

Schedule B (1)
Guideline on the Investigation Levels
for Soil and Groundwater

NEPC



National Environment Protection
(*Assessment of Site Contamination*)
Measure 1999



The following Guideline provides general guidance in relation to Investigation Levels for Soil and Groundwater in the assessment of site contamination.

This Guideline forms part of the National Environment Protection (Assessment of Site Contamination) Measure 1999 and should be read in conjunction with that document, which includes a Policy Framework and Assessment of Site Contamination flowchart.

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1. INTRODUCTION

The appropriate use of investigation levels is an important component in the assessment of existing contaminated sites. In particular, it is important to be able to select the most appropriate investigation levels for use from a range of environmental settings and land-use scenarios that are based on considerations including the protection of health, ecology, groundwater, structures, and aesthetics.

Owners and occupiers of sites on which potentially contaminating activities are occurring are subject to the environmental protection legislation applying in each jurisdiction, eg licensing of industrial activities either prohibits the discharge of wastes onto land or applies relevant controls.

In the Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites (ANZECC/NHMRC Guidelines (1992)) a balance between the use of soil criteria and site-specific assessment was recognised. This document builds on that approach and extends it to the assessment of groundwater. A site may be assessed wholly by site-specific means or, alternatively, the initial assessment can be based around the use of investigation levels. This section details a framework for the use of investigation levels. The framework is based upon a matrix of health, and environment-based soil and groundwater investigation levels. This approach will benefit from the further development of Investigation Levels at national and regional levels. The derivation of health-based investigation levels is outlined in [Schedule B\(7A\)](#), and the risk assessment methodologies are detailed in [Schedule B\(4\)](#). [Schedule B\(5\)](#), outlines a risk assessment framework whereby regional and land use specific ecological investigation levels may be established. Until such values have been established, interim values are proposed for sites in urban areas.

2. DEFINITIONS

A variety of terms have been used to describe soil criteria. In the National Environment Protection (Assessment of Site Contamination) Measure, the principal terms used are **Investigation Levels** and **Response Levels**. Where appropriate, other terms have been used such as **Aesthetic Guidelines** and **Structural Guidelines**.

The definitions of 'Investigation Levels' and 'Response Levels' were first detailed in the ANZECC/NHMRC Guidelines (1992). Further explanations (and qualifications to their use) are provided in that text and Schedules [B\(4\)](#), [B\(5\)](#), [B\(6\)](#) and [B\(7A\)](#).

Investigation Levels are commonly Health-based or Ecologically-based (HILs and EILs). Because of Australia's ecological diversity it is proposed that EILs will be developed for regional land use (Regional Ecologically Investigation Levels (REILs)) as required by the relevant jurisdiction.

An Investigation Level is the concentration of a contaminant above which further appropriate investigation and evaluation will be required. (ANZECC/NHMRC Guidelines (1992))

Response Level is the concentration of a contaminant at a specific site based on a site assessment for which some form of response is required to provide an adequate margin of safety to protect public health and/or the environment.

3. DERIVATION OF INVESTIGATION LEVELS

3.1 HEALTH BASED INVESTIGATION LEVELS (HILs)

The derivation of HILs is outlined in [Schedule B\(7A\)](#). The health risk assessment methodology (see [Schedule B\(4\)](#)) provides the basis for estimation of HILs. Contaminant levels for a standard residential site with garden/accessible soil (setting A in Table 5-A) are based on conservative assumptions to protect a young child living on the site (and assuming that home-grown produce contributes less than 10% of fruit and vegetable intake and that no poultry are kept). This exposure setting is also applied to daycare centres, kindergartens, preschools and primary schools to provide protection to young children from soil contaminants. HILs have been set for alternative exposure settings (D, E, F, see Table 5-A) where there is reduced access to soil, or reduced time in the setting for young children. Residential settings with substantial vegetable gardens, contributing more than 10% of fruit and vegetable intake, and with poultry providing eggs or meat require site specific assessments and no generic HILs have been derived for this setting. The basis on which HILs have been set should be assessed for relevance to the situation under consideration.

The list of HILs will be reviewed from time to time by national health advisory bodies.

