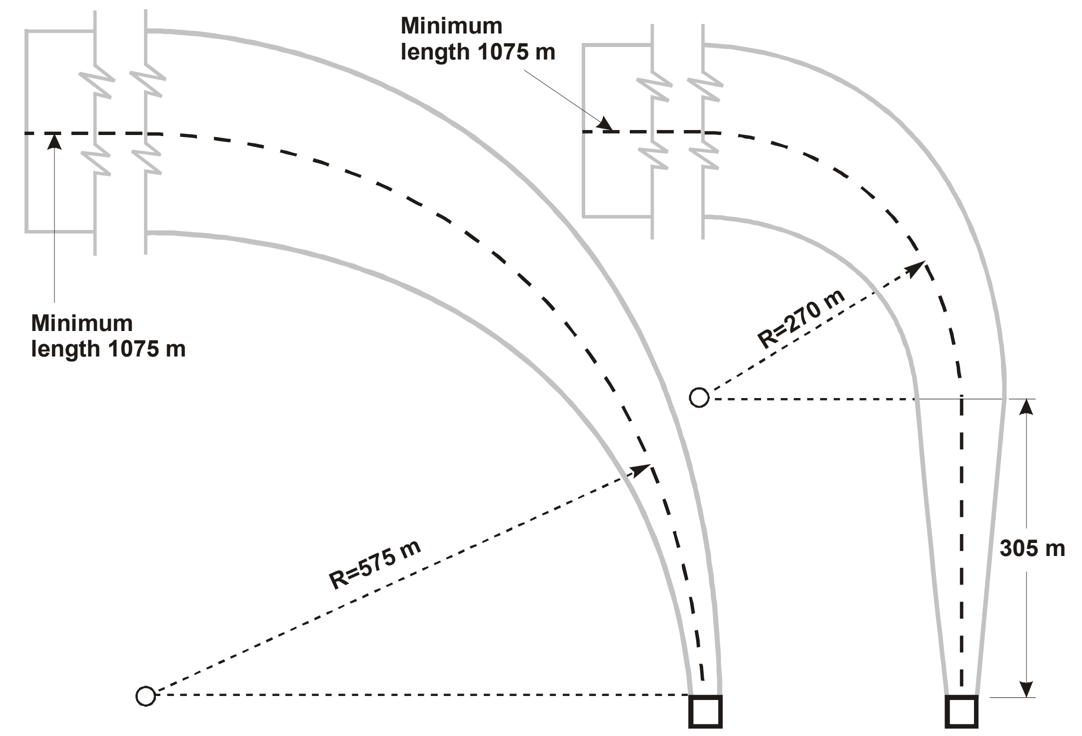
Figure 4 -- "Actual" Flt Path vs. Obstacle-Free Plane

Besides recommending two flight paths for operations in all wind conditions, the ICAO documents also recommend a minimum turn radius based on the formula:-

> $S + C_{R.}$ 575 m and $C_{R.}$ 270 m – where S is the length of the straight portion of the flight path and C_R is the radius of the turn. Maximum direction change is 90^o.

The ICAO formula for rate of flight path curvature is depicted in Transport Canada's heliport standards as shown in Figure 5 below.

Figure 5:- Depiction of Allowable Rate of Curvature for Flight Paths



Note 1: *Any combination of curve and straight portion may be established using the following formula: $S+Cr \geq 575$ m and $Cr \geq 270$ m, where S is the length of the straight portion and Cr is the radius of turn.*

Note 2: *The minimum length of the centre line of the curve and straight portion is 1075 m*

Figure 4-2. Curved approach and take-off climb surface for non-instrument FATO

The reason for specifying a maximum rate of curvature (minimum radius of curvature) in that way relates to the relationship of bank angle and airspeed to performance in helicopter operations. Low-level, low-speed manoeuvring – while within the capability of most modern helicopters – detracts from lift and therefore climb performance.

In order to ensure that flight manual performance figures are valid for heliport operations, it is preferable to limit the severity of low-level, low-speed manoeuvring by controlling the rate of curvature in accordance with the ICAO formula.

A secondary reason to limit bank angles (in particular) during approach and departure phases of flight is that turning (banking) precipitates blade-vortex interaction (BVI) – which is the main cause of the distinctive "blade-slap" or "wocka-wocka" sounds that are a characteristic of the impulsive nature of helicopter sounds and which some persons find irritating.

Minimising turns during descent to land is among the repertoire of techniques recommended by most helicopter manufacturers in the conduct of a "noise abatement approach".

We recommend that the ICAO formula for limiting curvature be observed in "prescribing" flight paths for the project. However, it should be noted that – so long as an 8:1 obstacle-free plane is observed, so long as noise-sensitive areas are not overflown at low-level, and so long as any low-speed manoeuvring is kept within capabilities of the particular helicopter -- then there is no reason why helicopters may not approach or depart along tracks that are outside the narrowly-prescribed corridors – specifically along any path within the minor arc between the "prescribed" flight paths.

Prevailing winds

Generally speaking, the central coast of NSW is characterized by a common pattern of winds:-

- Winter time – Prevailing westerlies due to the geostrophic influences of the high pressure systems, and exacerbated by early morning katabatic flow from the dividing range.

- Summer time – Light early morning katabatic (westerly) flow developing into afternoon nor'easterly sea breezes – and occasionally influenced by late afternoon "southerly busters" (though most "southerly busters" dissipate south of Newcastle).

Thus, while no flight path configuration is perfect in all cases – an east-west alignment would suit the prevailing winds in the general area.

4.3 Options for HLS Locations and Flight Path Alignment

Two HLS locations were proposed in the drawing titled “Concept – Preferred Option General Arrangement Option 5” supplied to us in our brief. We identified two other possible locations based upon our inspection of the site and aerial views of the vicinity. We have developed flight paths for four HLS locations which will enable better appreciation of the environmental impact of the proposal.

4.3.1 Option 1 – Location on western side of Marina Arm D

This option proposed a 25m x 25m floating pontoon located about 35 metres away from Marina Arm D connected by a 1.2 metre walkway. The location is depicted in Figures 6 and 7 below with the southern flight path aligned parallel to Arm D. We have shown tentative flight paths separated by the minimum 150^{o}. The north east flight path curves toward the east through the maximum allowable (90^{o}) at the maximum allowable rate of curvature.

Because that site is adjacent to a future arm of the Marina, there is the potential for rotor downwash impact on a number of vessels. A 30-metre radius around the centre of the HLS would have to be cleared of vessels during helicopter operations to ensure adequate separation from manoeuvring helicopters.

Figures 6 and 7 below illustrates a tentative layout for this proposed location.