3.2 ECOLOGICALLY-BASED INVESTIGATION LEVELS (EILs)

Ideally, ecologically-based guidelines will be developed at a regional level and related to land use. This will require the acquisition of data relevant to the regional flora, fauna, soils, climate, etc. Data or guidelines related to protection of ecological values should be critically reviewed for scientific validity and relevance to the region under consideration. Limitations in this regard should be noted. The development of regional guidelines should be done in a coordinated fashion and will require the identification of an adequate resource base. It is recognised that this will be a resource intensive process and that regional EILs (REILs) may not be developed for some time. In the interim, it is proposed that generic EILs are set for urban (comprising city, suburban and industrial areas) land use. Where REILs are established by individual jurisdictions, these take precedence over the generic EILs established for urban land use.

In the interim, EILs for an urban setting are provided based on considerations of phytotoxicity (copper, chromium, lead) and soil survey data (barium, phosphorus,

sulfur) from four Australian capital cities. The ANZECC B values were retained for the other contaminants, and for many of the metals, soil survey data supported these values. It is acknowledged that the EILs for an urban setting have not been derived to protect nominated ecological values and are somewhat arbitrary. In some circumstances, including the presence of a valued and sensitive species or coarse-grained, acidic soils, the establishment of more pertinent regional values should assume greater priority.

3.3 GROUNDWATER INVESTIGATION LEVELS (GILs)

[Schedule B\(6\)](#), provides a framework for the assessment of groundwater contamination based on the ANZECC Australian Water Quality Guidelines (1992) (AWQG) and the NHMRC/ARMCANZ Australian Drinking Water Guidelines (1996) (ADWG). The guideline values provided in these documents define acceptable water quality for various contaminants at the point of use and apply to the following settings identified in the framework for groundwater assessment: aquatic ecosystems (fresh and marine), drinking water and agricultural use (stock watering and irrigation).

When assessing groundwater contamination, the values in Table 5-B are applied as investigation levels at the point of extraction and as response levels at the point of use, or where there is the likelihood of an adverse environmental effect at the point of discharge (see [Schedule B\(6\)](#)). The ANZECC and NHMRC/ARMCANZ documents should also be consulted as these provide valuable narrative on these values.

It should be noted that some jurisdictions might have groundwater protection policies that require action even where levels do not exceed the AWQG values at the point of use.

3.4 INVESTIGATION LEVELS FOR SEDIMENTS

Investigation levels for the assessment of contaminated sediments have not yet been established on a national basis. Investigation levels for soils should not be applied directly to the assessment of contamination of sediments. Sediment assessment is a process separate from soil assessment.

Sediment guideline values are currently being developed for inclusion in the revised ANZECC/ARMCANZ "Australian and New Zealand Guidelines for Fresh and Marine Water Quality".

3.5 AESTHETIC GUIDELINES

There are no numeric Aesthetic Guidelines but the fundamental principle is that the soils should not be discoloured, malodorous (including when dug over or wet) nor of abnormal consistency. The natural state of the soil should be considered.

3.6 STRUCTURAL GUIDELINES

For some substances such as phenols and sulfates, their impact on structures (effects on PVC piping and cement, respectively) may override the health and environmental considerations. Guidelines for protection of structures in the built environment should be set for a small number of contaminants where this is a concern. A structural guideline of 2000 mg/kg is set for sulfate in soil.

4. APPLICATION OF INVESTIGATION LEVELS

4.1 GENERAL

For a particular site and proposed land use, the key investigation levels or guidelines that will prevail will need to be determined on a site-specific basis. Consequently, professional judgement should always be exercised.

As an example, when land is being assessed for its suitability for 'residential uses with minimal opportunities for soil access' and where there are no particular sensitive ecological values to be protected, HIL(D) would be applied, but with consideration given to aesthetics, the generic urban EIL, and guidelines for protection of the built environment. GILs would be applied in assessment of impacts of the site on groundwater.

4.2 SOIL ASSESSMENT

To accommodate the range of human and ecological exposure settings, a number of generic settings are used on which HILs and EILs can be based. Four categories of Health-based Investigation Levels (HILs) and an interim urban landuse setting for Ecologically-based Investigation Levels (EILs) are provided.