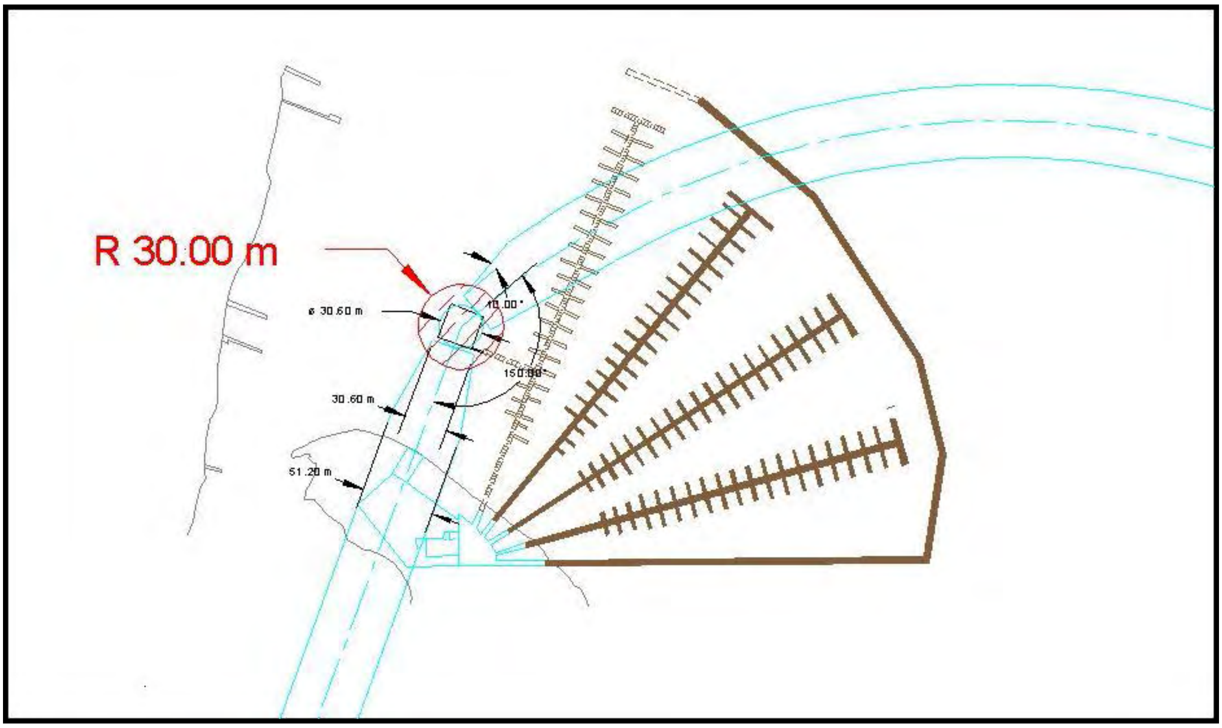


Figure 6 -- Option 1 HLS Layout

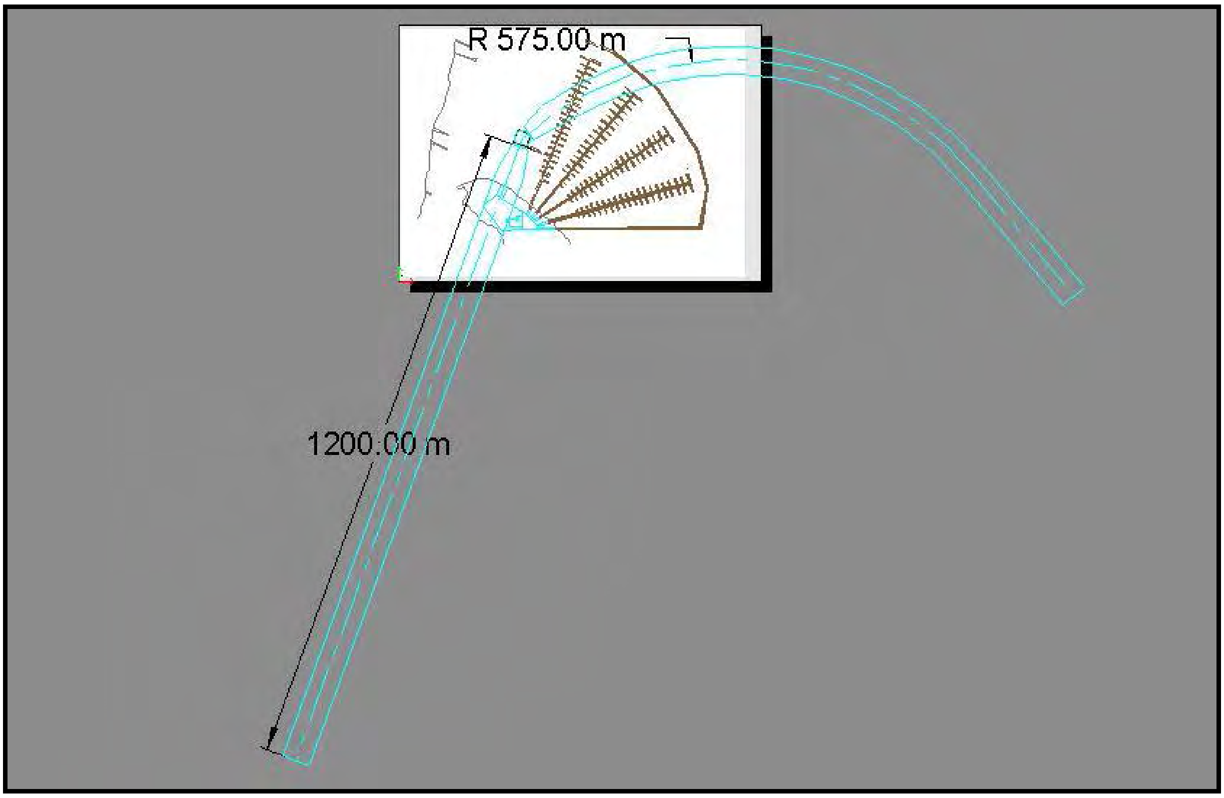


Figure 7 -- Option 1 Flight Paths

Figure 8 below indicates that the flight paths would over-fly a corner of the proposed Marina Arm D at about 10 metres (33 feet). The flight paths pass adjacent to Morisset East at about 50 metres (160 feet).

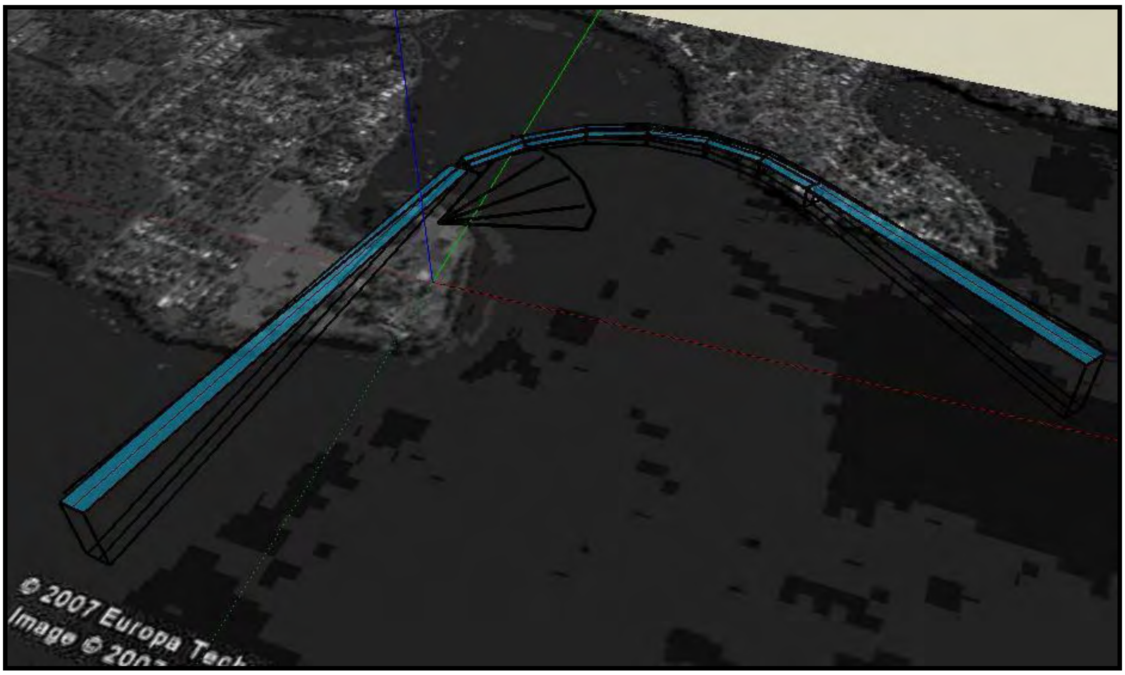


Figure 8 -- Perspective of Option 1 Flight Paths in the context of the vicinity

Main Advantage of Option 1 Location

- Handy to Marina Village

Disadvantages of Option 1 Location

- Rotor wash impact on Arm D of Marina
- Noise impact on East Morisset
- Noise impact on tourist accommodation and houses within the development

4.3.2 Option 2 – Location on southern side of Marina Arm A and Public Breakwater

This option also proposes a 25m x 25m floating pontoon located 10 metres away from the public breakwater connected by a 1.2 metre walkway. The location is depicted in Figure 9 below with the north eastern flight path aligned parallel to the breakwater.

The south western flight path is separated by the minimum 150^{o} and curves through just under 90^{o} at the maximum allowable rate of curvature. The flight path over-flies the waterfront tourist accommodation units.

Because of its proximity to the public breakwater, it would be necessary to provide a mechanism for clearing non-participants from within a 30-metre radius around the centre of the HLS during helicopter operations to ensure adequate separation from manoeuvring helicopters.

Figures 9 and 10 below illustrate one potential layout for this proposed location.

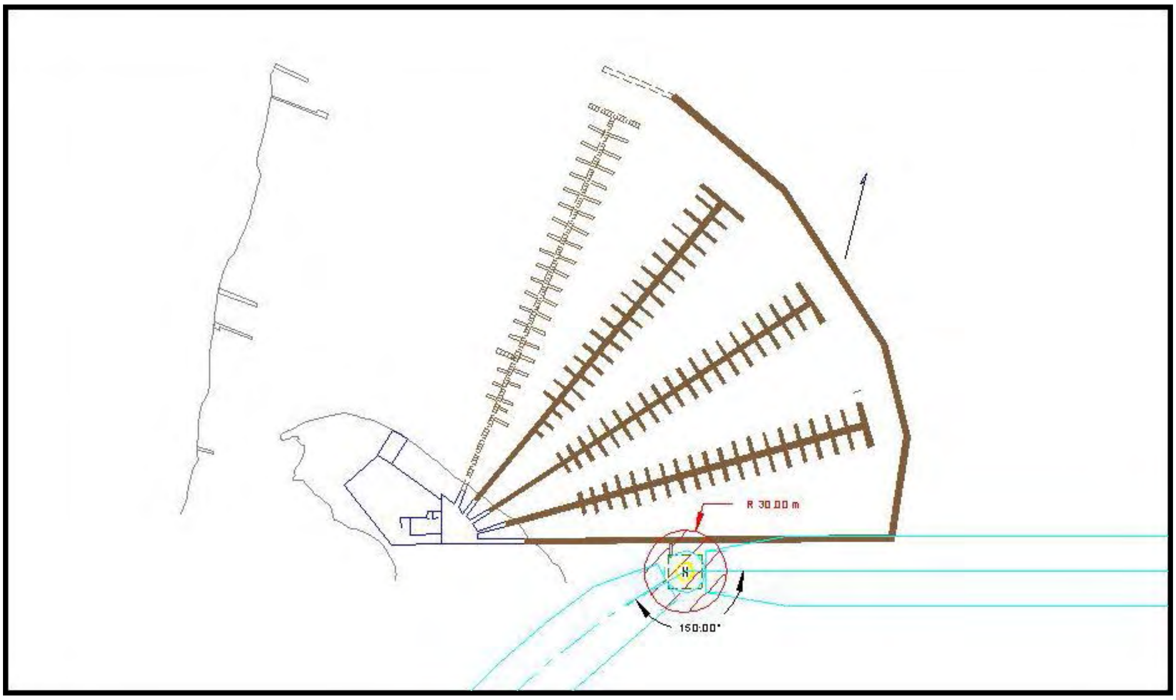
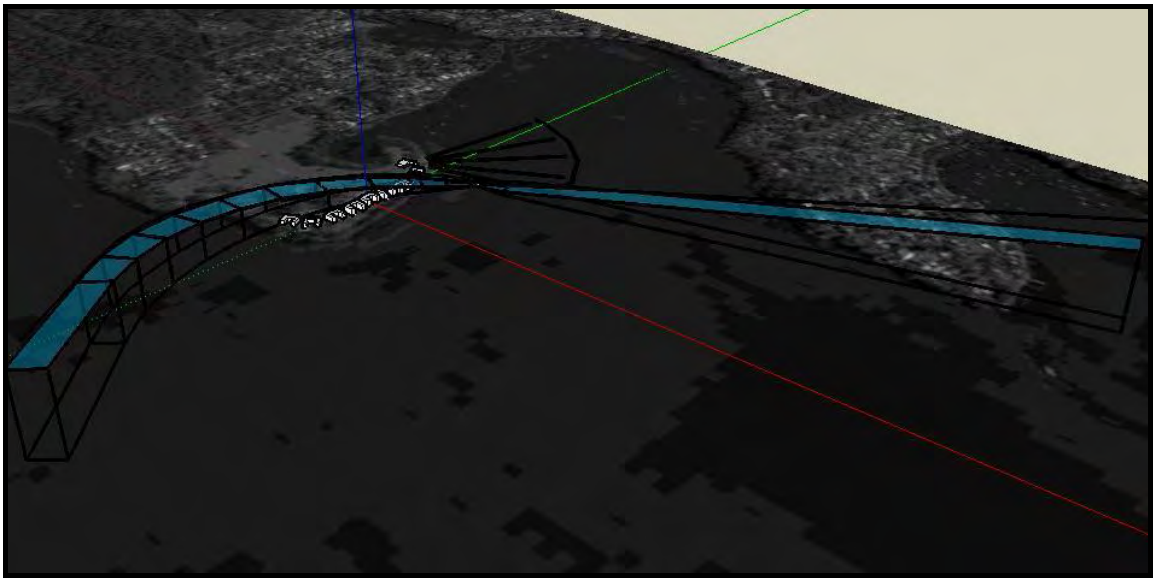


Figure 9 -- Option 2 Layout and 30m exclusion zone

Figure 10 -- Option 2 Flight Path Layout



Main Advantages of Option 2 Location

- Handy to Marina Village
- Flight paths have minimal noise impact off-site
- Flight path alignment favours prevailing winds

Disadvantages of Option 2 Location

- Rotor wash impact on Public Breakwater and Public Day Berths
- Need to cordon off 30m radius around HLS during helicopter movement
- Noise impact on tourist accommodation and houses within the development

4.3.3 Option 3 – Location on eastern side of Public Breakwater near corner of public breakwater – opposite end of Marina Arm A

This option also proposes a 25m x 25m floating pontoon located 10 metres away from the public breakwater connected by a 1.2 metre walkway. The location is depicted in Figure 11 below with both flight paths initially aligned parallel to the breakwater.

The flight paths are straight and remain over water as much as possible. Figures 11, 12 and 13 depict the layout of the facility and the flight paths in the context of the marina, the tourist accommodation, and the neighbourhood.

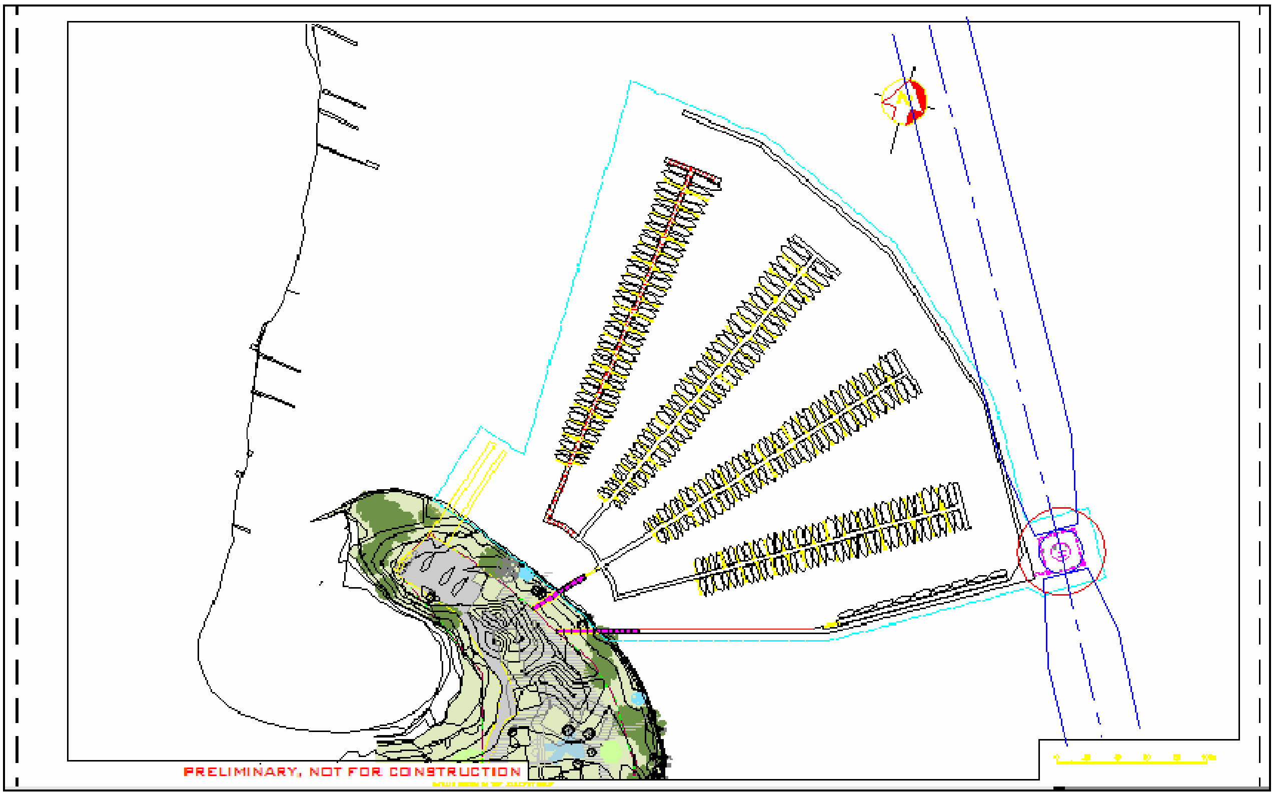


Figure 11 -- Option 3 Layout with flight paths aligned approximately 288/108 Degrees Magnetic. Note 30m exclusion zone (red circle) around helipad during helicopter movements.