HILs and EILs are not cleanup or response levels nor are they desirable soil quality criteria. They are to be used for assessment of existing contamination only and are intended to prompt an appropriate site-specific assessment when they are exceeded. Inappropriate use of investigation levels as default remediation criteria may result in unnecessary remediation adding to development costs, causing unnecessary disturbance to the site and local environment, and potential waste of valuable land fill space. Similarly, it is an abuse of investigation levels if they are interpreted as condoning contamination to these levels. Land is usually remediated to an extent which optimises current and future land use.

Site-specific health and ecological risk assessment should be conducted where exceedance of investigation levels indicates there is the likelihood of adverse effects on human health or ecological values for that site. Before comparison with soil criteria, there should be sufficient characterisation of the site to ensure that the comparison is meaningful and appropriate. [Schedule B\(7A\)](#) provides guidance about what types of exceedances trigger a detailed site-specific risk assessment.

When a site assessment indicates soil contaminants are present at concentrations above HILs or EILs, for a proposed or current use, then a site-specific risk assessment may be conducted to address relevant human health and ecological concerns. The level to which such assessments are conducted will depend on site-specific conditions. In cases of minor exceedance of investigation levels or exceedances related to contaminants which have low human toxicity and limited mobility, a qualitative risk assessment may be sufficient. The risk assessment process may lead to the development of site-specific response levels generated by risk assessment and agreed in consultation between the professionals assessing the site and the regulatory authorities.

In addition, appropriate investigation and/or response levels need to be developed when:

- investigation values are not available for contaminants of concern and/or data are not available to enable the derivation of guideline values;
- site conditions, receptors and/or exposure pathways differ significantly from those assumed in the derivations of HILs or EILs; and
- there are significant ecological concerns (eg. critical or sensitive habitat, threatened or endangered species, parklands and nature reserves).

Where soil concentrations exceed the site-specific response levels, responses may range from informing landowners and users about the nature of contamination and applying appropriate site management plans, to large scale remediation. The nature of the response must be determined on a site-specific basis.

HILs will apply across Australia. A site-specific health risk assessment should be conducted according to the framework on Health Risk Assessment, [Schedule B\(4\)](#), when Health-based Investigation Levels are exceeded for the current or intended land use.

When developed, REILs will take into account region-specific factors. The EILs presented in Table 5-A may be used as generic values at a national level. However, when applying the generic EIL or any REIL to a specific site, it should be critically reviewed to ensure relevant ecological values are protected. Where jurisdictions have established REILs, those levels would take precedence. Where REILs/EILs are exceeded, a site-specific investigation should be undertaken based on the ecological values and biota relevant to that site and to take account of the physico-chemical form and mobility potential of the contaminant on the site.

Any site assessment must include consideration of both HILs and EILs relevant to the site.

4.3 GROUNDWATER ASSESSMENT

[Schedule B\(6\)](#), provides a detailed account of the need and basis for assessment of risk from groundwater contamination. Table 5-B lists investigation levels for various use settings for the assessment of groundwater.

This Table contains a subset of the values in the AWQG relevant to the assessment of contaminated sites. The appropriate settings for current and potential uses of groundwater need to be identified for the aquifer undergoing assessment.

These settings for use are:

- raw drinking water source (where Australian Drinking Water Guidelines apply)
- agricultural use – stock watering
- agricultural use – irrigation
- protection of aquatic ecosystems – freshwater
- protection of aquatic ecosystems – marine

When groundwater from a monitoring well contains levels of contaminants above the appropriate investigation levels, then further investigation should be carried out to determine sources of contamination and to determine the lateral and vertical extent of contaminated groundwater. Modelling, or measurements at point of use, may be needed to predict impact on receptors. If this indicates that AWQG values are exceeded at the point of use, or discharge, of the groundwater, then an appropriate response is required.

5. LIMITATIONS IN THE USE OF INVESTIGATION LEVELS

5.1 GROUNDWATER CONCERNS

Groundwater protection may be a particular concern where associated with soils containing naturally low levels of trace elements. In most situations, soil contaminants at levels below appropriate EILs or HILs do not pose a threat to local groundwater sources. However, possible impacts on groundwater should always be considered. For example, some locations possess soils of high permeability containing very low levels of trace elements and direct connection to a groundwater source. In other cases the contaminant may be present in a highly leachable form or may be mobilised by site disturbance which results in geochemical changes to the contaminant. In these situations groundwater contamination may occur even when soil contaminant levels are below the appropriate EILs and HILs. The potential for groundwater contamination (with appropriate consideration of ambient groundwater quality) should be considered and caution exercised in the application of soil investigation levels. The form of the contaminant and its mobility should be defined in these investigations and the processes described in [Schedule B\(6\)](#) may need to be applied.