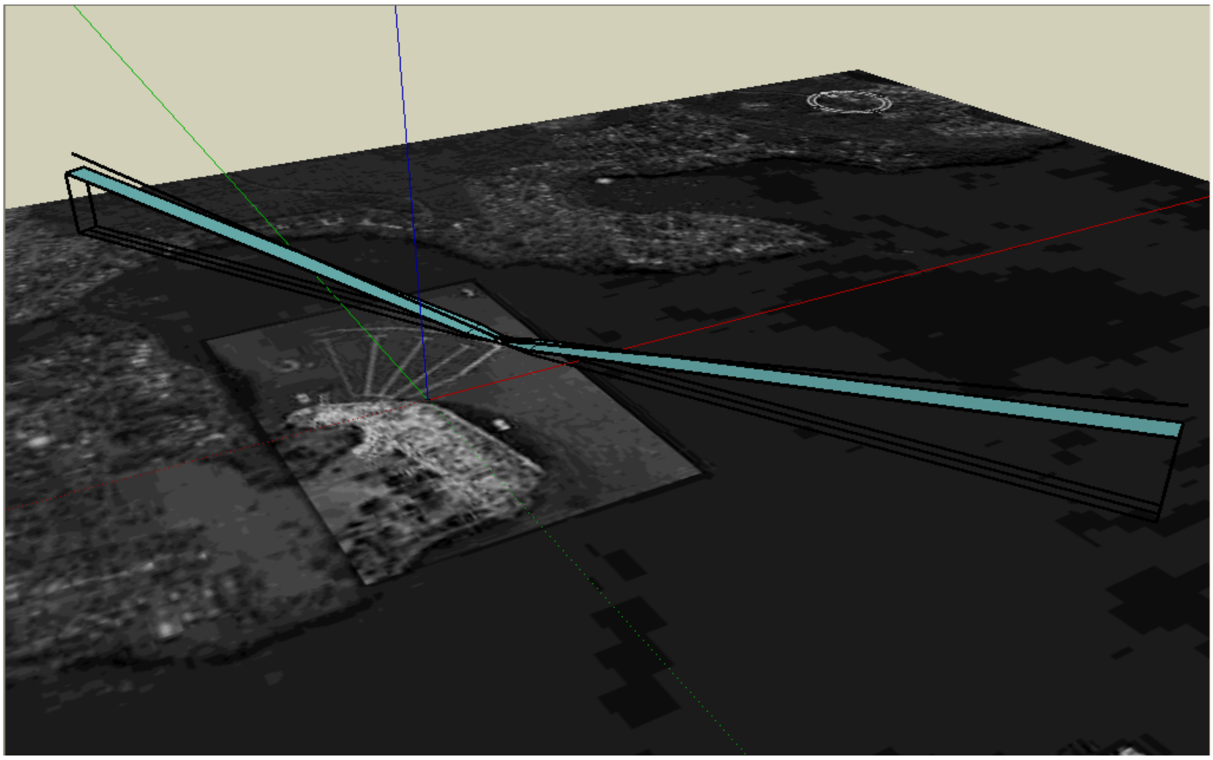


Figure 12 -- Option 3 Flight Paths

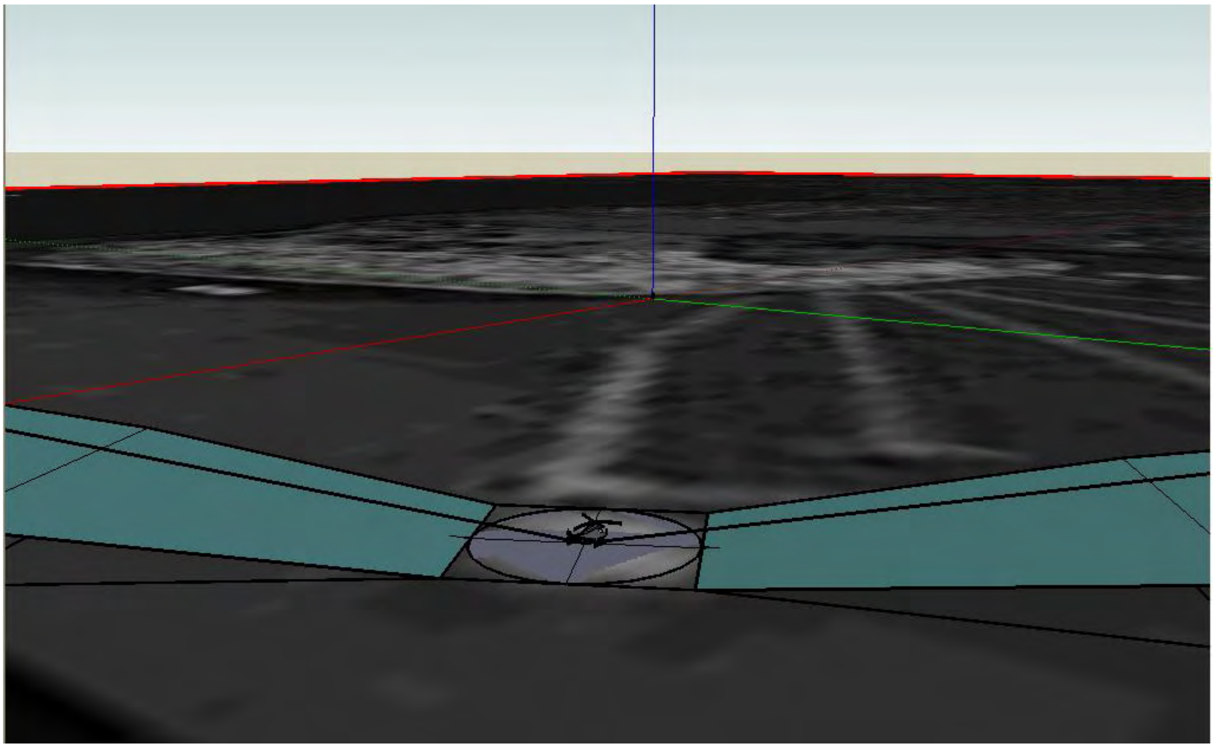


Figure 13 -- Flight Paths in the context of the marina and tourist accommodation

Main Advantages of Option 3 Location

- Flight paths have minimal noise impact both on-site and off-site
- Almost straight flight paths oriented approximately 180^{o} apart offers greatest operational flexibility

Disadvantages of Option 3 Location

- Some rotor wash impact on Public Breakwater and Public Day Berths
- Need to cordon off 30m radius around HLS during helicopter movement
- Distant from Marina Village (may need "golf buggy" or baggage handling trolley capable of operating on public breakwater)
- Not perfectly aligned with prevailing winds

4.3.4 Option 4 – Location off the south eastern point of the property

This option also proposes a 25m x 25m floating pontoon located about 40 metres away from the waterfront at the south eastern corner of the property connected by a 1.2 metre walkway.

The location is depicted in Figures 14 and 15 below with straight flight paths separated by 180^{o} and aligned approximately parallel to the waterfront.

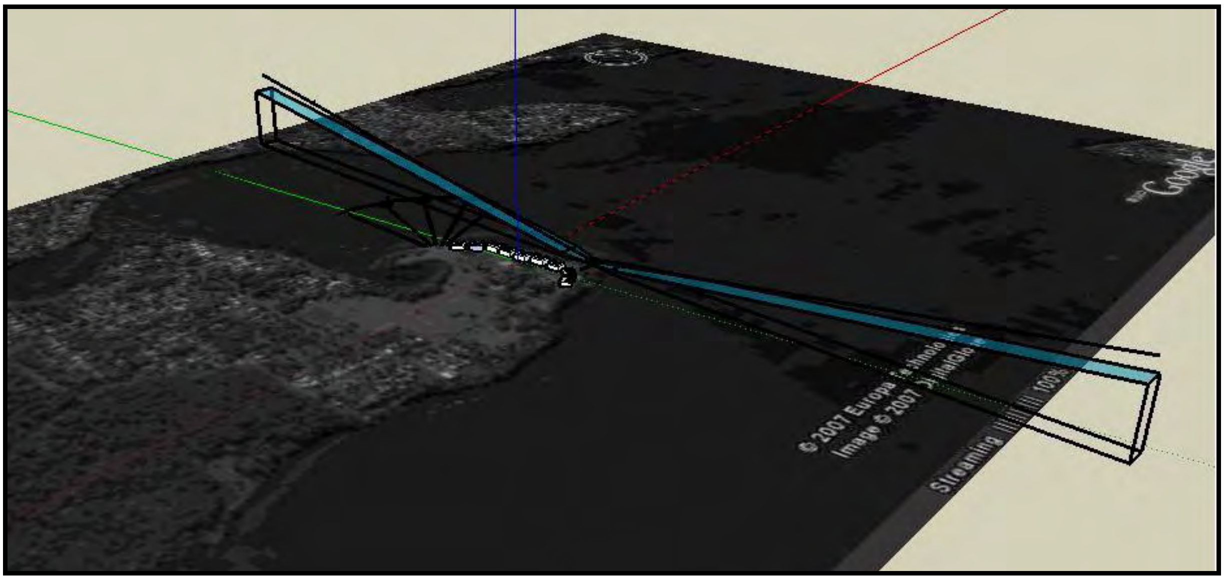


Figure 14 -- Option 4 Flight Paths

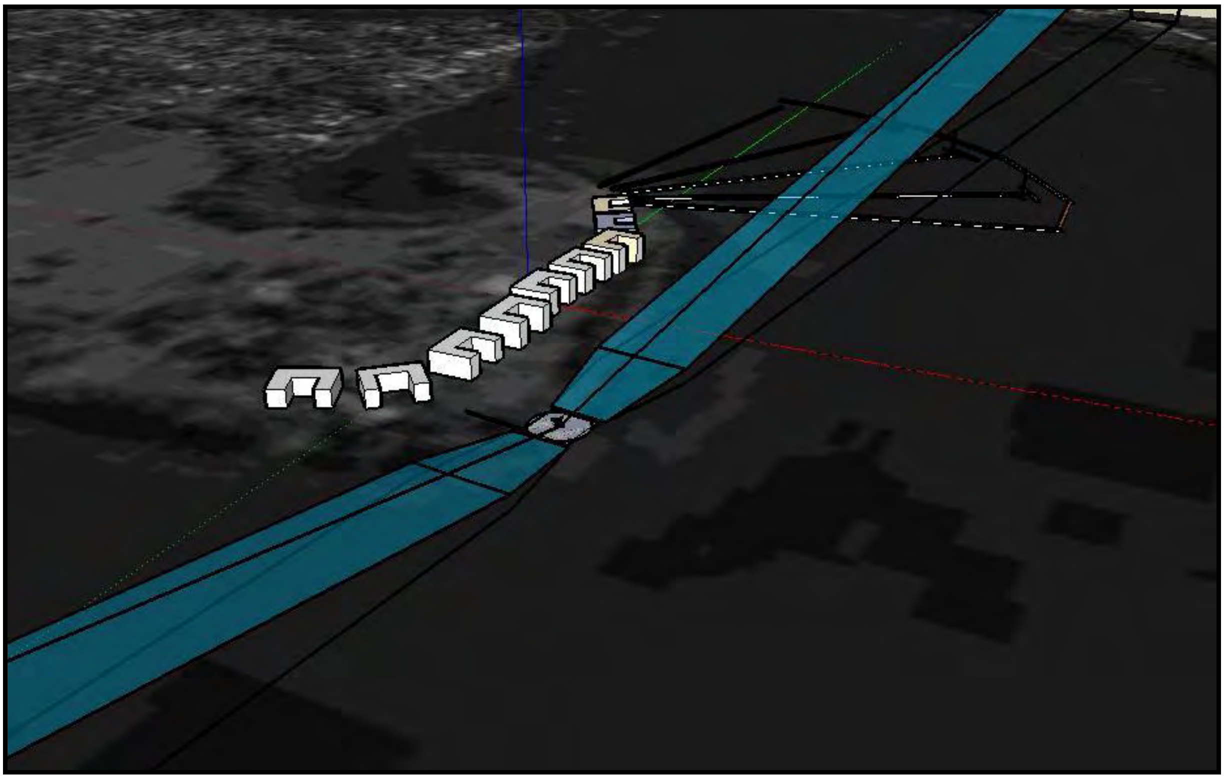


Figure 15 -- Option 4 Location in the context of the marina and tourist accommodation

Main Advantages of Option 4 Location

- Flight paths have minimal noise impact off-site
- Straight flight paths oriented 180^{o} apart offers greatest operational flexibility

Disadvantages of Option 4 Location

- Remote from Marina Village
- Requires construction of separate walkway and additional disturbance to sea bed for moorings
- Noise impact on tourist accommodation

4.3.5 Options for HLS Construction

We have identified two main alternatives for construction of a 25m x 25m helipad (combined, load-bearing GEA/LLA). One alternative is a floating metal pontoon. Another alternative is a fixed deck (constructed of metal or reinforced concrete) attached via beams and girders to fixed piers inserted into the lake bed. The level of the helipad would be above the level of the water level at high tide – having regard to any seasonal "king tides".

<u>Floating Pontoon</u>

The main advantages of the floating pontoon are:-

- Can be constructed off-site and floated into position.
- Can be temporarily or permanently relocated with minimal effort
- Minimal disturbance to sea bed for anchoring mooring lines
- Constant height of deck above water level – i.e. no need for safety fence around helipad

The main disadvantages of the floating pontoon are:-

- Deck movement (pitch, roll and deck heave) caused by wave action complicating take-off's and landings.
- Varying height of deck in relation to land with tidal movement.

<u>Fixed Deck</u>

The main advantages of a fixed deck are:-

- No special pilot training or effort needed to land on stationary deck.

The main disadvantages of a fixed deck are:-

- Construction required on-site complicated by environment protection controls
- Construction requires disturbance of lake bed.
- Requires horizontal "safety fence" or "safety shelf" due to height above surrounds at low tide.

Recommendation: Because the deck movement in the relatively calm, protected waters of Lake Macquarie would be minimal in all but the windiest conditions – we believe take-off's and landings can be made safely at such a facility without special pilot training – and we recommend that option.

The structural design parameters and load bearing capacity of the helipad will be in accordance with the ICAO Heliport Manual for the composite design helicopter (Bell

430/EC155). Fire protection will be in accordance with CAAP 92-2, the ICAO Heliport Manual, and/or – US Standard NFPA 418.

4.3.6 Lighting and Marking

Night operations are not proposed for the site, hence lighting of the HLS is not proposed.

Marking of the facility will be in accordance with CAAP 92-2 and the ICAO Heliport Manual.

A wind indicator will be position at a location to be determined – clear of the flight paths.

Preferred Options

As indicated above, the location which we believe is the most straight-forward from an aviation perspective is Option 3 with flight paths aligned over water as indicated. Although not perfectly aligned into the prevailing wind, having flight paths 180^{o} apart guarantees the ability to operate without any tail wind component irrespective of wind direction.

We believe that, on balance, the issue of deck movement with a floating pontoon helipad is a minor consideration. We believe that complexity of construction and the greater physical impact of a fixed-deck on piers set into the sea bed significantly outweigh any disadvantages of the floating pontoon. Nonetheless, we believe pilots will need to be aware of the possibility of deck movement caused by the wake of passing vessels – and be prepared to delay their arrival if there are large vessels manoeuvring in proximity to the helipad.

5 Summary of Impacts from Trinity Point Marina HLS

5.1 Acoustic Impact

The acoustic impact of helicopter take-off’s and landings at Trinity Point Marina HLS is the subject of an acoustic study by Arup**Acoustics** and will be reported upon elsewhere.

5.2 Rotorwash Impact

The rotor downwash impact of helicopter take-off’s and landings at Trinity Point Marina HLS was examined and a report is contained at Appendix C.

In summary, we concluded (in consultation with marina consultants) that the rotor wash velocities likely to be experienced by the vessels manoeuvring near, or moored within, the marina are similar in magnitude to those likely to be encountered in normal sailing by natural winds. Accordingly, we do not believe there is any fundamental incompatibility between the helicopter operations and the marina operations.

However, as noted in Section 4 above, CAAP 92-2 recommends that non-participants be kept at least 30 metres away from helicopters during take-off and landing operations.

5.3 Safety Impact

We analysed the possibility of helicopter accidents in the vicinity of the marina and concluded that the frequency of such accidents is extremely rare. A summary of this analysis is contained at Appendix D.

Appendix A -- Air Legislation and Other Sources of Design Criteria For Helicopter Landing Sites (HLS)

1) Civil Aviation Regulations 1988 and Civil Aviation Safety Regulations 1998

Except in the case of heliports used by high-capacity (30+ seats) scheduled air services, there are no requirements for licensing or site-specific approval of HLS by the Civil Aviation Safety Authority (CASA) in Australia. To the best of our knowledge, there are no mandatory HLS standards from any authority applicable in New South Wales or elsewhere in Australia.

Civil Aviation Regulation (CAR) 92 provides for take-off's and landings at places which are, in all the circumstances, safe and suitable for such operations. Safety and suitability of hospital landing sites are (legally) matters for pilots-in-command to determine prior to each operation.

The Civil Aviation Act, 1988 (Cth) provides inter alia:- "s. 20A. (1) No person may operate an aircraft in a careless or reckless manner so as to endanger the life of another person. (2) No person may operate an aircraft in a careless or reckless manner so as to endanger the person or property of another person." This criminal provision reinforces the duty of the pilot in command to select helicopter landing sites carefully. It also highlights the difficult choices pilots may have to make where there is inadequate separation or security at a landing site and curious onlookers gather to observe take off's and landings.

CASR Part 139 – Aerodromes establishes a regime for certification or registration of some aerodromes in Australia. Helicopter Landing Sites fall within the definition of "aerodrome". However, except in the case of aerodromes used by high-capacity transport operations (30+ passenger seats), there is no requirement to certify helicopter landing sites. There is also a requirement in that part for the registration of aerodromes that are open to the public and have a non-precision approach runway.

2) Civil Aviation Advisory Material

a) CAAP 92-2[1] -- Guidelines for the establishment and use of helicopter landing sites (HLS)

CASA provides non-mandatory design guidance for helicopter landing sites (HLS) in CAAP 92-2. The ". . . guidelines set out factors that may be used to determine the suitability of a place for the landing and taking-off of helicopters. Experience has shown that, in most cases, application of these guidelines will enable a take-off or landing to be completed safely, provided that the pilot in command:-

- has sound piloting skills; and
- displays sound airmanship."

Substantial compliance with CAAP 92-2 standard HLS criteria is recommended for the proposed Trinity Point Marina HLS (except as specifically indicated herein). However CAAP 92-2 is vague in many respects and completely silent on a number of design issues – most notably the characteristics of structural HLS.

b) CASR Part 139 – Aerodrome – Manual of Standards

Section 8.11 of the Aerodrome Manual of Standards contains information on marking of helicopter areas on aerodromes – however that material is not specifically relevant to off-airport HLS such as the proposed Trinity Point Marina HLS.

3) Designation of Airspace and Air Traffic Control

Rules and Responsibilities

Designation of particular airspace and development of the rules for operation within specific classes of airspace is a function of the Civil Aviation Safety Authority. Airservices Australia operates an Air Traffic Control (ATC) system and provides air traffic services in civil airspace across Australia and in the adjacent oceanic air routes. The Australian Defence Forces (ADF) provide air traffic control services for civil and military aircraft operating in military control zones (eg. RAAF Williamtown) and military restricted areas.

4) Other Relevant Design Criteria

We have considered the following additional reference material in providing our preliminary design advice:-

a) Building Code of Australia

The Building Code of Australia (BCA) does not have any specific design criteria for structural HLS. Indeed, some provisions of the BCA may be at odds with safe heliport design features (eg. BCA purports to require safety railings, etc. around elevated structures which would, on an elevated HLS, impinge the obstacle-free surfaces required for safe manoeuvring).

b) **International Civil Aviation Organization (ICAO) Technical Annex 14, Volume II - Heliports**

"Technical Annexes" to the Chicago Convention, 1944 contain the ICAO "Standards" and "Recommend Practices". As a signatory to the Chicago Convention and a member state of ICAO, Australia has a treaty obligation to implement ICAO "Standards" to the greatest extent practicable; and to notify ICAO of any differences between its regulations and ICAO "standards". (This Technical Annex is currently under review.)

c) **ICAO Heliport Manual (3rd Ed, 1995)**

The Heliport Manual is an advisory publication explaining and expanding upon ICAO Technical Annex 14. It contains considerably more detail than CAAP 92-2(1) and includes structural design guidance for elevated helidecks.

d) **US National Fire Protection Association (NFPA) Standard 418 – 2001:- Standard for Heliports**

This document contains fire protection standards for heliports including roof top heliports. NFPA standards are widely adopted throughout the USA and in many overseas jurisdictions. In some respects the NFPA fire code differs from the fire protection recommendations contained in the ICAO Heliport Manual.

e) **CAP 437 Offshore Helicopter Landing Areas - Guidance on Standards; UK CAA**

This reference details the assumptions involved in calculating "heavy landing loads" and "emergency landing loads".

f) **OFFSHORE TECHNOLOGY REPORT 2001/072: - Helideck structural requirements; PAFA Consulting Engineers for the Health and Safety Executive; UKOOA**

This reference contains a useful literature review regarding the assessment of structural loads for elevated heliports.