5.2 BACKGROUND VARIATION

In natural soils there are wide ranges of concentrations for certain elements, such as chromium, manganese, nickel and vanadium. These concentrations depend on the origins of the soil. The EILs set for these elements may be exceeded in certain regions and it would be more appropriate to apply regional background levels for comparison in assessment of site contamination. If such data are not already available, samples from adjacent property (not suspected of being contaminated by the activity which led to the site investigation being instigated) should be analysed to establish regional background levels.

5.3 MINERALISED AREAS

High levels of metals can be associated with ore bodies. Soils in mining areas may contain elevated levels of metals due to natural mineralisation in the area. This naturally occurring elevation requires community awareness programs where human settlement has occurred in the area to enable appropriate precautions to be taken (eg. importing soil for growing vegetables in the home garden). A significant amount of urban development is affected by arsenic associated with gold bearing ores, lead and other metals associated with the mining and smelting industry.

5.4 PHYTOTOXICITY

There are no generally accepted guidelines for phytotoxicity under Australian conditions at present. The derivation of any EIL, REIL or environmental response level should consider impacts on plant life. Soils should generally not be phytotoxic where the EILs in Table 5-A are applied (although certain plant species may have specific requirements for soil type or nutrients and cannot be expected to grow under all conditions). Plants adapted to nutrient poor soils may not tolerate levels of trace metals at the Investigation Levels (eg. flora of the Swan coastal plain).

5.5 ECOLOGICAL VALUES

A site-specific ecological risk assessment according to the framework in [Schedule B\(5\)](#), may be required where a particular ecological value is to be protected, or when the EIL is exceeded for the current or intended land use. Where areas of high conservation value have been identified, this information on flora and fauna to be protected should be used to identify the ecological values and hence key receptor(s) to be protected. This may be undertaken on a site-specific basis.

5.6 VOLATILE CONTAMINANTS

The derivation of soil criteria for volatile contaminants has been complicated by their complex environmental behaviours and the absence of a generally accepted model that could be used to determine exposures.

A model to determine exposure and soil criteria relevant to Australia is being developed by CSIRO in conjunction with the Environment Protection Authority (NSW) and the Public & Environmental Health Service in Adelaide. Another model is being developed by the Australian Institute of Petroleum. A process for the appraisal of the methodologies and determination of soil criteria is warranted as part of the future work plan that may arise from the MEASURE.

Information on appropriate analyte selection for total petroleum hydrocarbons/benzene/toluene/ethyl benzene/xylene and polycyclic aromatic hydrocarbons is provided in [Schedule B \(2\)](#), Section 4.6.2.

Table 5-A - Soil Investigation Levels (mg/kg)

Substances	Health Investigation Levels (HILs)						Ecological Investigation Levels (EILs)		Background Ranges ⁶
	A ¹	B ²	C ³	D	E	F	REIL ⁴	Interim Urban ⁵	
METALS/METALLOIDS									
Arsenic (total)	100			400	200	500		20	1 - 50
Barium								300	100 - 3000
Beryllium	20			80	40	100			
Cadmium	20			80	40	100		3	1
Chromium (III)	12%			48%	24%	60%		400	
Chromium (VI)	100			400	200	500		1	
Chromium (Total) ^{*7}									5 - 1000
Cobalt	100			400	200	500			1 - 40
Copper	1000			4000	2000	5000		100	2 - 100
Lead	300			1200	600	1500		600	2 - 200
Manganese	1500			6000	3000	7500		500	850
Methyl mercury	10			40	20	50			
Mercury (inorganic)	15			60	30	75		1	0.03
Nickel	600			2400	600	3000		60	5 - 500
Vanadium								50	20 - 500
Zinc	7000			28000	14000	35000		200	10 - 300
ORGANICS									
Aldrin + Dieldrin	10			40	20	50			
Chlordane	50			200	100	250			
DDT + DDD + DDE	200			800	400	1000			
Heptachlor	10			40	20	50			
Polycyclic aromatic hydrocarbons (PAHs)	20			80	40	100			
Benzo(a)pyrene	1			4	2	5			
Phenol	8500			34000	17000	42500			
PCBs (Total)	10			40	20	50			
Petroleum Hydrocarbon Components (constituents):									
• >C16 - C35 Aromatics ⁸	90			360	180	450			
• >C16 - C35 Aliphatics	5600			22400	11200	28000			
• >C35 Aliphatics	56000			224000	112000	280000			
OTHER									
Boron	3000			12000	6000	15000			
Cyanides (Complexed)	500			2000	1000	2500			
Cyanides (free)	250			1000	500	1250			
Phosphorus								2000	
Sulfur								600	
Sulfate ⁹								2000	