Appendix B – State and Local Planning and Environment Legisation

1) Planning Legislation

The proposed development is "major project" under Part3A of the Environmental Planning and Assessment Act, 1979 (NSW). That legislation is said to be intended to facilitate major project and infrastructure delivery and to encourage economic development while strengthening environmental safeguards and community participation.

This report is part of the concept plan development of the proposal.

In addition to the provisions of the EP&A Act, the Lake Macquarie Local Environmental Plan 2004, the Hunter Regional Environmental Plan 1989, and various State Environmental Planning Policies apply to the development site.

2) Zoning

The land within the development site is zoned Residential, Open Space, and Tourism and Recreation. Development of a Helicopter Landing Site for purposes that are ancillary to the use of the land for residential and tourism purposes would be consistent with the zoning of the site.

3) Pollution Control Legislation

Places used for take-off's and landings by helicopters more than 30 times in a week are "scheduled" under the Protection of the Environment (Operations) Act, 1997 (NSW). If the intended use of the HLS was for greater than that threshold – then an environment protection licence would be required.

However, the current proposal is to limit operations to less than 30 movements in any week.

Appendix C – Effects of Rotor Downwash Generated by Helicopters Landing and Departing at Trinity Point Marina HLS upon Moored and Manoeuvring Vessels and upon Pedestrians Walking upon the Marina Arms and Surrounding Breakwater

Introduction

Rotor downwash is the inevitable by-product of lift required by any aircraft to fly. "Heavier-than-air-craft" fly because the aerofoils, at any given instant, accelerate a mass of air downward that is at least equal to the mass of the aircraft. "Lift" is the equal and opposite reaction to that downward deflection of the air.

Because the rotating wings are capable of generating "relative airflow" solely due to the speed of rotation, it is not necessary for helicopters to have forward speed in order to fly.

However, the greater the forward speed, the greater the volume of air per unit of time that the lifting aerofoils interact with. The greater the volume (and mass) of air deflected downward by the rotor system, the less vertical acceleration must be imparted to that air mass in order to provide the "lift" necessary to fly.

In the case of a hovering helicopter -- particularly a helicopter hovering well clear of the ground -- there is invariably a column of descending air beneath the craft. Hovering "out-of-ground-effect" requires more power than is required for forward flight or for hovering "in-ground-effect" -- and is akin to trying to swim up a waterfall. Hovering (i.e. flying with zero-forward airspeed) also generates the most noticeable rotor downwash effects of all flight regimes.

The vertical velocity of the column of air beneath a hovering helicopter depends upon several factors including surface wind, main rotor radius, and "disc loading" (that is -- the weight of the helicopter divided by the 'swept' area of the rotor disc).

Larger helicopters not only have greater mass, but they generally have a higher "disc loading" when compared to smaller helicopters. This is because other design influences limit the practical main rotor radius on large helicopters.

Larger passenger capacity inevitably means greater impact due to rotor downwash in the vicinity of the landing site.

Standards or Regulations

Aside from Section 20A of the *Civil Aviation Act, 1988 (Cth)* – which prohibits reckless operations, there is little regulatory guidance in relation to helicopter rotor downwash. *Civil Aviation Advisory Publication (CAAP) 92-2[1]* provides:-

> "The pilot of a helicopter operating to, from or at an HLS should ensure that:
>
> the HLS is clear of all:
>
> - persons, other than persons essential to the helicopter operation; and
> - objects and animals likely to be a hazard to manoeuvring the helicopter, other than objects essential to the helicopter operation; and

no person outside the helicopter, other than a person essential to the operation is within 30 metres of the helicopter . . .”

On one hand, it is obvious that a minimum separation distance is prescribed to mitigate other risks in addition to rotor downwash. On the other hand, it is equally clear that mere compliance with the separation standards does not mean there cannot be hazards associated with rotor downwash – particularly from larger helicopters.

Calculations of Downwash

We are unaware of any widely accepted rotor downwash modelling tools available to predict accurately the effects of helicopters manoeuvring in the vicinity of a helicopter landing site upon persons and property in that vicinity – or specifically upon vessels or marina operations.

We have utilised three (3) tools in an effort to quantify the impact of helicopters operations – but none of the tools that we have available is capable of predicting the impact of helicopters in forward flight – as all are predicated upon the effects of hovering flight.

The three tools that we have used in this discussion paper are:-

- Aerodynamic formula for final downwash velocity (vertical) for helicopter hovering out-of-ground-effect
- Preliminary research reports by Ferguson – summarised by Negrette
- 1994 US FAA Report: - *Rotorwash Analysis Handbook (Volumes 1 & 2)* and accompanying “ROTWASH” computer software

1. Aerodynamic formula for final downwash velocity (vertical) for helicopter hovering out-of-ground-effect

Numerous textbooks on rotary-wing aerodynamics and helicopter principles set out the formula for calculating final downwash velocity as follows:-

- $\text{Velocity}_{(\text{final})}$ = Square Root [(2 x disc loading)/Air Density]

The formula illustrates the fact that – when operating at lower air density (due to higher elevation or higher air temperature – or both) the velocity of rotor downwash increases. Otherwise, the velocity is proportional to “disc loading”.

While there is reasonable scientific certainty in respect of the above formula – there is not a lot of practical value in knowing what the particular final downwash velocity is for a particular helicopter – unless it can be related to the physical impact upon marina operations.

The table below shows the final velocity (metric and imperial) for a range of helicopter types operating in NSW – or likely to be operated in the foreseeable future – calculated in accordance with the above formula:

	Disc loading		Air Density at S.L.		Final Velocity	
	Metric	Imperial	Metric	Imperial	Metric	Imperial
	Kg/m^2	Lbs/ft^2	Kg/m^3	$slugs/ft^3$	m/sec	ft/sec
AW139	42.78897861	8.764518314	0.1225	0.002377	26.43095854	85.87454191
S76C	37.56814994	7.695129654	0.1225	0.002377	24.76605641	80.46525238
BH412EP	34.95960439	7.16081811	0.1225	0.002377	23.89077335	77.62144588
EC155	38.89652174	7.96722166	0.1225	0.002377	25.20010423	81.8754796
AS365N3	37.95687023	7.774751703	0.1225	0.002377	24.89385474	80.88047088
BH430	32.77907959	6.714178574	0.1225	0.002377	23.13371233	75.16174439
EC145	37.7236675	7.726984505	0.1225	0.002377	24.8172644	80.63162783
BK117B2	35.2508469	7.220473666	0.1225	0.002377	23.99008193	77.9441008
SA365C2	32.55415594	6.66810719	0.1225	0.002377	23.0542062	74.90342788
A109E Grand	34.46648024	7.059810893	0.1225	0.002377	23.72167879	77.07205537
EC135	34.69467618	7.106552543	0.1225	0.002377	23.80007758	77.32677408
B0105	34.18954095	7.003085083	0.1225	0.002377	23.62618435	76.76179263
A109E Power	29.98952647	6.142791029	0.1225	0.002377	22.12746985	71.89244894
BH427	28.71743981	5.882227978	0.1225	0.002377	21.65308662	70.35117141
A119 Koala	29.52718937	6.048089962	0.1225	0.002377	21.95624196	71.33612723
AS355F2	28.96863663	5.933680927	0.1225	0.002377	21.74758223	70.65818892
BH407	25.22235381	5.166325279	0.1225	0.002377	20.29269651	65.93124553
AS350BA	25.06901247	5.134916187	0.1225	0.002377	20.23091692	65.73052282
BH206L3 & L4	20.20357566	4.138322872	0.1225	0.002377	18.16189132	59.00823065
EC120	21.83605819	4.470843396	0.1225	0.002377	18.88139488	61.33313103
Bell206B3	18.4445464	3.782627208	0.1225	0.002377	17.35325478	56.41533586
R44	14.43598996	2.922955796	0.1225	0.002377	15.35218655	49.59198943
R22	13.4468557	2.753367962	0.1225	0.002377	14.81689918	48.13184775

At the top of the table above is the Agusta-Westland AW139 proposed to be operated by the NSW Ambulance Service. Next, the S76C is the type operated at RAAF Williamtown for search and rescue duty. The BH412EP is similar to the Hunter Westpac Rescue helicopter currently operated out of Newcastle.

At the other end of the scale, the 2-seat piston-powered Robinson R22 is the most numerous helicopter type in Australia – with many privately-owned. The 5-seat Bell 206B Jetranger is the most common small turbine-powered helicopter.

In between these extremes are turbine powered single- and twin-engine helicopters of the kind operated in charter and corporate operations in eastern Australia – with seating capacity ranging from 5 to 12.

2. Preliminary research reports by Ferguson – summarised by Negrette

In 1985 the US Federal Aviation Administration (FAA) initiated a research program to develop a rotor wash analysis methodology. Much of the research was conducted by Samuel W Ferguson. A number of interim reports were produced and an early version of a computer program for modelling rotor downwash characteristics was developed.

To the best of our knowledge, the first effort at calculating separation criteria to avoid helicopter rotor wash mishaps was published in 1986. Refinements to the computer model and further analysis of rotor wash mishaps to validate the model continued until about 1992.

In February, 1992, *Rotor & Wing International* Safety columnist Art Negrette summarised Ferguson's work up to that stage in an article entitled:- "The Unseen Hazard of Rotor Downwash". We rely upon that article and the matrix contained therein for the discussion and calculations below.

It should be remembered that the separation distances referred to have no official "status" or recognition by any authority -- and may not have been entirely validated prior to promulgation.