¹ Human exposure settings based on land use have been established for HILs (see Taylor and Langley 1998). These are:
A. 'Standard' residential with garden/accessible soil (home-grown produce contributing less than 10% of vegetable and fruit intake; no poultry): this category includes children's day-care centres, kindergartens, preschools and primary schools.
B. Residential with substantial vegetable garden (contributing 10% or more of vegetable and fruit intake) and/or poultry providing any egg or poultry meat dietary intake.
C. Residential with substantial vegetable garden (contributing 10% or more of vegetable and fruit intake); poultry excluded.
D. Residential with minimal opportunities for soil access: includes dwellings with fully and permanently paved yard space such as high-rise apartments and flats.
E. Parks, recreational open space and playing fields: includes secondary schools.
F. Commercial/Industrial: includes premises such as shops and offices as well as factories and industrial sites.
(For details on derivation of HILs for human exposure settings based on land use see [Schedule B\(7A\)](#).)

² Site and contaminant specific: on site sampling is the preferred approach for estimating poultry and plant uptake. Exposure estimates may then be compared to the relevant ADIs, PTWIs and GDs.

³ Site and contaminant specific: on site sampling is the preferred approach for estimating plant uptake. . Exposure estimates may then be compared to the relevant ADIs, PTWIs and GDs.

⁴ These will be developed for regional areas by jurisdictions as required.

⁵ Interim EILs for the urban setting are based on considerations of phytotoxicity, ANZECC B levels, and soil survey data from urban residential properties in four Australian capital cities.

⁶ Background ranges, where HILs or EILs are set, are taken from the Field Geologist's Manual, compiled by D A Berkman, Third Edition 1989. Publisher - The Australasian Institute of Mining & Metallurgy. This publication contains information on a more extensive list of soil elements than is included in this Table. Another source of information is Contaminated Sites Monograph No. 4: Trace Element Concentrations in Soils from Rural & Urban Areas of Australia, 1995. South Australian Health Commission.

⁷ Valence state not distinguished - expected as Cr (III).

⁸ The carbon number is an 'equivalent carbon number' based on a method that standardises according to boiling point. It is a method used by some analytical laboratories to report carbon numbers for chemicals evaluated on a boiling point GC column.

⁹ For protection of built structures.

Table 5-B
Groundwater Investigation Levels

SETTING ¹⁰	Aquatic Ecosystems ¹¹		Drinking Water	Agricultural ⁹	
	Marine Waters µg/L	Fresh Waters µg/L	Health ¹⁰ / Aesthetic ¹¹ mg/L	Irrigation (mg/L)	Livestock (mg/L)
METALS/METALLOIDS					
Aluminium		<5 (if pH <6.5) <100(if pH >6.5)	(0.2)	5.0	5.0
Antimony		30	0.003		
Arsenic (total)	50.0	50	0.007	0.1	0.5
Barium			0.7		
Beryllium		4		0.1	0.1
Boron			0.3	0.5-6.0	5.0
Cadmium	2.0	0.2-2.0	0.002	0.01	0.01
Chromium (Total)	50.0	10		1.0	
Chromium (VI)			0.05	0.1	1.0
Cobalt				0.05	1.0
Copper	5.0	2.0-5.0	2.0 (1.0)	0.2	0.5
Iron		1000	(0.3)	1.0	
Lead	5.0	1.0-5.0	0.01	0.2	0.1
Lithium				2.5	
Manganese			0.5 (0.1)	2.0	
Mercury (total)	0.1	0.1	0.001	0.002	0.002
Molybdenum			0.05	0.01	0.01
Nickel	15.0	15.0-150.0	0.02	0.02	1.0
Selenium	70.0	5.0	0.01	0.02	0.02
Silver	1.0	0.1	0.1		
Thallium	20.0	4.0			
Tin (tributyltin)	0.002	0.008			
Vanadium				0.1	0.1
Zinc	50.0	5.0-50.0	(3.0)	2.0	20.0
ORGANICS					
1,2-dichloroethane			0.003		
Benzo(a)pyrene			0.00001		
Carbon tetrachloride			0.003		
Chlorobenzene			0.3 (0.01)		
Dichloromethane (methylene chloride)			0.004		
Ethylbenzene			0.3 (0.003)		
Ethylenediamine tetracetic acid (EDTA)			0.25		
Hexachlorobutadiene	0.3	0.1	0.0007		

¹⁰ Levels for recreational and industrial uses have not been set. For guidance on Recreational levels, see NHMRC/ARMCANZ, 1996. For recreational uses, toxic substances should, in general, not exceed the concentrations given for drinking water. For guidance on Industrial levels, see ANZECC, 1992. Industrial settings include: generic processes, hydro-electric power generation, textiles, chemical and allied industries, food and beverage, iron and steel, tanning and leather, pulp and paper, petroleum.

¹¹ Taken from Australian Water Quality Guidelines for Fresh and Marine Waters (AWQG) (ANZECC 1992)

SETTING ¹⁰	Aquatic Ecosystems ¹¹		Drinking Water	Agricultural ⁹	
	Marine Waters µg/L	Fresh Waters µg/L	Health ¹⁰ / Aesthetic ¹¹ mg/L	Irrigation (mg/L)	Livestock (mg/L)
ORGANICS (cont..)					
Monocyclic aromatic compounds					
Benzene	300.0	300.0	0.001		
Chlorinated benzenes		0.007-15.0 ¹²			
Chlorinated phenols	0.2-8.0	0.05-18.0 ¹³	0.04-1.5		
Phenol	50.0	50.0			
Toluene		300.0	0.8 (0.025)		
Xylene			0.6 (0.02)		
Pesticides	Footnote ¹⁴	Footnote ¹⁵	Footnote ¹⁶		See guidelines for raw water for drinking water supply (AWQG, ANZECC 1992)
Aldrin	10.0 ng/L	10.0 ng/L	0.0003		
Chlordane	4.0 ng/L	4.0 ng/L	0.001		
DDT	1.0 ng/L	1.0 ng/L	0.02		
Dieldrin	2.0 ng/L	2.0 ng/L	0.0003		
Heptachlor	10.0 ng/L	10.0 ng/L	0.0003		
Phthalate esters					
di-n-butylphthalate		4.0			
di(2-ethylhexyl)phthalate		0.6			
other phthalate esters		0.2			
Polyaromatic hydrocarbons					
Polychlorinated biphenyls	0.004	0.001			
Polycyclic aromatic hydrocarbons	3.0	3.0			
Styrene (vinylbenzene)			0.03 (0.004)		
Tetrachloroethene			0.05		
Trichlorobenzenes (total)			0.03 (0.005)		
Vinyl chloride			0.0003		
OTHER					
Calcium					1,000.0
Chloride			(250.0)	30.0 700.0 ¹⁷	
Cyanide	5	0.005	0.08		
Fluoride			1.5	1.0	2.0
Nitrate-N			50.0		30.0
Nitrite-N			3.0		10.0
AESTHETIC PARAMETERS					
Colour and clarity	< 10% change in euphotic depth	< 10% change in euphotic depth			

¹² See table 2.8, p.2-49 AWQG (ANZECC 1992) for further information

¹³ See table 2.9, p.2-50 AWQG (ANZECC 1992) for further information

¹⁴ See table 2.10 also, p.2-55 (ANZECC 1992) for further information

¹⁵ See table 2.10 also, p.2-55 (ANZECC 1992) for further information

¹⁶ See table on p32 (Guidelines for Pesticides), p32 (NHMRC/ ARMCANZ 1996)

¹⁷ Maximum chloride concentration should be set according to the sensitivity of the crop. For further information. (See Tables 5.1, 5.2, 5.3, 5.4, ANZECC 1992)

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