Figure 1 below illustrates the effect of wind on rotor downwash flow patterns. The report noted that surface winds up to 9 knots tend to strengthen the rotor wash downwind
from the main rotor, whereas winds 10 knots and stronger tend to decrease the rotor wash.

Figure 2 is a separation matrix developed by Ferguson and his associates based upon the concept of a "Hazard Index" -- being the "disc loading" (lbs/ft^2) of the helicopter multiplied by its rotor radius (ft).

The matrix provided for different separation criteria applying to different risks, that are described as follows:-

Class I risks

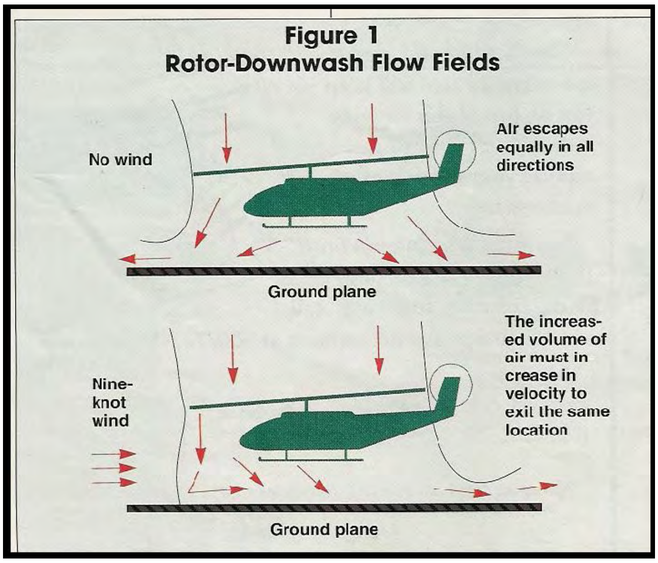
- The general public
- Aircraft loading or unloading
- Maintenance operations
- Unsecured light aircraft
- Public parking lots
- Structures with open doors/windows
- All other potentially hazardous situations not covered by Class II/III

Class II risks

- Secured, ready-for-flight rotorcraft
- Parked and secured (tied down) aircraft
- Structures meeting uniform building codes

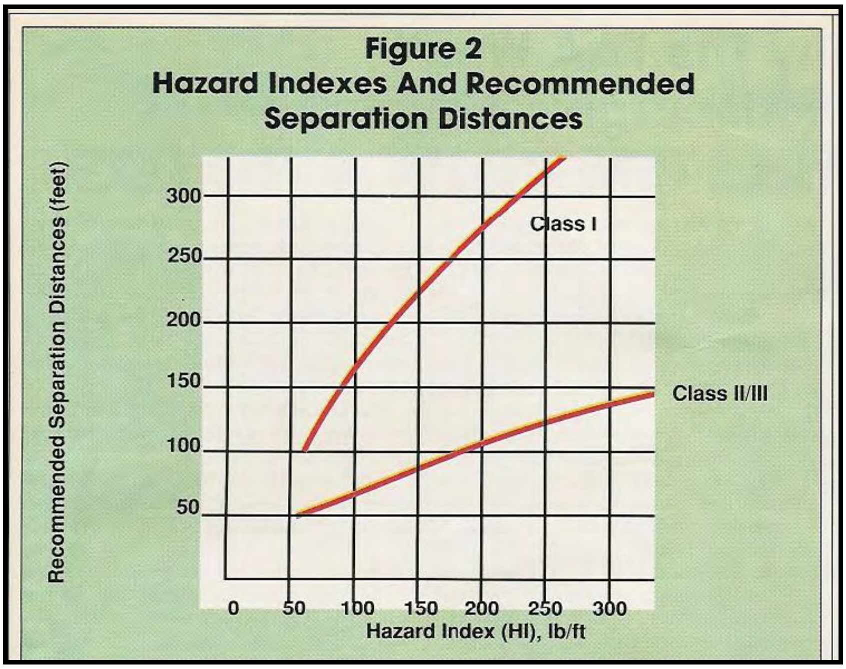
Class III risks

- Equipment, objects and vehicles not required in routine rotorcraft operations (eg. Trash barrels, tarpaulins, construction materials) which can contribute to creating other hazards



The table below shows the calculated hazard index for the same helicopter types for which we calculated the final downwash velocities above.

Type/Model	Rotor Diameter		Disc loading		H.I.
	Metric	Imperial	Metric	Imperial	
	metres	Feet	Kg/m2	Lbs/ft2	
AB139	13.8	45.2778	42.78897861	8.764518314	198.41905
S76C	13.41	43.99821	37.56814994	7.695129654	169.28597
BH412EP	14.02	45.99962	34.95960439	7.16081811	164.69746
EC155	12.6	41.3406	38.89652174	7.96722166	164.68486
AS365N3	11.94	39.17514	37.95687023	7.774751703	152.28849
BH430	12.8	41.9968	32.77907959	6.714178574	140.98701
EC145	11	36.091	37.7236675	7.726984505	139.4373
BK117B2	11	36.091	35.2508469	7.220473666	130.29706
SA365C2	11.7	38.3877	32.55415594	6.66810719	127.98665
A109E Grand	10.83	35.53323	34.46648024	7.059810893	125.42894
EC135	10.2	33.4662	34.69467618	7.106552543	118.91465
B0105	9.84	32.28504	34.18954095	7.003085083	113.04744
A109E Power	11	36.091	29.98952647	6.142791029	110.84974
BH427	11.3	37.0753	28.71743981	5.882227978	109.04268
A119 Koala	10.83	35.53323	29.52718937	6.048089962	107.45409
AS355F2	10.69	35.07389	28.96863663	5.933680927	104.05864
BH407	10.7	35.1067	25.22235381	5.166325279	90.686316
AS350BA	10.69	35.07389	25.06901247	5.134916187	90.050743
BH206L3 & L4	11.28	37.00968	20.20357566	4.138322872	76.579003
EC120	10	32.81	21.83605819	4.470843396	73.344186
Bell206B3	10.24	33.58	18.4445464	3.782627208	63.510311
R44	10	33	14.43598996	2.922955796	48.228771
R22	7.67	25.17	13.4468557	2.753367962	34.651136



The approximate separation distances recommended under this particular study for a cross-section of helicopter types likely to operate at Trinity Point are:-

Type/Model	Hazard Index	Separation from Class 2/3 Risks	Separation from Class 1 Risks
AS365N2/3	152	85 ft (26 m)	225 ft (69 m)
Bell 430	141	80 ft (25 m)	210 ft (64 m)
A109E Power	111	70 ft (21 m)	180 ft (55 m)
Bell 407	91	60 ft (18 m)	150 ft (46 m)
Bell 206B	64	55 ft (17 m)	110 ft (34 m)
R22	35	< 50 ft (<15 m)	< 70 ft (<21 m)

With respect to the "Class 1 Risks" (including members of the public) it appears that mere adherence to the 30-metre separation recommended by CAAP 92-2 will be insufficient to mitigate that risk.

3. 1994 US FAA Report: - *Rotorwash Analysis Handbook (Volumes 1 & 2)* and accompanying "ROTWASH" computer software

The work by Ferguson referred to above culminated in publication of detailed reports and a DOS-based software program for calculating the horizontal rotor wash pressures and velocities at various heights above the surface and distances from the helicopter. While the software outputs quite precise data in relation to particular parameters – the accompanying documentation makes it clear that the data has not been comprehensively validated – and should only be used for indicative purposes.

The study indicated a wall jet rotor wash flow pattern shown in Figure 3 below.

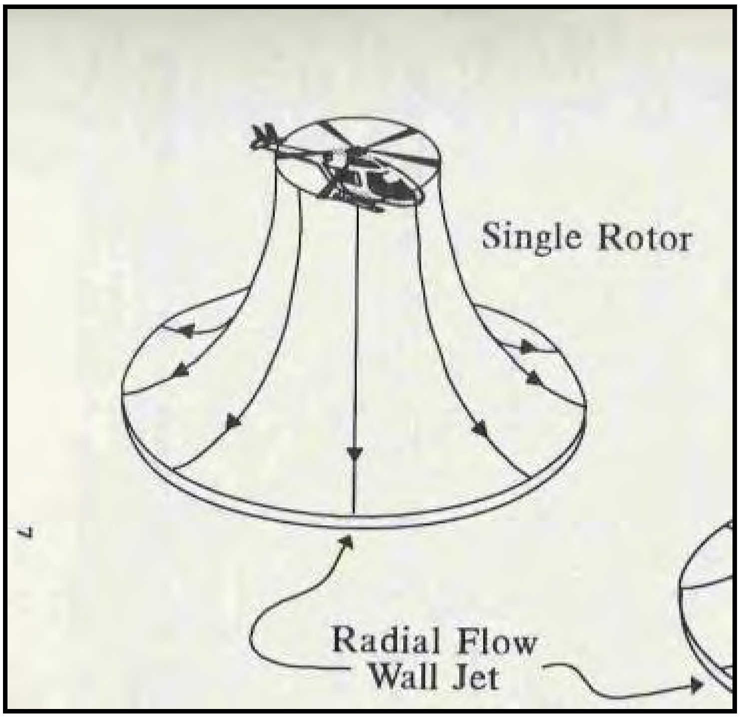


Figure 3 -- Walljet Profile for typical rotor wash

Figures 4 to 7 below illustrate the output of the ROTWASH program in regard to two sample helicopters (Bell 407 and Bell 430) over distances of 180 feet (55 m) and 90 feet (27.5 m). All other parameters were constant:- e.g. hovering with maximum all-up-weight at sea level, nil wind, approximately 10 feet skid height.

The approximate distance from the helipads tentatively drawn in relation to Arm A of the marina in the concept plan is 55 metres (180 feet). The shorter distances is used to estimate velocities and pressures just inside the 30 metre "exclusion zone" specified in CAAP 92-2 – for example at the Public Day Berths along the inside of the breakwater.

The tabular outputs (shown in Figures 4 – 7 below) are expressed in imperial units as follows:-

FT = Feet (divide by 3.281 to obtain metres)
FPS = Feet per Second
KN = knots
PSF = Pounds per Square Foot (divide pounds by 2.205 to obtain kilograms)

SINGLE ROTOR VELOCITY PROFILE AT RADIUS = 90.0 FT

PROFILE BOUNDARY HEIGHT = 20.19 FT
HALF-VEL.HEIGHT = 7.21 FT
MAX-VEL HEIGHT = 2.02 FT

HEIGHT (FT)	MEAN VELOCITY (FPS)	MEAN VELOCITY (KN)	PEAK VELOCITY (FPS)	PEAK VELOCITY (KN)	MEAN Q (PSF)	PEAK Q (PSF)
.00	.000	.000	.000	.000	.000	.000
3.00	19.535	11.580	38.871	23.041	.454	1.796
6.00	13.175	7.809	31.739	18.814	.206	1.197
9.00	8.138	4.824	26.187	15.523	.079	.815
12.00	4.337	2.571	18.609	11.031	.022	.412
15.00	1.735	1.028	9.304	5.515	.004	.103
18.00	.308	.183	1.983	1.176	.000	.005
21.00	.000	.000	.000	.000	.000	.000
24.00	.000	.000	.000	.000	.000	.000
27.00	.000	.000	.000	.000	.000	.000

Figure 4 -- Bell 407 at Max Weight, 10 foot hover, from 90 feet (27.5 metres)

Figure 4 indicates that a peak velocity of about 23 knots (38.871 feet per second) would be experienced at a height 3 feet (about 1 metre) above the surface at a distance of 90 feet (27. metres) from the hovering helicopter. The mean velocity at that point would be about half the peak velocity – assuming nil wind conditions. Peak pressure at the same point is 1.796 pounds per square foot (psf); mean pressure is 0.454 psf.

←LH

SINGLE ROTOR VELOCITY PROFILE AT RADIUS = 180.0 FT

PROFILE BOUNDARY HEIGHT = 40.39 FT
HALF-VEL.HEIGHT = 14.42 FT
MAX-VEL HEIGHT = 4.04 FT

HEIGHT (FT)	MEAN VELOCITY (FPS)	MEAN VELOCITY (KN)	PEAK VELOCITY (FPS)	PEAK VELOCITY (KN)	MEAN Q (PSF)	PEAK Q (PSF)
.00	.000	.000	.000	.000	.000	.000
3.00	10.531	6.242	12.637	7.491	.132	.190
6.00	9.767	5.790	11.721	6.948	.113	.163
9.00	8.089	4.795	9.707	5.754	.078	.112
12.00	6.587	3.905	7.905	4.686	.052	.074
15.00	5.249	3.112	6.299	3.734	.033	.047
18.00	4.069	2.412	4.883	2.894	.020	.028
21.00	3.043	1.804	3.652	2.165	.011	.016
24.00	2.169	1.285	2.602	1.543	.006	.008
27.00	1.444	.856	1.733	1.027	.002	.004

Figure 5 – Bell 407 at Max Weight, 10 foot hover, from 180 feet (55 metres)

Figure 5 represents the same helicopter and conditions as above but from twice the distance. At 180 feet (55 metres – i.e. the approximate distance from helipad to the closest berths in the concept drawings) the peak velocity is about 7.5 knots.

←[H

SINGLE ROTOR VELOCITY PROFILE AT RADIUS = 90.0 FT

PROFILE BOUNDARY HEIGHT = 20.08 FT
HALF-VEL.HEIGHT = 7.17 FT
MAX-VEL HEIGHT = 2.01 FT

HEIGHT (FT)	MEAN VELOCITY (FPS)	MEAN VELOCITY (KN)	PEAK VELOCITY (FPS)	PEAK VELOCITY (KN)	MEAN Q (PSF)	PEAK Q (PSF)
.00	.000	.000	.000	.000	.000	.000
3.00	26.027	15.428	52.623	31.194	.805	3.291
6.00	17.503	10.375	43.275	25.652	.364	2.226
9.00	10.765	6.381	35.779	21.209	.138	1.521
12.00	5.694	3.375	25.233	14.957	.039	.757
15.00	2.240	1.328	12.410	7.356	.006	.183
18.00	.374	.222	2.485	1.473	.000	.007
21.00	.000	.000	.000	.000	.000	.000
24.00	.000	.000	.000	.000	.000	.000
27.00	.000	.000	.000	.000	.000	.000

Figure 6 – Bell 430 at Max Weight, 10 foot hover, from 90 feet (27.5 metres)

Figure 6 above clearly shows that the larger Bell 430 (9300 lbs versus 5000 lbs) has a much greater rotor wash impact compared to the Bell 407. From 90 feet, the peak velocity reaches about 32 knots and the peak pressure is 3.3 psf.

←[H

SINGLE ROTOR VELOCITY PROFILE AT RADIUS = 180.0 FT

PROFILE BOUNDARY HEIGHT = 40.16 FT
HALF-VEL.HEIGHT = 14.34 FT
MAX-VEL HEIGHT = 4.02 FT

HEIGHT (FT)	MEAN VELOCITY (FPS)	MEAN VELOCITY (KN)	PEAK VELOCITY (FPS)	PEAK VELOCITY (KN)	MEAN Q (PSF)	PEAK Q (PSF)
.00	.000	.000	.000	.000	.000	.000
3.00	14.072	8.341	16.886	10.009	.235	.339
6.00	13.014	7.714	15.616	9.257	.201	.290
9.00	10.764	6.380	12.994	7.702	.138	.201
12.00	8.752	5.188	10.882	6.450	.091	.141
15.00	6.961	4.126	9.258	5.488	.058	.102
18.00	5.382	3.191	8.591	5.092	.034	.088
21.00	4.012	2.378	7.471	4.429	.019	.066
24.00	2.847	1.688	6.058	3.591	.010	.044
27.00	1.884	1.116	4.509	2.673	.004	.024

Figure 7 -- Bell 430 at Max Weight, 10 foot hover, from 180 feet (55 metres)

Figure 7 shows that the peak velocity from the Bell 430 dissipates to about 1/3 it's value when the separation distance is doubled.

Impact of Rotor Downwash in Forward Flight

As mentioned above, all of the tools for calculating rotor downwash effects are predicated upon hovering flight. We are unaware of any means of predicting the rotor downwash effect from a helicopter over-flight with forward airspeed.

Appendix D – Safety Impact of the Proposal

The incidence of third party injuries or fatalities caused by helicopter operations world-wide is so rare as to preclude quantification. We are unaware of a single instance of personal injury to non-participants caused by helicopter accidents in Australia in over 60 years of civil and military helicopter operations.

Indeed, the incidence of property damage caused by helicopter crashes is extra-ordinarily infrequent. Nonetheless, fear of helicopter mishaps is a common community reaction when confronted with the prospect of locating a helicopter landing site within a community.

The helicopter accident rate (i.e. accidents and fatal accidents per 100,000 flight hours) can be calculated from statistics kept by the Australian Transport Safety Bureau (ATSB) and the Bureau of Transport and Regional Economics (BTRE).

For the six-year period 1999-2004 (latest comprehensive data available) the data for single-engine and multi-engine civil helicopters operating in Australia is set out below.

	Year	1999	2000	2001	2002	2003	2004	Total
S-E	Accidents	28	45	41	23	29	36	202
	Fatal	6	3	5	2	6	4	26
	Hrs Flown	218900	230200	243400	267900	261000	272400	1493800
M-E	Accidents	0	1	2	0	0	2	5
	Fatal	0	0	0	0	0	0	0
	Hrs Flown	38500	39400	35000	43800	35800	39300	231800
Total	Accidents	28	46	43	23	29	38	207
	Fatal	6	3	5	2	6	4	26
	Hrs Flown	257400	269600	278400	311700	296800	311700	1725600
	Accident Rate	10.87801	17.06231	15.4454	7.37889	9.770889	12.19121	11.99583
	Fatal Accident Rate	2.331002	1.11276	1.795977	0.641643	2.021563	1.283285	1.506722

We have previously indicated that the HLS will have fewer than 30 movements per week (a movement being defined as either a take-off or a landing). Conservatively assuming each movement involves the helicopter being within a 1200 metre radius of the HLS (i.e. actually departing or arriving from the facility – as opposed to navigating in the "enroute" phase of the flight) takes less than one minute, the maximum exposure of the vicinity of the HLS to helicopter operations can be calculated to be less than 26 hours per year (movements per annum/60).

Further assuming that all phases of flight have the same accident risk per unit of time, we predict 0.003119 accidents per year and 0.000392 fatal accidents per year within that 1200 metre proximity. Put another way, we predict about 320 years between helicopter accidents and 2550 years between fatal helicopter accidents within that proximity to the HLS – attributable to air traffic utilising that facility.

Again, we emphasise that these frequencies are not tantamount to the the frequency of incidents involving third parties – but they define the limits of the worst-case scenario. Clearly the risk to the community from helicopter take off's and landings at Trinity Point Marina is very slight.